

ABSTRACT

GRAY, VICTORIA MARIE. The Influence of Yeasts at Prolonging the Shelf-Life of Probiotics in Yogurt. (Under the direction of Dr. Trevor G. Phister.)

Since their discovery, lactic acid bacteria have been used extensively in both the industrial manufacturing of various food products and for the production of ingredients such as lactic acid and amino acids. A rapidly growing use is in the area of probiotics, whereby yogurt has been the food carrier of choice for the administration of probiotics in large part due to its long shelf life and prophylactic attributes. Different approaches and strategies aimed at optimizing the viability of probiotics in yogurt have included microencapsulation of the probiotic, packaging techniques and studies evaluating the interaction of different probiotics with the starter culture bacteria. Research has found that the presence of yeasts, both naturally occurring and those that are commercially added, in LAB and probiotic food products offer a means by which they extend their viability in the product. Recent studies performed by Liu and Tsao found improved counts of some LAB and probiotic bacteria in yogurt when the yeast *W. saturnus var. saturnus* was added. There exists a need to further investigate the synergism between yeasts and LAB at the transcriptome level in order to better understand their interactions. In this study, *L. plantarum* WCFS1, a recognized probiotic lactic acid bacterium, was chosen to evaluate its growth in yogurt with and without several different yeast species over an extended shelf life. Samples were set aside to monitor cell growth and viability, changes in the yogurt and gene expression for microarray analysis. Preliminary findings from the study found sustained counts of *L. plantarum* WCFS1 over time when co-cultured with the yeast organism, *W. saturnus*. Based on the microbiological and chemical analyses from this study, it can be assumed that modifications to the acidic environment of the yogurt are being made by the

yeast which in turn benefits the probiotic bacterium. There is still a need for a transcriptomic explanation as to elucidate the interactions occurring between the organisms. Microarray analysis, although very promising, still presents hurdles in analyzing cultures from a mixed population and complex matrix such as dairy products. More stringent measures in extracting high quality and quantity RNA from *L. plantarum* WCFS1 from the yogurt samples must be taken in future studies so as to ensure adequate starting material for microarray hybridization for eventual gene expression analysis.

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The Influence of Yeasts at Prolonging the Shelf-Life of Probiotics in Yogurt

by
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DEDICATION

I would like to dedicate this work to Mamá, Dad, Ela, Robert, John and Ruxin. All of your continuous support throughout this endeavor gave me the strength and courage to never quit and be the best I can be. Thank you for believing in me.

BIOGRAPHY

Victoria M. Gray was born in Worcester, Massachusetts. In December of 2008 she graduated from Meredith College with a double major in Biology and Spanish. During her time as an undergraduate, Ms. Gray spent a semester abroad in Salamanca, Spain. During her senior year she pursued undergraduate research opportunities where she studied pigmented bacteria isolated from the Meredith Pond under the direction of Dr. Jason Andrus. In the fall of 2009, Ms. Gray began graduate studies at North Carolina State University in the Department of Food, Bioprocessing and Nutrition Sciences pursuing a major in Food Science with a minor in Biotechnology under the advisement of Dr. Trevor Phister. During her time in the Food, Bioprocessing and Nutrition Sciences Department, Ms. Gray presented her work at the Institute of Food Technologists Annual Meeting in both 2010 and 2011. In the summer of 2011 Ms. Gray interned at Novozymes, a global biotechnology company, with the Customer Solutions Baking team. Ms. Gray was also an active member in the department where she served as the 2010-2011 NCSU Food Science Club Vice President.

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CHAPTER 1: LITERATURE REVIEW

Introduction

The group of microorganisms known as lactic acid bacteria (LAB) is defined as Gram-positive rod or cocci shaped organisms that are acid tolerant and non-sporulating and that produce lactic acid as their major metabolic end product. They are environmentally ubiquitous, found throughout the food chain from plants to the gastrointestinal (GI) tract of humans and other animals. They are however, primarily associated with food fermentations. In 1857, Louis Pasteur revealed that LAB initiated lactic acid fermentation and that they were the organisms responsible for souring milk (Stiles, 1997). History, however, indicates that LAB had been used in food production as far back as 3000 BC for the production of bread, cheese and alcoholic beverages via fermentation (Stiles *et al.*, 1996). Joseph Lister continued LAB investigations in 1873, where his work began to classify all the different kinds of LAB (Stackebrandt, 1988). Orla-Jensen's work in 1919 provided taxonomic classification of seven genera of LAB. Today there exist numerous sequenced LAB genomes representing a variety of different species and strains of both ecological and industrial importance (Figure 1.). The National Center for Biotechnology Information (NCBI) has a summary of complete microbial genomes, including LAB genomes as well as those genomes currently undergoing sequencing (Doelle, 1969) (Thompson, 1987) (Salminen, 1998) (Siezen *et al.*, 2005). (<http://www.ncbi.nlm.nih.gov/genomes/lproks.cgi>).

Since their discovery, LAB have been used extensively in both the industrial manufacturing of various food products and for the production of ingredients such as

lactic acid and amino acids. Dairy foods such as cheese, butter and yogurt make up a large portion of fermented foods produced by LAB. A rapidly growing use is in the area of probiotics, the majority of which are represented by LAB and commonly administered via dairy foods or in supplement form (Lourens-Hattingh, 2001), (Gerdes, 2006).

Probiotics are beneficial microbes that have the ability to alter the human gut resulting in a balanced microflora and overall improved health. Yogurt has been the food carrier of choice for the administration of probiotics in large part due to its long shelf life and prophylactic attributes making it a popular food option among consumers. However, several challenges and hurdles have presented themselves in the addition of probiotics to food products, especially to yogurt, due to several factors including strain differences, ingredient formulation, packaging, starter culture conflict and shelf life issues. Different approaches and strategies aimed at optimizing the viability of probiotics in yogurt have included microencapsulation of the probiotic, packaging techniques and studies evaluating the interaction of different probiotics with the starter culture bacteria. The aim of this review is to examine current practices for the industrial production of probiotic containing yogurt as well as the strategies that are implemented for making and maintaining probiotic cultures for food products.

Lactic Acid Bacteria

The heterogeneous group of bacteria classified as lactic acid bacteria (LAB) are organisms that stem from two phyla, the *Firmicutes* and *Actinobacteria*. LAB are typically Gram-positive rods and cocci, that are non-spore forming, anaerobic to

microaerophilic, catalase negative having a low GC content that excrete lactic acid as the primary metabolic end-product during sugar fermentation. LAB can be encountered in numerous environmental niches and therefore can be isolated from a range of different food matrices such as milk, meat, beverages and vegetables as well as from the oral cavities of mammals (Salminen and Wright, 1998). Figure 1. summarizes the features of selected LAB genomes that have been sequenced.

LAB are typically classified as either homofermentative or heterofermentative bacteria. Homofermenters produce greater than or equal to 85% lactic acid as their metabolic end product during sugar fermentation. Homofermenters rely on glycolysis to break down six carbon sugars into two three carbon sugars (Wood, 1961). On the other hand, heterofermenters, through the phosphoketolase pathway, generate approximately 50% lactic acid with the other by-products being carbon dioxide, ethanol and acetate (Hutkins, 2006). There are, however, LAB that are facultative heterofermentative utilizing both the glycolysis and phosphoketolase pathways depending upon the circumstances (Doelle, 1969).

LAB are capable of metabolizing an array of different sugars including galactose, lactose, glucose, maltose, sucrose, fructose and mannose. In order for these sugars to be utilized, it is imperative that they are able to enter through the outer membrane of LAB and gain access to the inside of the cell. Therefore, much of the total energy reservoir of the cell is used to conduct active transport of sugars, amino acid and peptidases. Additionally, the mode of sugar transportation can differ based on the type of sugar and the species of bacteria (Thompson, 1987). Studies investigating the genomics of some

LAB have revealed that many of these functions were obtained via a series of events such as their divergence from the *Bacilli* ancestor and horizontal gene transfer allowing rapid acclimation to a nutrient-rich environment (Klaenhammer, 2002). The three most common mechanisms of sugar transport in LAB are the phosphoenolpyruvate-dependent phosphotransferase system (PEP), ATP Binding Cassette transport systems and symports. Regulation of these transport systems by the cell is monitored at both the biochemical and the transcriptional levels (Hutkins, 2006).

Dairy Lactic Acid Bacteria

The genera of LAB that are commonly associated with the production of fermented dairy products are *Lactobacillus*, *Lactococcus*, *Leuconostoc* and *Streptococcus*. The *Lactococcus* species as well as *Streptococcus thermophilus* are homolactic producers whereas *Leuconostoc* is a heterolactic acid producer. The *Lactobacillus* species are generally homo- and heterolactic LAB.

A study investigating the adaptive nature of *Lactococcus* subsp. *cremoris* provides the sequence of plasmids revealing how this particular LAB has adapted over time to the dairy environment (Siezen *et al.*, 2005). The SK11 plasmid encodes a number of necessary yet competitive properties beyond lactose and protein metabolism that include functions for the enhancement of ion uptake, folate precursor biosynthesis, peptide utilization during carbon starvation, cold shock stress response and copper resistance (Siezen *et al.*, 2005). The origin of some of these functions is thought to have been acquired by horizontal gene transfer involving plasmid DNA exchange between *enterococci*, *streptococci*, and *lactobacilli* under

dairy environmental conditions granting LAB such as *Lactococcus lactis*, acquired attributes specific to the dairy environment (Siezen *et al.*, 2005). These qualities, among many others, are what make this LAB ideal for industrial manufacture of dairy products.

Another attribute responsible for the evolving nature of LAB is the occurrence of clustered regularly interspaced short palindromic repeat (CRISPR) loci in their genome. CRISPRs are “hypervariable genetic loci” that function as an acquired immunity system active against foreign plasmids and phages (Horvath, 2009). The short segments, known as “spacers”, play an important role in the genome where they recognize and terminate these foreign genetic elements based on previous exposure and thereby allowing the prokaryote to adapt and evade virus predation (phages) within a particular ecological niche (Barrangou, 2007). By identifying the different families of CRISPR loci in LAB genomes, further information can be acquired regarding phage exposure, as well as how phage and host genomes have evolved from common niches (Horvath, 2009).

These reasons combined explain why LAB are so commonly used in dairy industrial applications for starter culture production, dairy fermentations as well as probiotics for fermented dairy products. In the age of the “-omics” 25 LAB genomes have been sequenced and documented with several more in progress (Kyrpides, 2009). This new system for retrieving background knowledge on particular LAB will be useful in quantitative predictions of behavior under different conditions and monitoring the interactions between different species and strains of bacteria. With an established global network of LAB genomics, mechanisms of unclear function and regulation, such as quorum sensing, can be revealed and contribute to more efficacious industrial application (Zhu *et al.*, 2009).

Lactobacilli

Lactobacilli are generally characterized as gram-positive species having a low GC content and accounting for over 100 different species. *Lactobacilli* are considered GRAS organisms and are commonly used as the primary fermentative organism in dairy, meat and vegetable fermented food products eliciting preservation, flavor, texture, and nutrition. With regards to probiotic cultures, depending upon the species or the strain, they may either be autochthonous, i.e. naturally existing within the human gastrointestinal tract (GIT) or allochthonous, meaning they transiently colonize the GIT when consumed (McAuliffe, 2002). *Lactobacilli* are found primarily in the small intestine and it is for this reason that many species are exploited for their probiotic value as they are naturally tolerant to bile and acid. Figure 2. summarizes a list of the sequenced genomes of several different *Lactobacillales*.

Of the *Lactobacilli* species, *L. acidophilus*, *L. casei*, *L. gasseri*, *L. johnsonii*, *L. salivarius*, *L. plantarum* and *L. reuteri* are marketed probiotic cultures (McAuliffe, 2002). As a result of advances in genome sequencing and comparative genomics, many essential genes for probiotic organisms have been identified. The utilization of complex dietary polysaccharides like fructooligosaccharides (FOS) and raffinose, have been compared among different probiotic species and depending on the *Lactobacilli* species, sucrose gene clusters, sugar operons and cell surface specific enzymes that mediate FOS transport and uptake have been defined; these are essential genes in the evolutionary adaptation of organisms that have experienced a phylogenetic shift to nutrient rich environments such as dairy foods and the GIT (McAuliffe, 2002).

Further genomic investigations have also identified genes related to acid, osmotic and oxidative tolerance mechanisms which involve an array of stress response and regulatory mechanisms including maintenance of intracellular pH, ATPase proton pumps, repair systems for damaged DNA and proteins, uptake and biosynthesis of osmoprotectants and proteins (Klaenhammer, 2002).

Lactobacillus plantarum WCFS1

Lactobacillus plantarum WCFS1 has a completely sequenced genome thereby making it an ideal probiotic bacterium for laboratory studies. Looking at its genome one can begin to understand the possible mechanisms they rely on for interaction in the GIT. *L. plantarum* WCFS1, an isolate from human saliva (Hayward, 1956), has a chromosome containing 3,308,274-bp granting it the largest genome of all the *Lactobacilli* (Kleerbezem, 2003). With its large genome *L. plantarum* WCFS1 is more than adequately equipped, with ample genes responsible for transport and stress adaptation, to live and thrive in a vast number of environmental, nutrient-rich niches from dairy and meat fermentations to its natural niche in the human GIT (Kleerbezem, 2003). A study investigating the survivability and persistence of *L. plantarum* WCFS1 in the GI tract of mice observed *in situ* induction of transporter and stress related genes that aided in efficient removal of toxic compounds encountered in the GIT (Bron, 2004).

Both glycolysis and phosphoketolase pathway machinery are present classifying *L. plantarum* WCFS1 as a facultative heterofermentative LAB, although when grown on glucose it becomes a characteristic homolactic organism where glucose is transformed into

pyruvate via the Embden- Meyerhoff-Parnas (EMP) pathway which is subsequently converted to lactate via lactate dehydrogenase enzymes (Kleerbezem, 2003). In agreement with the importance of breaking down pyruvate for fermentative organisms, additional genes encoding lactate dehydrogenase and related enzymes can be found in significant redundancy within its genome (Kleerbezem, 2003).

L. plantarum WCFS1 has an exceptionally high number of genes responsible for sugar transport, those of which are predicted to be of the phosphoenolpyruvate (PEP)-dependent phosphotransferase system (PTS) transporters (Kleerbezem, 2003). Contrary to most other LAB, *L. plantarum* WCFS1 is without an extracellular protease for the degradation of proteins, where instead it utilizes the uptake systems of oligopeptides and di- and tripeptides (Opp and Dtp) where it then relies on intracellular peptidases of different specificity, a number of which are able to cleave the N-terminal proline residues (Kleerbezem, 2003). Interestingly, nine genes responsible for sugar transport which involved parts of the PTS system directed towards *N*-acetylglucosamine, sorbitol, sucrose, and cellobiose were induced upon introduction to the GI tract of mice (Bron, 2004). Also of the nine genes were enzymes related to ribose permease and kinase as well as di- and polysaccharide hydrolases (Bron, 2004).

L. plantarum is also equipped with the necessary pathways for amino acid biosynthesis with the exception of those responsible for branched-chain amino acids valine, leucine, and isoleucine synthesis (Kleerbezem, 2003). Bron and others also reported the induction of an additional set of nine genes within the GI tract that are responsible for the

acquisition and biosynthesis of certain amino acids, nucleotides, cofactors, and vitamins, all of which could be found in available amounts in the GIT environment (Bron, 2004).

It is important to note that the location of these vital genes are near the origin of replication in the genome, where in fact a 213-kb region is found to harbor the genes encoding sugar transport, metabolism, and regulation; it is this region referred to as the “lifestyle adaptation” island that is believed to have been acquired through horizontal gene transfer based on its characteristically low GC content in comparison to the rest of the genome (Kleerbezem, 2003). Additionally, parallel genomic studies have shown homology of many of these essential genes to pathogenic bacteria, especially to the closely related *Listeria innocua* and *Listeria monocytogenes* (Bron, 2004).

Based on the presented information, *L. plantarum* WCFS1 is an exceptional probiotic candidate in large part due to its capacity to thrive in different environments because of its large genome comprising of a significant proportion of genes dedicated to transport, regulation, and signaling all of which are regarded as potentially highly expressed (Kleerbezem, 2003). As a probiotic *L. plantarum* WCFS1 has the advantage of already being native to the gut microbiota where rather than utilizing mucin, actually is able to bind to mucin potentially due to the production of cell surface structures resembling mucin (Kleerbezem, 2003). *L. plantarum* has also demonstrated tolerance to prolonged exposure to hydrochloric acid as well as bile salts, foreign components that are initially encountered by probiotics in the host GIT (de Vries, 2006). In addition to mucus-binding, it is hypothesized based on genomic analysis that the bacterium is covered with extracellular proteins responsible for aggregation and intracellular adhesion, all in agreement with the genomic

data revealing this species containing a high proportion of genes encoding cell surface proteins and related enzymes (Kleerbezem, 2003); (Bron, 2004). As for its therapeutic effects and mechanism it has been shown to generate short-chain fatty acids that are capable of reducing the enzymatic activity leading to the production of carcinogenic compounds (Shah, 2007).

L. plantarum WCFS1 and Quorum Sensing

The ability of *L. plantarum* to grow in a variety of different environmental niches is also supported by the large presence of surface anchored proteins, aiding the microbe in recognition and potential binding to a variety of different substrates secreted or found in different environments (de Vries, 2006). The work by Kleerbezem et al. revealed *L. plantarum* WCFS1 to have genes coding for 13 sensor regulator pairs linked to the two-component system (TCS) family, in a quantity higher than most species. In conjunction, work done by Sturme et al. which focused on quorum sensing in *L. plantarum* WCFS1 was able to identify five of the 13 to be candidate quorum sensing (QS)-TCS, further supported by the identification of their respective autoinducing (AI) agents.

In *L. plantarum* WCFS1, the putative TCSs are made of histidine protein kinases (HPK) members of the HPK₁₀ subfamily having transmembranes 3-5 segments long; located downstream are genes encoding response regulators (RR) containing a HTH (Helix-turn-helix)-DNA-binding domain belonging to the LytTR family (Sturme, 2007) with an additional TCS characteristic of the HPK₇ subfamily and the RRs having a HTH-DNA-

binding domain of the LuxR family (Fuqua, 1994); (Sturme, 2007). Typically encoded upstream of the operon is the respective AI peptide (Sturme, 2007).

The TCS *plt* locus follows the scheme of HPKs of the HPK₁₀ subfamily and with RRs having HTH-DNA-binding domain of LytTR (Sturme, 2007). The *pltAKR* operon is responsible for production and secretion of the unmodified PltA peptide upon which processing is based on cell-density; however the role of this peptide is still unclear (Sturme, 2007).

In *L. plantarum* WCFS1 there are two TCS homologous to the Agr-QS system referred to as *LamKR* and *LamBDCA* that are responsible for phenotypes related to adhesion, morphology and viability based on a cross-communication mechanism (Fujii, 2008). In *S. aureus* the Agr-QS system is responsible for its pathogenic factors, however in *L. plantarum* the synonymous *Lam*-QS system provides it with the ability to adhere to different surfaces and survive in different ecological niches (Fujii, 2008). The AI for the *lamBDCA*-QS system is a cyclopentapeptide thiolactone (*LamD*) that is processed and exported via an ABC transporter encoded by *lamB* (Sturme, 2007). Fujii and others studying *lamKR* found that based on the protein homology of the *lamKR* and *lamCA* that cross-communication occurs based on the observance of interchangeable binding of LamA and LamR to the promoter regions of either operon impacting the transcription of the related genes (Fujii, 2008); (Sturme, 2007). The difference between the two *lam* operons is that unlike *lamBDCA*, the *lamKR* system lacks a *lamB* gene perhaps due to the convenience of LamR ability to utilize the promoter region of *LamBCDA* (Fuji, 2008).

Plantaricin is the antimicrobial peptide (AMP) produced by *L. plantarum* WCFS1 and is an example of a class II antimicrobial peptide (AMP) involved in a TCS *pln* similar to *L. plantarum* C11 that is essential to bacterial competition (Sturme, 2007). Class II AMPs are described as small, heat stable, unmodified peptides that, different than Class I AMPs, have a glycine-glycine motif serving as a marker for cleavage of the preceding leader peptide during export (Nes, 1996); (Quadri, 2002). Studies of *L. plantarum* C11 display plantaricin A as having a dual role as an AI for AMP production as well as for its own production (Quadri, 2002). Plantaricin A is responsible for the induction of four additional operons whose genes encode class II AMP-like precursors, class II AMP immunity proteins, an ABC transporter with its accessory protein aiding in the processing of glycine-glycine leaders and subsequent secretion of Pln peptides (Quadri, 2002).

An orphan peptide-based QS-TCS has been linked to phenotypes responsible for bacteriocin production and biofilm formation. Additional work is still needed to elucidate regulatory mechanisms of different QS systems that *L. plantarum* WCFS1 may rely on under different environmental circumstances and in the presence of different species and how that affects global gene regulation outcome.

Probiotics

The “Probiotic Approach” is the concept of altering gut microflora through the replacement of harmful microbes and the replenishing of “friendly” bacteria with specific strains of bacteria in an effort to restore microbial balance and overall health. Probiotics have become an increasingly popular addition to food formulation and dietary supplements,

particularly with fermented dairy products such as yogurt. Probiotics offer potential health benefits to those with gastrointestinal tract (GIT) diseases and those considered lactose intolerant and are therefore attractive to a variety of populations including young, old, immunocompromised, and pregnant. Current studies in probiotic research are looking at novel applications of probiotics with recent work focusing on pediatric and neonatal applications, vaccine delivery, as well as, industrial applications such as prevention of harmful bacterial growth in poultry processing facilities via competitive exclusion (Zhao *et al.*, 2006).

Lactobacillus and *Bifidobacteria* are the most extensively used probiotic species in functional foods, however, it is important to note that other genera of bacteria are also considered probiotic candidates including *Enterococcus*, *Pediococcus*, *Bacillus*, *Streptococcus*, *Lactococcus*, *Propionibacterium*, and even the yeast *Saccharomyces* (Champagne *et al.*, 2011). Phylogenetically, *Lactobacillus* species belong to the *Firmicutes* whereas *Bifidobacterium* are members of the *Actinobacteria* phylum. Based on the understanding that probiotic characteristics and behaviors are dependent on species and mostly strain, generalizations regarding potential health benefits and performance in different food systems and hosts cannot accurately be made (Williams, 2010). However it is generally accepted that probiotic bacteria have a high tolerance to acid and bile, the ability to adhere to and colonize the intestinal mucosa, produce antimicrobial substances and antagonize pathogenic bacteria, all of which require validation with clinically documented data for each probiotic strain (Borchers, 2009). In addition, probiotics offer three different strategies for contributing to improved human health: 1) producing by-products from

fermentation such as organic acids that in turn positively influence the host; 2) outcompeting exogenous or pathogenic bacteria; 3) eliciting a response from the host immune system via production of defined polysaccharides (Saier, 2005). Sarkar summarizes the selection criteria for probiotic cultures for use in food and supplements (Table 1.) (Sarkar, 2008).

Dosage

According to the World Health Organization, probiotics are defined as “live microorganisms which when administered in adequate amounts confer a health benefit on the host.” Based on this definition of probiotics, typically, the “adequate amount” necessary in benefiting the host ranges from $10^8 - 10^{11}$ per day so as to ensure arrival and colonization of the probiotics to the small intestine to achieve beneficial therapeutic effects (Guraken, 2010). However, it is important to note that currently recommendations for a standardized dose of probiotics do not exist. To date, there is only recommendation for humans to consume probiotics with no guarantee of receiving proposed health benefits. The reason is in part due to the different species and strains of probiotics used either singularly or in mixed cultures that are then applied to different food or supplement matrixes. Figure 3. summarizes commonly used species of probiotics and their respective dosage regimens.

Investigations concerning the consumption and delivery of probiotics show a recovery of $10^6 - 10^8$ of probiotic *lactobacilli* per gram in human feces (Goldin BR, 1992). Similar studies using *in vitro* gastrointestinal models reveal a survivability of 10 - 40% of probiotics out of the total amount consumed (Sanders, 1999). Studies focusing on *L. plantarum* have shown significant survival in the human ileum based on plate counts when

consumed by healthy adults at a dose of 10^8 cells, suggesting that the location of the ileum and its components are ideal for *L. plantarum* growth and survival (Vesa, 2000) (de Vries, 2006). Similar clinical studies involving healthy adults consuming *L. plantarum* demonstrated increased amounts of carboxylic acids, acetic acid and propionic acid in total fecal matter, potentially a direct effect of the probiotic on neighboring microflora as *L. plantarum* is a lactic acid producer (Johansson, 1998). Given the information on the presence and interaction of *lactobacilli* in feces and their activity, it is for this reason that viable cell plate counting is currently considered the standard for probiotic containing products assuming viability as the factor associated with functionality (Sanders, 1999). However, no strong correlation can be made between fecal recovery and appropriate dose since fecal recovery does not properly convey clinical results due to many factors effecting probiotic colonization of the intestinal tract such as the strains incorporated, the type of food vehicle or matrix used for administration, and the individual's gastric pH, intestinal motility and microbiota (Boyle, 2006). Champagne *et al.* (2011) provide recommendations for methods to determine viable cell counts of probiotics. Probiotic cultures are prepared as frozen and/or concentrated and dried, either in loose powder form, tablets or capsules (Champagne *et al.*, 2011). Depending on the form of the probiotic culture, different methodologies for preparation and enumeration for viability are to be used where in either case it is assumed that the culture has already experienced some degree of stress and damage (Champagne *et al.*, 2011).

Another aspect worthy of consideration is research negating the need for probiotics to be “live and active” in order to confer health benefits. Although cell viability is often used as

an indicator of the number of cells present at the time of consumption, research suggests situations in which viable cell activity is not necessary, examples being the improvement of lactose digestion, different types of immunomodulation, as well as anti-hypertensive effects (Sanders, 1999). “Probioactives” is the concept in which bioactive compounds produced by the probiotic organism offer a greater potential for the improvement of the host’s GIT (Farnworth, 2010). These studies and opinions further emphasize the need for more research to be completed elucidating the mechanism of probiotic organisms, especially relative to strain type and viability. The emerging field of ‘metabolomics’ could also prove helpful in identifying key compounds utilized and produced by probiotics and how they are then received and metabolized by the human body.

Interestingly in the evaluation of probiotics, clinical assessments and conclusions in the past relied heavily on *in vitro* or animal studies that omitted a dose-response evaluation (Sanders, 1999). However, advances in *in vitro* screening of strains has shifted from a static system to models simulating functions of human gastroenterology from the stomach to the colon in an effort to better understand probiotic interaction in the human GIT (Sanders, 1999). As probiotic research continues to evolve, dose-response studies are more common especially in evaluating probiotic efficacy in populations of particular diseases and disorders as well as their use as a long-term preventative supplement for healthy individuals (Kalliomaki *et al.*, 2001), (Christensen *et al.*, 2006). An ideal dose-response design would include a wide range of doses, however, issues with dose-response studies in the past have been the use of only two different doses for comparison (Donnet-Hughes *et al.*, 1999), (Gill *et al.*, 2001), (Christensen *et al.*, 2006).

Safety of Probiotics

In preparing a single or mixed culture of probiotics for human consumption, whether in supplement form or in a food product, many factors are to be considered regarding safety. The general criteria for probiotic use in humans takes into consideration safety for food and clinical use requiring that the organism be nonpathogenic and unable to acquire virulence factors or antibiotic resistance while creating no damaging effect to the intestinal mucosa. The antibiotic resistant nature of many *Lactobacilli* is of great concern based on the possibility that these antibiotic resistant genes could be horizontally transferred to indigenous microbiota in the GI tract (Wassenaar, 2008). Probiotics and innate gut microbiota having acquired antimicrobial resistance could in turn jeopardize the host by potentially donating these genes to pathogenic bacteria (Wassenaar, 2008). This safety concern requires antibiotic susceptibility assessment to investigate the virulence profile, antimicrobial nature and foreign DNA acquisition capability of probiotic strains as candidates for food or supplements (Saarela, 2009) (Wassenaar, 2008).

Also emphasized as part of the criteria is the identification and documentation of the genus, species, and strain so as to better analyze and predict the strain survivability, colonization, and compound production since these factors are known to be unique to the different strains of probiotics (Saarela, 2009). Strain identification also provides evidence that the organism is non-pathogenic and unable to invade, translocate, or survive and multiply in the bloodstream resulting in opportunistic infections and septicemia (Wassenaar, 2008). For example, studies in mice evaluating the safety of *L. plantarum* 299v concluded

that it was unable to trigger inflammation of any sort nor able to translocate outside of the intestine (de Vries, 2006).

Yogurt

Yogurt is one of the oldest fermented dairy food products and within the past 20 years it has become a popular choice among consumers as a functional food. Yogurt is an example of the symbiotic relationship bacteria can display, in this case between *Streptococcus thermophilus* and *Lactobacillus delbrueckii* sbsp. *bulgaricus*. Both organisms are thermophilic growing at 45°C and higher. Together as a mixed culture in milk, the organisms stimulate the growth of one another through the exchange of necessary metabolites. *S. thermophilus* provides *L. bulgaricus* with formic acid, pyruvic acid, folic acid and carbon dioxide whereas the proteolytic activity of *L. bulgaricus* sustains growth and activity of *S. thermophilus* by providing it with amino acids (Siewerts *et al.*, 2010). Upon closer examination of the mixed culture growth kinetics, both organisms utilize the free amino acids and di-,tri-, and oligopeptides found available in the milk during exponential growth. During this phase *S. thermophilus* flourishes and *L. bulgaricus* counts remain low. As the resources become scarce, especially in amino acids, exponential growth slows and *L. bulgaricus* initiates production of extracellular proteases which supply peptides thus generating a second exponential growth phase of the culture (Siewerts *et al.*, 2008). During this second growth phase *L. bulgaricus* counts outnumber *S. thermophilus* (Siewerts *et al.*, 2008). The PrtB protease anchored in the cell wall of *L. bulgaricus* drives production of smaller peptides from caseins that are transported intracellular by different peptide

transporters; once inside endo- and aminopeptidases further breakdown the peptides into amino acids encouraging *L. bulgaricus* into a third exponential growth phase (Siewverts *et al.*, 2008). The growth curves (Figure 4.) of each bacterium, either in mono- or together as a mixed culture, illustrate the advantage each one provides for optimal growth and fermentation of milk when grown together (Siewverts *et al.* 2010). Likewise, the schematic diagram in Figure 5. illustrates the mutualistic relationship that *L. bulgaricus* and *S. thermophilus* have during the fermentation of milk into yogurt (Siewverts *et al.* 2008).

Another growth factor for *L. bulgaricus* are long chain fatty acids (LCFA) where *S. thermophilus* is able to produce them since *L. bulgaricus* lacks the necessary pathway for de novo biosynthesis of LCFA (Partanen, 2001). Various TCSs and RRs are employed by *S. thermophilus* for responding to environmental stresses, especially when grown in milk (Thevenard *et al.*, 2011). Transcriptomic studies of *S. thermophilus* LMD-9 by Thevenard *et al.* revealed constant expression of TCS01 and TCS05 which are responsible for various environmental changes and for cell viability via cell wall restructuring, respectively (Thevenard *et al.*, 2011). The expression of 8 different response regulators when grown in milk were consistent, except for 4 (*rr01*, *rr02*, *rr05* and *rr09*) whose expression increased during the presence of *L. bulgaricus*, in some cases as high as 6-fold (*rr02* and *rr09*) and thereby substantiating the impact that *L. bulgaricus* has on the regulatory system of *S. thermophilus* (Thevenard *et al.*, 2011).

Although the lactic acid produced gives yogurt a “tart” taste, acetaldehyde largely contributes to the perceived aroma and flavor produced by *L. bulgaricus* (Siezen, 2008). The characteristic thick and smooth consistency of the yogurt is due to the decrease in pH that

coagulates the casein (Siezen, 2008). *S. thermophilus* also contributes to texture through the production of exopolysaccharides (EPS) under acidic conditions which then form a matrix with the surrounding milk proteins (Sieuwert *et al.*, 2008). Starter cultures for industrial yogurt manufacture are available as either a liquid, air-dried, freeze-dried, freeze-dried concentrate or frozen culture and are maintained and cultivated specifically to insure product consistency and quality (Siezen, 2008).

Yogurt has the convenience of being a food product that can be mass produced and made affordable to consumers while also being a safe food option, especially for those with lactose intolerance. It is regarded as a great source of calcium and protein. However, commercial yogurt is a complex food system as it is offered in a variety of choices from set versus stirred, flavor and texture varieties to fat and sugar content and formulation. Determinants of the final product involve the starter culture, processing parameters and the condition and properties of the milk being used (Soukoulis, 2006). The fermentation process is also determined and monitored by the pH which is a function of time and temperature; the end point being a pH value that reflects a product with the desired organoleptic qualities, typically between 4.2 and 4.5 (Soukoulis, 2006).

Heat pretreatment of milk prior to fermentation also has an impact on product texture, whereby heat causes the whey protein to denature and consequently, associate with casein micelles based on the coupled action of disulfide bonding and hydrophobicity (Law, 1996), (Soukoulis, 2006). Based on earlier work, it is generally accepted that by increasing denaturation of whey proteins, fermentation times are then reduced (Shaker, 2000), (Soukoulis, 2006). In addition to heat treatment and pH, it is common practice to add

protein fortifiers as texture agents, ranging from skim milk powders, milk protein concentrates, whey protein concentrates and caseinates added for the improvement and consistency of product texture (Soukoulis, 2006).

Bio Yogurt and Its Challenges

Bio yogurt is a functional dairy food product that contains live strains of a probiotic bacterium, often *Lactobacillus acidophilus* and/or *Bifidobacterium* whose invention stems from the early works of Eli Metchnikoff and Tissier (Pasteur Institute, France) where it is believed that the addition of these live cultures will result in a therapeutic effect enhancing GI health (Lourens-Hattingh, 2001). For a probiotic culture to be used in food, two factors must be met: 1) survival and increase in cell concentration at the beginning and end of fermentation and 2) survival in the final product during storage at refrigeration (Gilliland, 2002). Similar to traditional yogurt, bio yogurt undergoes the same processing procedures where the probiotic culture to be added is done either simultaneously with the starter culture or after fermentation by the starter culture (Lourens-Hattingh, 2001). Compared to the yogurt culture bacteria (*S. thermophilus* and *L. bulgaricus*) probiotic bacteria grow poorly in milk due to a lack of proteolytic properties, therefore the activity performed by the yogurt culture, which are much higher in proteolytic activity, creates more suitable conditions for the probiotic culture by providing the necessary amounts of peptides and amino acids (Shihata, 2001). Although research has already shown that bacterial species can have either proto-cooperative or antagonistic relationships towards each other, more recent studies evaluating the interactions between LAB starter cultures and probiotics observed four

different types of behavior: stimulation, delay, complete inhibition, and no effect (Vinderola, 2002). The outcome is largely associated with the genera/species/strains of the bacteria, further stressing the importance of proper strain implementation when developing a probiotic containing fermented food product (Vinderola, 2002). The starter cultures themselves can have an antagonistic effect towards the probiotic culture; for instance, *L. bulgaricus* has been shown to produce substances, including hydrogen peroxide, bacteriocins and organic acids, that reduce the stability of probiotic *L. acidophilus* strains (Lourens-Hattingh, 2001). Removal of *L. bulgaricus* from the starter culture for the production of bio yogurt is a strategy often used for the improvement in viability of *L. acidophilus* (Dave, 1998).

Other challenges arise with the addition of probiotic cultures to fermented dairy products that revolve around yogurt formulation, acidity, storage conditions and shelf viability. In some cases the addition of cysteine, whey protein concentrate, acid casein hydrosylates or tryptone was found to improve viability of *L. acidophilus* and bifidobacteria while reducing the amount of time needed for fermentation (Dave, 1998). Yogurt being a low pH (~4.2) product that is stored at refrigerated temperatures creates a big hurdle for the survival of probiotic organisms due to many species and strains having a low tolerance to both conditions (Lourens-Hattingh, 2001). Research done by scientists at Danisco USA Inc., Madison, Wisconsin has found that a pH below 4.0 is a hindrance to the viability of the probiotic organism where a pH of 4.0-4.2 offers more favorable conditions for viability (Gerdes, 2006).

Strategies for Improving Shelf-viability of Probiotics in Yogurt

The maintenance of probiotic culture viability involves two main areas of concern: 1) handling and storage; 2) appropriate evaluation methods. Problems with maintaining the probiotic culture viability throughout storage and distribution has been a common theme among commercial manufacturers. The viability of the probiotic culture to be implemented is critical since the benefits the probiotics offer to the human host are only achieved at high concentrations of the organism. Reports on probiotic containing products, however, have announced cell counts lower than those initially added and at unacceptably low numbers (Shah, 2000); (Tsao and Liu, 2009). Viability depends on several factors such as how the microbe is grown and stabilized, how it is handled and stored as well as time and temperature exposure to moisture once the microbe is in the product (CAST, 2011). Manufacture of the functional food and passage of the probiotic culture through the GIT are also key factors to consider regarding viability (Figueroa-Gonzalez, 2011). Despite the harsh conditions of yogurt, it is believed that by introducing the probiotic culture to such conditions, milk components may provide a protective matrix to the organism and may actually prepare the organism to withstand the extreme conditions encountered in the human GIT by turning on necessary genes (Gerdes, 2006) (Linn, 2008). On the contrary, Muller and others (2011) found that the stress responses occurring throughout storage in a yogurt-like product for *L. johnsonii* NCC 533 had no correlation to survival mechanisms induced upon exposure to the suboptimal conditions of the matrix (Stackebrandt *et al.*, 1988); (Stiles, 1996); (Muller *et al.*, 2011).

In an effort to improve shelf stability of probiotics, methods have been studied and implemented including the selection of strains with higher acid and bile resistance, two phase fermentation, strain adaptation and pretreatment, micro-nutrient supplementation, improved packaging, and micro-encapsulation (Shah et al., 2000). In two-phase fermentation, the probiotic culture ferments the milk for about 2 hours followed by fermentation by the traditional yogurt cultures resulting in enhanced viability of both *L. acidophilus* and *B. longum* cultures after 6 weeks of storage, the explanation of which is still to be defined (Lankaputhra, 1995). Studies done by Shah et al. (2000) comparing different packaging materials concluded that thickness was an important quality for improving the survival of both *L. acidophilus* and Bifidobacteria in yogurt (Sarkar, 2010).

Microencapsulation is a technology that has proven most efficient at prolonging survival of probiotic cultures since it is best at maintaining viability during processing and storage. Microencapsulation is the packaging of solids, liquids or even gases in such a way that releases its contents in a controlled manner dependent on the conditions of its environment or matrix (Shahidi, 1993). The method can rely on different techniques including emulsion, spray-drying, spray-congealing, fluidized bed coating, extrusion, phase separation and electrostatic technique (Figueroa-Gonzalez, 2011). The materials most commonly used for the actual coating include water-soluble or insoluble polymers, waxes, fatty acids and lipids (Figueroa-Gonzalez, 2011). Although a promising solution, research is still focusing on ways in which to improve the cost of implementing such a method as well as fine-tuning the release factor of the organism to the host.

Another area being studied for the extension of probiotic culture viability is synbiotics, which is the combination of adding a probiotic culture with a non-digestible substance, or prebiotic, that facilitates the growth of beneficial bacteria and aids in their implantation in the human gut to improve GIT stability (Andersson, 2001), (Figuroa-Gonzalez, 2011). Prebiotics are typically oligosaccharides, either extracted from plant material or synthetically produced from polysaccharides, which serve as a fermentable substrate for selective bacteria residing in the large intestine (Figuroa-Gonzalez, 2011). Due to the difficulties in isolating and purifying prebiotics they are an expensive option for functional food manufacturers. However, studies using prebiotics in conjunction with microencapsulation have proven the positive effects of adding either fructo-oligosaccharides and/or resistant starches to the coating formulation for Bifidobacteria (Chen, 2007); (Crittenden, 2006). Similar results have yet to be found with *Lactobacilli* species.

LAB and Yeast Interactions in Fermented Dairy Products

Many of the fermented foods produced today provide niches for mixed communities of yeast and bacteria. Indirect interactions in mixed communities are situations of competition, commensalism, mutualism, ammenalism or neutralism (Linten, 1982). Direct interactions are those that entail predation and parasitism (Fredrickson, 1977). Throughout the production of a given food matrix, there is the potential for any one of these interactions to occur either in succession or simultaneously. Factors that influence the interactions in industry include the starter cultures used, the processing equipment, conditions and the environment that ultimately selects for the survival of certain bacteria and yeasts.

In the production of dairy products, yeast and lactic acid bacteria interactions are quite common. The origin of yeasts in the processing environment is not necessarily an indication of poor sanitation but rather a display of the ability of the yeast to withstand cleaning and sanitizing agents, utilize lactose, galactose and organic acids, even at low temperatures while also having proteolytic and lipolytic activity (Fleet, 1990); (Laubascher, 1999). In yogurt yeasts are commonly introduced as a contaminant via the addition of fruit, honey or sugar where they are a source of available carbohydrates for the yeast (Viljoen, 2001). Studies evaluating the starter cultures used in yogurt production found contaminating yeasts counts to be stable or increased, possibly pointing to a symbiotic effect of one organism providing essential growth factors for the other (Viljoen, 2001). Viljoen and others studied the effects of temperature abuse on yogurt finding that, contrary to literature, low temperatures were actually effective at inhibiting yeast growth whereas temperatures above 5°C supported yeast growth which in turned stabilized the LAB present based on a significant decrease in pH (Viljoen, 2003).

In a study aiming to extend the shelf-life of probiotics in yogurt, Liu and Tsao (2009) reported five different yeasts capable of significantly enhancing the survival of *Lactobacillus rhamnosus* DR20 by 10^3 to 10^6 -fold during incubation at 30°C whereby the direct correlation between yeast viability and *L. rhamnosus* DR20 could be observed (Figure 6.). Furthermore, the study goes on to examine the effects of the yeast, *Williopsis saturnus* var. *saturnus* CBS254, when co-cultured with different LAB species where results showed significant improvement in the viability of *L. rhamnosus* DR20, *L. reuteri* DSM20016, and *L. acidophilus* ATCC4356, by as much as 10^6 -fold (Figure 7.) Based on preliminary findings,

the authors predict that the effects of the yeast go beyond nutrient excretion to mechanisms not yet defined (Liu and Tsao, 2009). The convenience of *W. saturnus* var. *saturnus* is its inability to utilize lactose and galactose as fermentable substrates and thereby preventing the occurrence of off-flavors and odors as well as gas production in the final product.

Liu and Tsao continued experiments with *W. saturnus* where they tested it under a range of different temperatures (4 °C – 40 °C) and co-cultured with LAB. Temperature had an impact whereby the increase in temperature accelerated the decline in LAB counts (Figure 8.). However, LAB with *W. saturnus* between 10 °C and 30 °C exhibited a direct relationship; as temperature increased so did the effects of *W. saturnus* on total LAB revealing improved counts of LAB by up to 10⁷-fold (Liu and Tsao, 2010). As a comparison, dead *W. saturnus* yeast cells were co-inoculated into yogurt with *L. rhamnosus* DR20 where results showed slightly improved counts of *L. rhamnosus* DR20 even with the non-viable yeast (Figure 9.) (Liu and Tsao, 2010).

Kefir is a prime example of the interaction yeast and bacteria display in milk-based products in which a mutualistic relationship is established. The yeasts play a pivotal role as provider of amino acids and vitamins for bacterial growth; as the bacteria grow, acid production increases and the by-products produced supplement the growth of the yeasts (Viljoen, 2001). Similarly, in koumiss the organic acids excreted by the initial metabolic activity of LAB create competitive conditions that select for the growth and fermentation by yeast populations resulting in a stabilized shelf-life and safe to eat food (Oberman, 1985). A study by Gadaga and others investigated the effects of different yeast species on the growth of different LAB species found from African naturally fermented milk (NFM). The studies

found improved survivability of some LAB strains when co-cultured with yeast strains at refrigeration over a week long period and more specifically, found increased counts of *Lactobacillus paracasei* subsp. *paracasei* Lb11 grown in the presence of three different yeast strains (Gadaga *et al.*, 2001). Additional reports further substantiate the synergistic effects displayed between some strains of LAB and yeasts, for instance, Cheirslip and others who found similar interactions between *Lactobacillus kefiranofaciens* and *S. cerevisiae* (Cheirsilp *et al.*, 2003), (Narvhus *et al.*, 2003).

Yeast in food

Yeasts have for centuries been used in the preservation of food and beverage commodities including wine, beer and breads. *Saccharomyces cerevisiae* serves as the model eukaryote as having the first completely sequenced and annotated genome. Thanks to discoveries made in yeast genomics, several other yeast species have been defined and exploited for their use in industrial manufacture of food ingredients and processing aids (Fleet, 2006). Aside from being a safe food option, yeasts offer health benefits as being a great source of B vitamins, proteins, peptides, amino acids and minerals that come available in dietary and supplement form (Fleet, 2006). Although not typically associated with dairy food production, yeasts offer an important role in providing flavor and texture attributes of cheeses as well as serving as the primary organism in the fermentation of milk products like kefir and koumiss (Fleet, 1990); (Frohlich-Wyder, 2003). Among their use in many cheeses, the species most commonly associated with fermented milks include: *Candida*, *Galactomyces*, *Kluyveromyces*, *Saccharomyces* and *Torulasporea* (Romano, 2006).

Kluyveromyces lactis is the primary organism for the industrial production of chymosin for the cheese industry. If the yeast is to be used in yogurt-like products, the yeast should be non-lipolytic and unable to utilize lactose and galactose, in order to prevent the occurrence of off-flavor and/or aromas, and should therefore be inoculated at low amounts to minimize such possibilities (Roostita, 1996), (Liu and Tsao, 2009). Yeasts can also be implemented as a secondary starter culture for the development of organoleptic qualities in the products but also as a way to aid the growth of other microorganisms (Romano, 2006).

Despite their usefulness in the food industry, yeasts can also be a common food and beverage spoilage issue. Common commodities of yeast spoilage include those that are high acid, low pH containing more than 10 % (w/v) sugar and more than 5 % NaCl that implement weak organic acids such as sorbic, benzoic and acetic acids (Fleet, 2006).

Zygosaccharomyces is an example of a spoilage organism whose resilience is the result of efficiently tolerating extreme conditions of high sugar, ethanol and organic acids. The ability to exist and spoil in a variety of different food and industrial ecosystems is reflective of the extensive network of stress responses controlled at the molecular level. Under stressful conditions, specific responses are triggered that can result in, for instance, trehalose accumulation and antioxidant production or induction of ionic effluxers (Walker, 2006).

Most of the available information that contribute to the exploitation and control of yeasts come from studies investigating the tolerance and stress response of *S. cerevisiae* while there is still a gap of information missing related to non-*Saccharomyces* yeast species. Data obtained from molecular studies in stress response and adaption from a broader group of

yeast species in combination with improved efforts in hygiene and good manufacturing practices are ways in which yeasts can be understood in a more fundamental meaning.

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TABLES AND FIGURES

Table 1. Probiotic Culture Standards (Sarkar, 2008); (Liu, 2010)

<i>Probiotic Culture Standards</i>	
Have a beneficial impact on the host	Able to grow in milk and acidify it
Survival to the GIT where it remains live and active; viable in the distal tract with recovery in feces	Resistant to cultured milk acidity to ensure viability during storage
No immune reaction from host towards the probiotic strain	Resistant to gastric juices and bile salts
No pathogenic, toxic, allergic, mutagenic, or carcinogenic effects from the probiotic or any of its fermentation by-products	Transit capacity
Genetically stable, no plasmid transfer	Able to implant and colonize in the human gut
Convenient and reproducible production	Able to utilize endogenous and exogenous nutrients
Viable during processing and storage	Genera is of human origin
Resistance to digestive enzymes residing in the intestine (i.e. lysozymes)	Resistance to oxygen
Tolerance to toxic metabolites and primarily phenols produced during digestion	Capable of producing antimicrobial substances
Resistance to antibiotics and viruses	Must be proven safe and effective

Table 1. Features of sequenced LAB genomes

Species	Primary application	NCBI accession number	Genome size	Plasmids	Pseudogenes	Prophages (complete)	Proteins	Refs
<i>Lactobacillus acidophilus</i> NCFM	Probiotic	NC_006814	1.9 Mb	0	0	0	1864	[1]
<i>Lactobacillus brevis</i> ATCC 367	Starter culture	NC_008497	2.3 Mb	2	49	1	2221	[7]
<i>Lactobacillus casei</i> ATCC 334	Starter culture, probiotic	NC_008526	2.9 Mb	1	82	2	2776	[7]
<i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i> ATCC 11842	Starter culture	NC_008054	1.9 Mb	0	533	0	1562	[9]
<i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i> ATCC BAA-365	Starter culture	NC_008529	1.9 Mb	0	192	0	1725	[7]
<i>Lactobacillus gasseri</i> ATCC 33323	Probiotic	NC_008530	1.9 Mb	0	48	1	1763	[12]
<i>Lactobacillus johnsonii</i> NCC 533	Probiotic	NC_005362	1.9 Mb	0	0	2	1821	[8]
<i>Lactobacillus plantarum</i> WCFS1	Vegetable fermentation, probiotic	NC_004567	3.3 Mb	3	42	2	3009	[6]
<i>Lactobacillus reuteri</i> F275	Probiotic	NC_009513	2.0 Mb	0	39	0	1900	
<i>Lactobacillus sakei</i> subsp. <i>sakei</i> 23k	Starter culture	NC_007576	1.9 Mb	0	0	1	1879	[4]
<i>Lactobacillus salivarius</i> subsp. <i>salivarius</i> UCC118	Probiotic	NC_007929	1.8 Mb	3	49	2	1717	[5]
<i>Lactococcus lactis</i> subsp. <i>cremoris</i> MG1363	Starter culture/type strain	NC_09004	2.5 Mb	0	82	2	2434	[10]
<i>Lactococcus lactis</i> subsp. <i>cremoris</i> SK11	Cheese production	NC_008527	2.4 Mb	5	144	4	2509	[7]
<i>Lactococcus lactis</i> subsp. <i>lactis</i> IL1403	Milk fermentation	NC_002662	2.3 Mb	0	1	3	2321	[3]
<i>Leuconostoc mesenteroides</i> subsp. <i>mesenteroides</i> ATCC 8293	Starter culture	NC_008531	2.0 Mb	1	19	1	2009	[7]
<i>Oenococcus oeni</i> PSU-1	Secondary wine fermentation	NC_008528	1.8 Mb	0	122	0	1701	[7]
<i>Pediococcus pentosaceus</i> ATCC 25745	Starter culture	NC_008525	1.8 Mb	0	20	2	1757	[7]
<i>Streptococcus thermophilus</i> CNRZ1066	Starter culture	NC_006449	1.8 Mb	0	0	1	1915	[2]
<i>Streptococcus thermophilus</i> LMD-9	Starter culture	NC_008532	1.8 Mb	2	206	1	1710	[7]
<i>Streptococcus thermophilus</i> LMG 18311	Starter culture	NC_006448	1.8 Mb	0	0	0	1889	[2]

Figure 1. Sequence and Annotated LAB Genomes (Pfeiler, 2007)

TABLE 1. General features of the sequenced genomes of *Lactobacillales*

Species/strain	Genome length (bp)	No. of plasmids (no. of genes)	No. of proteins	Reference	Association
<i>Lactobacillus plantarum</i> WCFS1 ^a	3,308,274	3 (50)	3,009	22	Plant/meat material
<i>Lactobacillus johnsonii</i> NCC 533 ^a	1,992,676	0	1,821	43	GIT ^b
<i>Lactobacillus acidophilus</i> NCFM	1,993,564	0	1,864	2	GIT
<i>Lactobacillus sakei</i> subsp. <i>sakei</i> 23K	1,884,661	0	1,879	8	Meat material
<i>Lactobacillus salivarius</i> subsp. <i>salivarius</i> UCC118	1,827,111	3 (320)	1,717	9	GIT
<i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i> ATCC 11842	1,864,998	0	1,562	57	Yogurt, cheese
<i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i> ^a	1,856,951	0	1,725	28	
<i>Lactobacillus gasseri</i> ^a	1,894,360	0	1,763	28	GIT
<i>Lactobacillus brevis</i> ^a	2,340,228	2 (37)	2,221	28	Plant/meat material
<i>Pediococcus pentosaceus</i> ^a	1,832,387	0	1,757	28	Plant/meat material
<i>Oenococcus oeni</i> ^a	1,780,517	0	1,701	28	Wine
<i>Leuconostoc mesenteroides</i> ^a	2,075,763	1 (34)	2,009	28	Plant material
<i>Lactobacillus casei</i> ^a	2,924,325	1 (20)	2,776	28	Dairy products
<i>Lactococcus lactis</i> subsp. <i>lactis</i> ^a	2,365,589	0	2,321	7	Dairy products, bacteriocins
<i>Lactococcus lactis</i> subsp. <i>cremoris</i> ^a	2,641,635	5 (129)	2,509	28	
<i>Streptococcus thermophilus</i> CNRZ1066	1,796,226	0	1,915	5	Yogurt, cheese
<i>Streptococcus thermophilus</i> LMG 18311	1,796,846	0	1,889	5	
<i>Streptococcus thermophilus</i> LMD-9 ^a	1,864,178	2 (6)	1,718	28	

^a Species that were analyzed as part of a recent comparative-genomic project (28).

^b GIT, gastrointestinal tract.

Figure 2. Summary of sequenced genomes of Lactobacillales (Markarova, 2007)

Table 2. Probiotic Species and Dosing ^a	
Indication and Probiotic	Recommended Dosage Regimen
Acute infectious diarrhea in infants and children <i>Lactobacillus rhamnosus</i> GG (LGG)	At least 10 ¹⁰ CFU in 250 mL of oral rehydration solution ²⁵ ; 10 ¹⁰ –10 ¹¹ CFU twice daily for 2–5 days ²⁶
<i>Lactobacillus reuteri</i>	10 ¹⁰ –10 ¹¹ CFU daily up to 5 days ²⁶
Antibiotic-associated diarrhea <i>Saccharomyces boulardii</i>	4 × 10 ⁹ –2 × 10 ¹⁰ CFU daily for 1–4 wk ²⁰
LGG	6 × 10 ⁹ –4 × 10 ¹⁰ CFU daily for 1–2 wk ²⁰
<i>Lactobacillus acidophilus</i> and <i>Lactobacillus bulgaricus</i>	2 × 10 ⁹ CFU daily for 5–10 days ²⁰
<i>L. acidophilus</i> and <i>Bifidobacterium longum</i>	5 × 10 ⁹ CFU daily for 7 days ²⁰
<i>L. acidophilus</i> and <i>Bifidobacterium lactis</i>	1 × 10 ¹¹ CFU daily for 21 days ²⁰
<i>Clostridium difficile</i> infection <i>S. boulardii</i>	2 × 10 ¹⁰ CFU (1 g) daily for 4 wk plus vancomycin and/or metronidazole ²⁰
Travelers' diarrhea LGG	2 × 10 ⁹ bacteria daily starting 2 days before departure and continued throughout trip ²⁴
<i>S. boulardii</i>	5 × 10 ⁹ –2 × 10 ¹⁰ CFU daily starting 5 days before departure and continued throughout trip ²⁴
Irritable bowel syndrome VSL#3 ^b	9 × 10 ¹¹ CFU daily for 8 wk ²⁸
<i>Bifidobacterium infantis</i> 35624	10 ⁹ –10 ¹⁰ CFU daily for 4 wk ²⁸
LGG and other organisms	8–9 × 10 ⁹ CFU daily for 6 mo ^{23,28}
Ulcerative colitis (UC) <i>Escherichia coli</i> Nissle 1917	Active UC: 5 × 10 ¹⁰ bacteria twice daily until remission (maximum of 12 wk), followed by 5 × 10 ¹⁰ bacteria daily for a maximum of 12 mo ²⁹ ; inactive UC: 5 × 10 ¹⁰ bacteria daily (study duration was 12 wk) ³⁰
<i>S. boulardii</i>	Active UC: 250 mg 3 times daily for 4 wk plus mesalamine ⁴²
VSL#3 ^b	Active UC: 1.8 × 10 ¹² bacteria (two 3-g sachets) twice daily for 6 wk plus conventional therapy ⁴³
Crohn's disease <i>S. boulardii</i>	Maintenance therapy: 1 g daily for 6 mo plus mesalamine ⁴⁴
Pouchitis VSL#3 ^b	Maintenance therapy: 1.8 × 10 ¹² bacteria daily, given as 3-g sachets twice daily (study duration was 9 mo) ⁴⁵ ; maintenance therapy: 1.8 × 10 ¹² bacteria daily, given as two 3-g sachets once daily (study duration was 12 mo) ⁴⁶
Atopic disease prevention LGG	10 ¹⁰ CFU daily for 2–4 wk before expected delivery in pregnant women, followed by infant administration for 6 mo ²⁰
Vulvovaginal candidiasis LGG	10 ⁹ bacteria per suppository inserted twice daily for 7 days ⁵⁴
<i>L. rhamnosus</i> GR-1 and <i>Lactobacillus fermentum</i> RC-14	At least 10 ⁹ bacteria suspended in skim milk given orally twice daily for 14 days ⁵⁵
<i>L. acidophilus</i>	8 oz yogurt containing ≥10 ⁸ CFU/mL ingested daily for 6 mo ⁵⁶

^aCFU = colony-forming units.
^bVSL#3 is a mixture of eight probiotic organisms (*Lactobacillus casei*, *L. plantarum*, *L. acidophilus*, *L. bulgaricus*, *B. longum*, *Bifidobacterium breve*, *B. infantis*, and *Streptococcus thermophilus*).

Figure 3. Probiotic Species and Dosage (Williams, 2010)

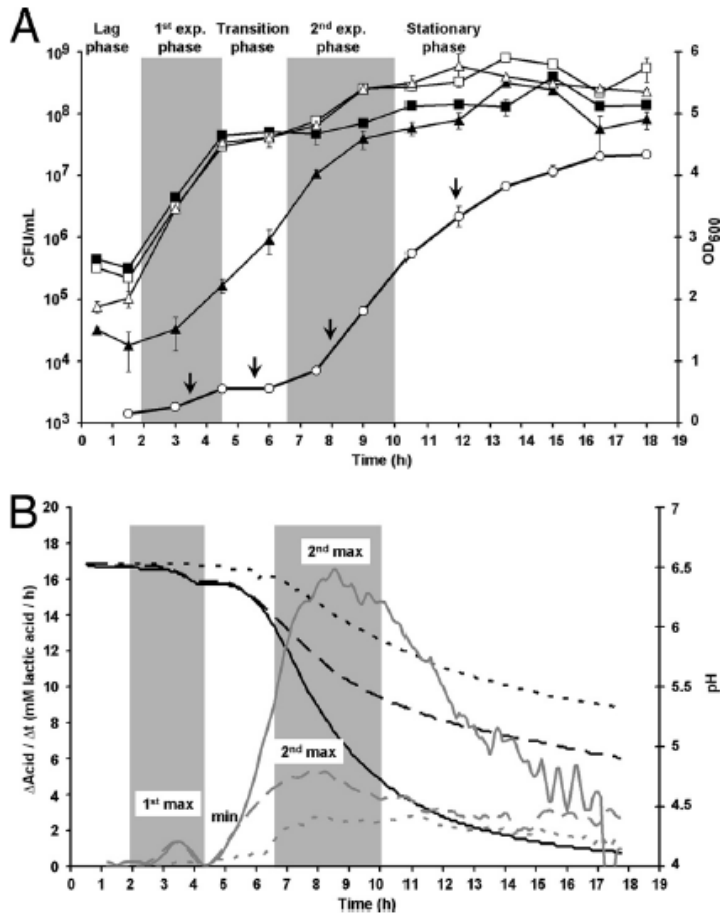


FIG. 1. Growth and acidification of monocultures and mixed cultures grown in 10% reconstituted skim milk at 42°C. (A) CFU per ml of *S. thermophilus* in monoculture (■) and mixed culture (□) and *L. bulgaricus* in monoculture (▲) and mixed culture (△), and the OD₆₀₀ of the mixed culture (○). Error bars indicate the standard deviations of triplicate measurements. Gray and white boxes indicate the five distinct growth phases of the mixed culture. Arrows indicate sampling points for transcription profiling. (B) pH (black lines) and acidification (mM lactic acid/h) (gray lines) of typical milk fermentations of *S. thermophilus* (dashed lines), *L. bulgaricus* (dotted lines), and the mixed culture (solid lines). In the *S. thermophilus* and mixed culture, the two exponential phases display a maximal acidification rate (1st and 2nd max). In between, at the transition phase at $t = 4.5$ h, there is a point at which the acidification rate drops almost to zero.

Figure 4. Growth curves of mono- and mixed cultures of *L. bulgaricus* and *S. thermophilus* in milk (Sieuwerts *et al.* 2010)

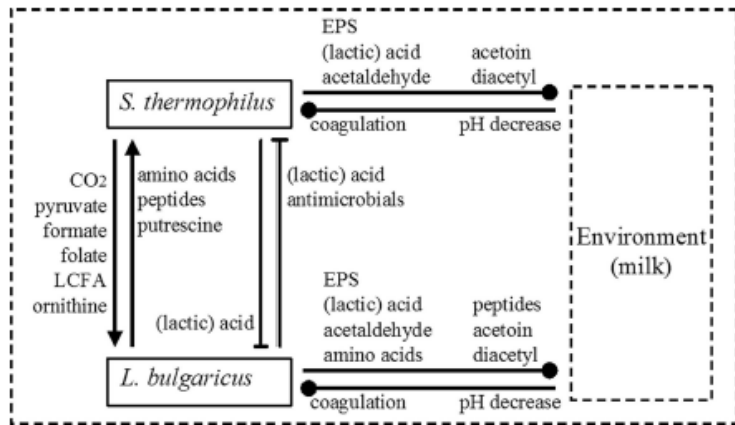


FIG. 1. Schematic representation of the validated and hypothesized interactions that occur between *Streptococcus thermophilus*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, their environment, and the compounds relevant for yogurt characteristics. ▼, positive interactions; +, negative interactions; ●, interactions that do not specifically promote or decrease the growth of the other species. LCFA, long-chain fatty acids. See text for references.

Figure 5. Interaction between *L. bulgaricus* and *S. thermophilus* in milk (Sieuwert, 2008)

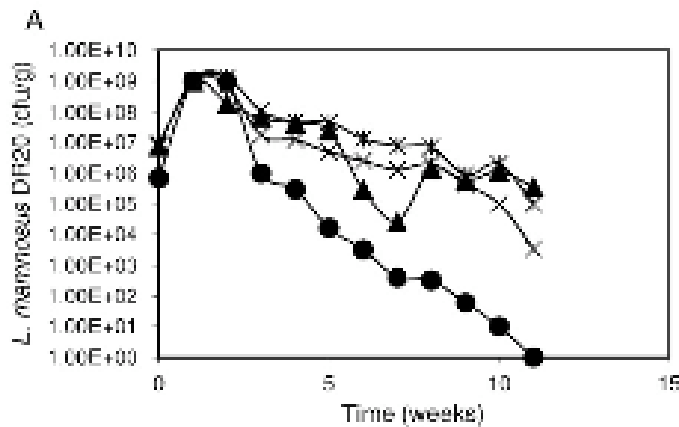


Figure 6. Stability of *L. rhamnosus* DR20 in fermented milk by: *G. candidum* (triangle); *S. pombe* (x); *P. subpelliculosa* (*) compared to the control having no added yeast (black circle) (Shao-Quan and Liu, 2009)

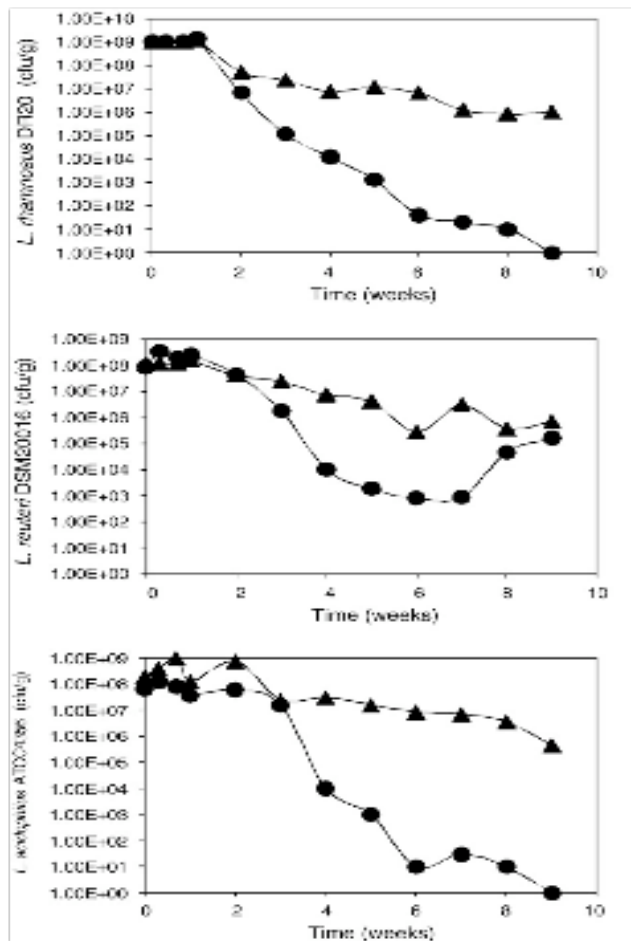


Figure 7. Effects of *W. saturnus* in fermented milk with: *L. rhamnosus* DR20 (top), *L. reuteri* DSM20016 (middle), *L. acidophilus* ATCC4356. Growth with yeast (triangle); growth without yeast (circle) (Shao-Quan and Liu, 2009)

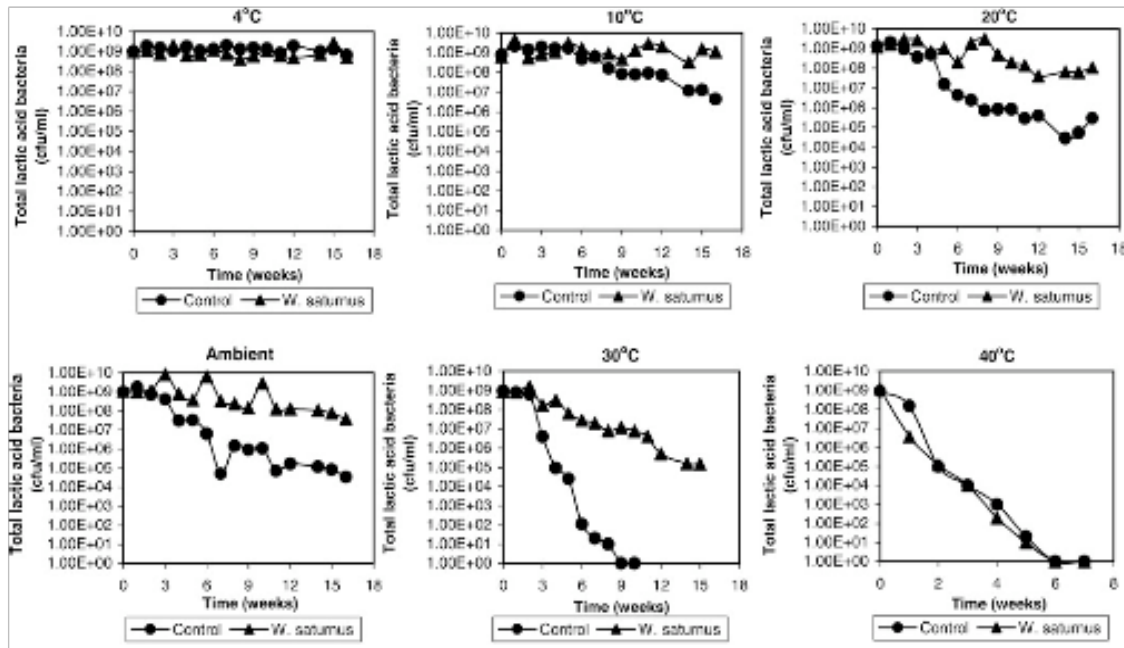


Figure 8. Effect of *W. saturnus* on LAB growth in yogurt under different temperatures

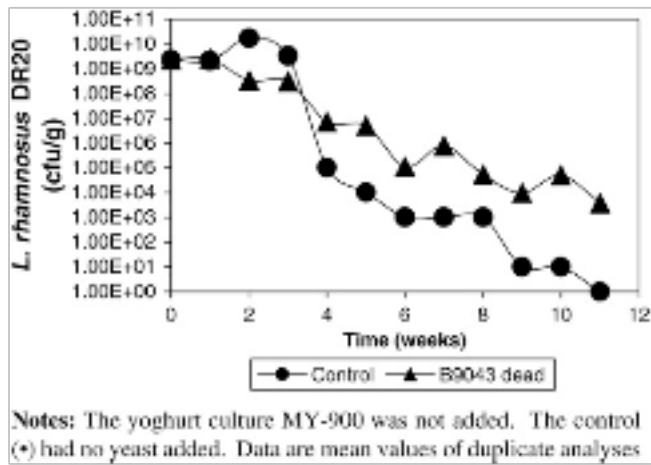


Figure 9. Effect of non-viable *W. saturnus* on LAB growth in yogurt

**CHAPTER 2: THE INFLUENCE OF YEASTS AT PROLONGING THE SHELF-
LIFE OF PROBIOTICS IN YOGURT**

1. Introduction

Prolonging the shelf viability of probiotics is of great importance to probiotic food manufacturers where a number of different strategies are currently being researched and employed. The variety of approaches ranges from strain specific starter cultures (Sarkar, 2010) to product formulation (Dave, 1998) and packaging techniques (Sarkar, 2010) to microencapsulation (Shahidi, 1993); (Shah, 2000); (Andersson, 2001); (Figuroa-Gonzalez, 2011). Each strategy presents its pros and cons yet understanding the needs and requirements of specific probiotic organisms still remains a challenge.

Lactic acid bacteria (LAB) encounter a number of obstacles and hurdles under dairy conditions which in turn trigger a number of different responses related to stress. The stress response of LAB to dairy environments has been well studied and is characterized by a network of different regulators (van de Guchte *et al.*, 2002). Examples of environmental stress from dairy matrices include oxidative, cold, heat, osmotic and acid and the response to each varies widely between species as well as strains.

Research has found that the presence of yeasts, both naturally occurring and those that are commercially added, in LAB and probiotic food products offer a means by which they extend their viability in the product. Recent studies performed by Liu and Tsao (2009, 2010) found improved counts of some LAB and probiotic bacteria in yogurt when the yeast *W. saturnus var. saturnus* was added. The yeast *W. saturnus var. saturnus*, formerly regarded as *Hansenula saturnus* (Barnett *et al.*, 1983); (Erten and Tangular, 2010), is described as a mycocinogenic yeast where current studies are investigating its killer yeast toxin capabilities

for applications in the medicine and biotechnology industries (Tsao and Liu, 2009); (Ochigava *et al.*, 2010).

There exists a need to further investigate the synergism between yeasts and LAB in order to better understand their interactions; one approach is to involve transcriptome studies so as to better observe effects and how that impacts gene expression (Maligoy *et al.*, 2008); (Liu and Tsao, 2009). The use of DNA microarrays has proven successful in studies aiming to elucidate microbial interactions based on gene expression. Advances in this technique now make it possible to study prokaryotic systems but usually in pure culture. Since it is well understood and accepted that the biological niche of most microbes consists of a mixed population in a complex matrix it would then be ideal to mimic those conditions to then analyze for more accurate and useful findings since presence and activity of each organism impacts the interactions and outcomes that occur (Dennis *et al.*, 2003), (Maligoy *et al.*, 2008). This has, however, presented many challenges mainly concerning the incorporation of clean and stable RNA from the organism of interest, although many studies have successfully established methods specific to their investigations (Dennis *et al.*, 2003).

The information presented in this study will help to better understand the interaction between the probiotic bacterium (in this case *L. plantarum* WCFS1) and its matrix as well as the starter culture involved, which may in turn provide insight into the requirements for extending shelf viability of probiotic bacteria in yogurt. Through this study, not only will we gain insight into the interaction taking place at the transcriptional level, but will also explore the potential and functionality of a relatively unknown yeast

species while also studying an interaction mimicking one found close to its natural or commercial niche using microarray analysis.

2. Materials and Methods

2.1 Microorganisms, media, enumeration and culture conditions

Lactobacillus plantarum WCFS1 (ATCC BAA-793) was initially cultured in MRS broth and kept at 30°C without aeration. Glycerol stocks of the bacterium were kept at -80 °C as back up. For screening and plate count purposes, a rifampicin and streptomycin resistant form of *L. plantarum* WCFS1 was created by exposing the culture to increasing amounts of both antibiotics in MRS broth and confirming its resistance to growth on MRS agar plates containing rifampicin (0.576 ug/mL) and streptomycin (50 ug/mL). These concentrations were chosen based on the concentrations they are normally added to media. Resistance of the culture was maintained through routine culturing in MRS broth with both antibiotics present which served as a marker to distinguish it from our yogurt starter culture and basing it off of the phylogenetic distance between *L. plantarum* WCFS1 and *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. *Saccharomyces cerevisiae* (Phaff Yeast Culture Collection 01-158), *Kluyveromyces marxianus* (Phaff Yeast Culture Collection 55-82), *Pichia guillermondii* (Phaff Yeast Culture Collection 54-197) and *Williopsis saturnus* var. *saturnus* (CBS 254) yeast strains were cultured in potato dextrose (PD) broth at 30°C without aeration. The media used for the study was obtained from BD Scientific (Franklin Lakes, NJ) while the antibiotics were ordered from Fisher Scientific (Waltham, MA).

Selective media was used to enumerate *L. plantarum* and yeasts from yogurt. Samples were plated on MRS agar containing rifampicin and streptomycin to select for *L. plantarum* WCFS1 alone. Samples were also plated on PD agar containing kanamycin (30 ug/mL) to inhibit LAB growth. All plates were incubated at 30 °C for 2-3 days.

2.2 Yogurt production

The yogurt starter culture was comprised of freeze dried cultures of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* which were supplied by a commercial vendor. Yogurt cultures were inoculated into pre-warmed, whole fat milk supplied by NCSU Dairy at a rate of 20 DCU/100L. Fermentations were stopped once a pH of 4.5 was reached and placed at 4°C. Yogurt was used no more than 3 to 4 days after being made.

2.3 Effect of different yeasts on *L. plantarum* WCFS1 viability in yogurt

The different yeast species were inoculated into their respective flask containing 100mL of yogurt at 10^5 cfu/mL, followed by inoculation of *L. plantarum* WCFS1 at 10^7 cfu/mL, in duplicate (Table 2.). Yeast counts were obtained by hemacytometer and concentration was calculated following the equation:

$$\text{Concentration per milliliter} = \text{total count in four squares} \times 2,500 \times \text{dilution factor}$$

Treatments were compared to *L. plantarum* WCFS1 alone in yogurt. One set was incubated at 30 °C and the other set at 4 °C, both cases without agitation. Samples for plate count and pH measurements were taken every three days for 11 weeks using MRS agar plates containing rifampicin and streptomycin and PD agar plates with kanamycin.

2.4 Yeast Cell Free Supernatant Study

S. cerevisiae and *W. saturnus* were inoculated separately into 100 mL of PD broth and incubated at 30° C overnight (without agitation) and then filtered sterilized (.45 µm) to create the cell free supernatant (CFS). The CFS was inoculated into 100 mL of yogurt at an amount that matched the volume of live *S. cerevisiae* and *W. saturnus* yeast cells inoculated (1.30 mL and 378 µl, respectively) along with the rifampicin and streptomycin resistant *L. plantarum* WCFS1 strain and incubated at 30 °C and 4 °C (without agitation). Cell counts were taken every 3 days for 11 weeks using MRS agar plates with rifampicin and streptomycin. The study was performed in duplicate.

2.5 Heat Killed Yeast Study

Cultures of *S. cerevisiae* and *W. saturnus* were heat killed at 95 °C for 20 minutes. Microscopic counts with methylene blue and cultures streaked onto PD plates confirmed cell death. *S. cerevisiae* and *W. saturnus* were then inoculated separately with rifampicin and streptomycin tolerant *L. plantarum* WCFS1 into 100 mL of yogurt. Cell counts were taken every 3 days for 11 weeks using MRS plates with rifampicin and streptomycin. The experiment was performed in duplicate.

2.6 *L. plantarum* WCFS1 co-cultured with *W. saturnus* in yogurt

Based on microscopic counts, 10^7 cfu/mL of *L. plantarum* WCFS1 and 10^5 cfu/mL of *W. saturnus* were inoculated into 1 L of yogurt in triplicate. As a control, an overall count of 10^7 cfu/mL of *L. plantarum* WCFS1 was inoculated into 1 L of yogurt and in triplicate. No

control of *W. saturnus* was set up for this study since we had observed its growth in yogurt in previous experiments. Treatments were incubated at 30 °C without agitation. Samples for cell count, pH, and HPLC analysis were taken every 3 days for 24 days, serially diluted in HPLC grade water and plated on MRS plates containing rifampicin and streptomycin and on PD plates containing kanamycin.

2.7 RNA Isolation

Fifty milliliter samples were collected every three days for a period of 15 days from each treatment and replicate. Samples were collected from days 6, 18 and 24 from the yogurt incubation after inoculation with the probiotic strain and yeast culture. Quenching was performed by adding cold 60 % glycerol (-20 °C) and stored at -20 °C for 30 minutes so as to arrest cellular processes. The pH of the samples was then adjusted to 7.0 with 1M NaOH. The chelant, trisodium citrate was added to 25 % (w/v) to bind and separate calcium ions in the samples collected from the yogurt; samples were stored at -20 °C for 30 minutes with intermittent vortexing to avoid ice crystal formation. Samples were subsequently spun at -9 °C for 16 minutes. The supernatant was then removed and the pellet was resuspended in a solution containing: 50 % (wt/vol) guanidine thiocyanate (Amresco LLC, Solon, OH), 0.5 % (wt/vol) N-laurylsarcosine (Fisher Scientific, Pittsburgh, PA), and 2.5 % (vol/vol) of a 1 M trisodium citrate (Capitol Scientific, Inc., Austin, TX) solution. Samples were then centrifuged at 4 °C for 15 minutes. The supernatant was discarded and the pellet was resuspended in Trizol (Ambion – Life Technologies Corporation, Carlsbad, CA) for RNA extraction followed by treatment with phenol and chloroform and chloroform/isoamyl

alcohol (24:1) for removal of residual protein (Fisher Scientific, Pittsburgh, PA). The MoBio Spin Column kit (MO BIO Laboratories, Inc., Carlsbad, CA) plus the Turbo DNase kit (Invitrogen – Life Technologies Corporation, Carlsbad, CA) were used for RNA isolation and clean up. The extracted RNA was eluted with TE buffer. To check the RNA quality and quantity, A260/A280 and A260/A230 ratios were obtained from spectrophotometric (BioMate 3, Thermo Scientific, Waltham, MA) readings for each sample.

2.8 mRNA and cDNA synthesis and labeling

Prior to converting the extracted RNA into cDNA, mRNA was first isolated from the total RNA in order to achieve higher sensitivity for the microarrays. The MICROBExpress Kit (Invitrogen – Life Technologies Corporation, Carlsbad, CA) was used to isolate for the mRNA from *L. plantarum* WCFS1. The isolated mRNA was resuspended in nuclease-free water which was then analyzed for quantity and quality using a nanodrop (ND-1000 Spectrophotometer, NanoDrop, Thermo Fisher Scientific, Inc., Wilmington, DE) with optical density set at 260 nm.

Labeled cDNA was made from the mRNA using Superscript Indirect cDNA Labeling System (Invitrogen Corporation, Carlsbad, CA). The kit incorporates amino-modified dUTP and dATP into the newly made cDNA allowing for greater labeling efficiencies and higher signal intensities with less starting material. Labeled cDNA from the control set was fluorescently labeled with Cy3 dye and cDNA coming from the treatment set were labeled with Cy5 fluorescent dye.

2.9 Microarray hybridization

A 385K array of *L. plantarum* WCFS1 was supplied by Roche Nimblegen, Inc. (Madison, WI) for microarray analysis. Exactly 8 µl of both Cy3 and Cy5 labeled cDNA from control and treatment groups were loaded onto the array. Arrays were hybridized at 42 °C for 17 hours using the NimbleGen MAUI hybridization system (Roche Nimblegen, Inc., Madison, WI). Arrays were immediately washed and prepared afterwards to be scanned and analyzed for gene expression. The Axon GenePix 4000B scanner was used to scan each of the arrays followed by image analysis using NimbleScan 2.6 software.

2.10 High Pressure Liquid Chromatography

The concentration of lactose, galactose, citric acid, lactic acid and propionic acid were measured using Waters high-pressure liquid chromatography (HPLC) system (Waters, Milford, MA) where supernatants of the samples were analyzed by the Breeze HPLC System (Waters, Milford, MA) using an Aminex HPX-87 ion exchange column with 0.5 mM H₂SO₄ as the mobile phase and a flow rate of 0.5 mL/minute. Separations were carried out at 60 °C with 10 µL volume injections for a 30 minute run time.

3. Results

3.1 *L. plantarum* WCFS1 Growth with and without Yeasts

Results from *L. plantarum* WCFS1 inoculated with four different yeasts species in yogurt at 30 °C over an eleven week time span revealed optimal viability when co-cultured with either *S. cerevisiae* or *W. saturnus* (Figure 10.). The initial and final pH values for each *L.*

plantarum WCFS1 and yeast treatment combination were recorded (Table 3.) revealing that yogurt containing *L. plantarum* WCFS1 with *P. guilliermondii* had the highest final pH value (~7.05) followed by *W. saturnus* (~5.85). Although the difference in pH observed between *P. guilliermondii* and *W. saturnus* was unexpected, further studies were carried out with just *W. saturnus* to compare the findings with those of Tsao and Liu. Viability at 4 °C exhibited stabilized concentrations of *L. plantarum* WCFS1 after about 70 days with yeasts and only 60 days without them (Figure 11.).

3.2 *L. plantarum* WCFS1 Growth with Heat Killed Yeast and Cell Free Supernatant from Yeast

Further studies involving a cell free supernatant (CFS) from each yeast were conducted to investigate the effects of cell absence and/or signaling compounds. Additional treatments using heat killed (HK) yeasts with *L. plantarum* WCFS1 were implemented to test for the possibility of added nutrients provided by the yeast as well as the effect of their presence although no longer viable. When comparing both CFS and HK treatments, it was observed that after approximately 35 days at 30 °C, *L. plantarum* WCFS1 counts drastically decreased below detection levels (Figures 12. and 13.). Incubation at 30 °C served as an accelerated shelf life study and could therefore be representative of the loss of *L. plantarum* WCFS1 viability towards the end of the yogurt's shelf life. When comparing heat killed and cell free supernatant fermentations, treatments with *W. saturnus* maintained concentrations of *L. plantarum* WCFS1 at or around 10^7 cell/mL at 30 °C almost 5 days longer.

3.3 *L. plantarum* WCFS1 cultured with and without *W. saturnus* in yogurt

In both the control set (*L. plantarum* WCFS1 alone) and the treatment set (*L. plantarum* WCFS1 with *W. saturnus*) there is an initial increase in cells/mL for the first 6 days in yogurt. In both instances counts slightly decrease and plateau for another 6 days. At 12 days *L. plantarum* WCFS1 counts begin to decrease whereas *L. plantarum* WCFS1 with *W. saturnus* present has counts that are maintained just below 10^8 cfu/mL (Figure 14.). After 24 days in yogurt with *W. saturnus* present, final counts of *L. plantarum* WCFS1 were 4.90×10^7 cfu/mL compared to 1.92×10^7 cfu/mL of *L. plantarum* WCFS1 with *W. saturnus* (Figure 14.). *W. saturnus* counts were stabilized around 3.0×10^6 cfu/mL during the 24 day trial (Figure 14.).

3.4 HPLC Analysis of Yogurt with *L. plantarum* WCFS1 with and without *W. saturnus*

Aliquots of yogurt were set aside for HPLC analysis from yogurt containing *L. plantarum* WCFS1 with and without *W. saturnus*. There were no significant differences in the amounts of lactose, citric acid or galactose present between *L. plantarum* WCFS1 by itself in yogurt than with *W. saturnus* present (Figures 15., 16., and 17., respectively). Differences could be observed in the amounts of lactic acid and propionic acid. After about 12 days, lactic acid amounts appear to plateau to just under 3 g/100mL in yogurt containing just *L. plantarum* WCFS1, however, around the same time point yogurt containing *L. plantarum* WCFS1 with *W. saturnus* decreases in lactic acid amounts to as low as ~2.2 g/100mL (Figure 18.). Similarly, propionic acid amounts appear to gradually decrease in yogurt to less than 0.002 g/100mL with both *L. plantarum* WCFS1 and *W. saturnus* whereas propionic acid amounts

decrease to only 0.006 g/100mL (Figure 19.) in yogurt containing *L. plantarum* WCFS1 alone (Figure 19.).

3.5 Microarray Analysis of *L. plantarum* WCFS1 with and without *W. saturnus* var. *saturnus*

The MICROBExpress Kit used to enrich for bacterial mRNA to later convert to cDNA, is specific to prokaryotes and after using the kit on pure cultures of *W. saturnus*, results confirmed its inability to isolate mRNA from eukaryotic RNA (Invitrogen – Life Technologies Corporation, Carlsbad, CA). The NimbleGen Kit also called for 3 µg of labeled cDNA for hybridization on a 385K array. After scanning the arrays and extracting the information of off the chips, hybridization did not result in strong enough signals to interpret for gene expression analysis (data not shown).

4. Discussion

After analyzing the different yeasts and treatments used in this study it is apparent that the yeast presence has an overall impact on the viability of *L. plantarum* WCFS1 and the magnitude by which they affect them is dependent on the yeast species. After comparing the effect of different yeasts inoculated with *L. plantarum* WCFS1 into yogurt, optimal levels of the bacterium (10^7 cfu/mL) were stabilized for up to 60 days in yogurt at 30 °C with the yeast *W. saturnus* (Figure 10.). *L. plantarum* WCFS1 was initially maintained at 10^7 cfu/mL with *S. cerevisiae* and *K. marxianus* but after about 13 days *L. plantarum* WCFS1 counts decline by almost 1 log but then increase starting around day 34 up to 10^8 cfu/mL by the end of 70 days (Figure 10.). This effect could be the result of the yeast responding to the suboptimal

conditions of the yogurt environment (organic acid, pH, temperature) or to the high temperature of 30 °C which could be accelerating growth and metabolism of the organisms present in the yogurt. Certain yeasts belonging to the *Ascomycota* phylum have the advantage of being resistant to weak organic acids, a response whose regulation comes from an overlap of different genes dedicated to environmental stress (Gasch, 2007). The ability of *W. saturnus* to maintain high counts of *L. plantarum* WCFS1 in yogurt kept at 30 °C may be due to the ability of this yeast to assimilate the lactic acid and propionic acid in the yogurt to raise the pH to favorable conditions based on the visible decrease in lactic acid and propionic acid concentrations and higher final pH values (Figure 18. and Figure 19., respectively; Table. 3.). Possible pathways responsible for this effect could involve flavin dependent enzymes for lactate (Witte *et al.* 1989). Lactose, galactose and citric acid trends showed no difference between *L. plantarum* WCFS1 with and without *W. saturnus* (Figures 15., 16., 17., respectively). Seeing as lactic acid and citric acid are two of the main organic acids in yogurt (Soulides, 1955), the fact that lactic acid was utilized over citric acid suggests the ability and preference of *W. saturnus* to utilize this organic acid in comparison to the latter and may also be what contributes to its stability in yogurt at 30 °C over time. It is plausible that *W. saturnus* also relies on extracellular proteolytic and/or lipolytic enzymes whose by-products could also benefit *L. plantarum* WCFS1. Evidence of lipolytic activity by *W. saturnus* could be from the noticeable formation of isoamyl acetate aroma (data not shown) due to the breakdown of triglycerides from milk fat into short chain fatty acids and then esters via esterification, however the use of lipases usually is associated with low water systems (Liu *et al.*, 2004). In order for esters to be produced, there must be available alcohols, which are

usually provided by dairy yeasts. In this study, the noticeable production of the fruity ester could also be the product of alcoholysis by either the yogurt culture or *L. plantarum* WCFS1 whereby the alcohol provided by *W. saturnus* reacts with the fatty acids broken down during fermentation of milk. In *S. cerevisiae*, the enzyme, alcohol acetyltransferase, primarily catalyzes the biosynthesis of isoamyl acetate, however, in the yeasts *Hansenula mrakii* and *Hansenula anomala*, both alcohol acetyltransferase and esterase are used for isoamyl acetate biosynthesis (Inoue *et al.*, 1997); (Yoshioka and Hashimoto, 1981); (Liu *et al.*, 2004), suggesting an alternative explanation for the presence of isoamyl acetate by *W. saturnus*, although further research would be required to substantiate the presence and concentration of isoamyl acetate in the yogurt.

In some instances, yeasts are able to support bacterial growth and viability under dairy environments through a couple of different mechanisms involved in commensalism and symbiosis (Graham, 1943); (Soulides, 1955). Examples of such include products like kefir, acidophilus-yeast milk, koumiss and laban (Lourens-Hattingh *et al.*, 2002). The early studies by Graham (1943) showed that yeasts that utilize lactose and/or galactose compared to those that do not can often compromise LAB stability due to the production of compounds like acids. According to previous studies, instead of the yeast producing acids, the non-lactose fermenting yeast utilizes the lactic acid produced by the bacterial culture to in turn increase overall pH in the yogurt product (Subramanian P. and Shankar, 1983). A decrease in lactic acid and propionic acids from this investigation could be suggesting the ability of *W. saturnus* to assimilate these particular organic acids which could be the function behind *W. saturnus* in sustaining high counts of *L. plantarum* WCFS1 in yogurt over a long period of

time. Slight increases in citric acid concentration were also observed in both the control and treatment sets at 30°C from this study which could indicate that either the starter culture or the probiotic bacterium, *L. plantarum* WCFS1, is producing it as a metabolic by-product under dairy conditions and high temperature settings.

In regards to gene expression of the probiotic bacterium, extraction of RNA from mixed populations coming from a complex matrix such as yogurt remains a challenge. In order to avoid limited amounts of RNA for downstream investigations it would be ideal to have a larger amount of starting material to work with and to inoculate the bacterium of interest at a higher rate, thereby providing secure numbers of the probiotic bacterium and since in some instances they are inoculated into yogurt as high as 10^9 cfu/mL. Ways in which to improve the RNA extraction method from complex matrices and mixed populations while sensitizing hybridization involve pH adjustment, changing hybridization temperatures and incorporation of non-specific genomic DNA from the partner organism in this case from *W. saturnus* (Maligoy *et al.*, 2008). Maligoy and others (2008) studying the effects of co-culturing *Lactococcus lactis* with *Saccharomyces cerevisiae* found significant changes in the expression of genes related to pyrimidine metabolism where the ethanol produced by the yeast was the common factor in regulating those genes.

5. Conclusion

The preliminary findings from this study indicate that the use of a non-lactose, as well as non-galactose, fermenting yeast displays similar abilities to yeasts that do in preserving survival of probiotic organisms in yogurt during shelf-life. Based on the microbiological and

chemical analyses from this study, it can be assumed that modifications to the acidic environment of the yogurt are being made by the yeast which in turn benefits the probiotic bacterium. There is still a need for a transcriptomic explanation as to elucidate the interactions occurring between the organisms. Microarray analysis, although very promising, still presents hurdles in analyzing cultures from a mixed population and complex matrix such as dairy products. More stringent measures in extracting high quality and quantity RNA from *L. plantarum* WCFS1 from the yogurt samples must be taken in future studies so as to ensure adequate starting material for microarray hybridization for eventual gene expression analysis. Alternative methods for gene expression analysis could be the use of RNA sequencing and/or real time (RT)-PCR of hypothetical genes associated with growth in yogurt and with yeast present. Further studies evaluating the formation of ester compounds by *W. saturnus* in the yogurt as well as its implications on *L. plantarum* WCFS1 survival would also be an area of interest as to learning the metabolic and adaptive activity of this particular yeast. HPLC analysis of a more inclusive set of organic acids would supplement preliminary findings and assumptions regarding the activity *L. plantarum* WCFS1 alone in yogurt compared to *L. plantarum* WCFS1 grown with *W. saturnus* in the yogurt at 30 °C and 4 °C.

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TABLES AND FIGURES

Table 2. Inoculation rate of organisms into yogurt

Organism	Inoculation (cells/mL)
<i>Lactobacillus plantarum</i> WCFS1	10 ⁷
<i>Saccharomyces cerevisiae</i>	10 ⁵
<i>Kluyveromyces marxianus</i>	10 ⁵
<i>Pichia guilliermondii</i>	10 ⁵
<i>Williopsis saturnus</i> var. <i>saturnus</i>	10 ⁵

Table 3. Initial and final pH values of *L. plantarum* WCFS1 with and without yeasts in yogurt at 30 °C and 4 °C

Treatment	Initial pH	Final pH (30°C)		Standard Deviation	Final pH (4°C)		Standard Deviation
		1	2		1	2	
Replicate		1	2		1	2	
<i>L. plantarum</i> WCFS1	4.2	4.4	4.4	0.0	4.4	4.4	0.0
<i>L. plantarum</i> WCFS1 w/ <i>S. cerevisiae</i>	4.2	4.5	4.4	0.07	4.5	4.4	0.07
<i>L. plantarum</i> WCFS1 w/ <i>K. marxianus</i>	4.2	5.5	4.4	0.78	4.9	4.4	0.35
<i>L. plantarum</i> WCFS1 w/ <i>P. guilliermondii</i>	4.2	8.0	6.1	1.3	4.5	4.4	0.07
<i>L. plantarum</i> WCFS1 w/ <i>W. saturnus</i>	4.2	5.6	6.1	0.35	4.5	4.4	0.07

Table 4. Initial and final pH values of *L. plantarum* WCFS1 with and without Cell Free Supernatant of yeasts and Heat Killed yeasts in yogurt at 30 °C and 4 °C

Treatment	Initial pH	Final pH (30°C)		Standard Deviation	Final pH (4°C)		Standard Deviation
		1	2		1	2	
Replicate		1	2		1	2	

Table 4. Continued

Treatment	Initial pH	Final pH (30°C)		Standard Deviation	Final pH (4°C)		Standard Deviation
		1	2		1	2	
Replicate		1	2		1	2	
<i>L. plantarum</i> WCFS1	4.3	4.0	3.9	0.07	4.2	4.1	0.07
<i>L. plantarum</i> WCFS1 w/ HK <i>S. cerevisiae</i>	4.4	3.9	4.2	0.21	4.0	4.0	0.0
<i>L. plantarum</i> WCFS1 w/CFS <i>S. cerevisiae</i>	4.3	3.9	4.0	0.07	4.2	4.2	0.0
<i>L. plantarum</i> WCFS1 w/HK <i>W. saturnus</i>	4.4	3.8	4.2	0.3	3.8	4.0	0.14
<i>L. plantarum</i> WCFS1 w/CFS <i>W. saturnus</i>	4.3	4.0	3.9	0.07	4.4	4.0	0.28

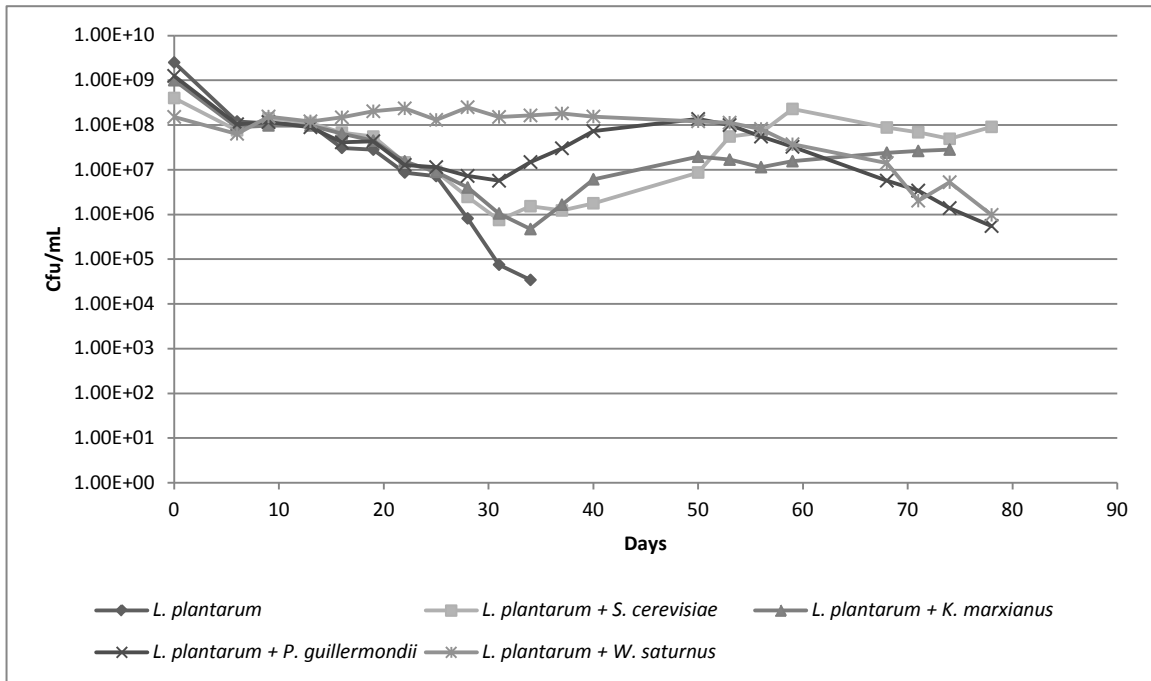


Figure 10. *L. plantarum* WCFS1 growth in yogurt with and without yeasts at 30 °C
 The graph here represents growth curves of *L. plantarum* WCFS1 with and without different yeast species in yogurt kept at 30 °C for eleven weeks.

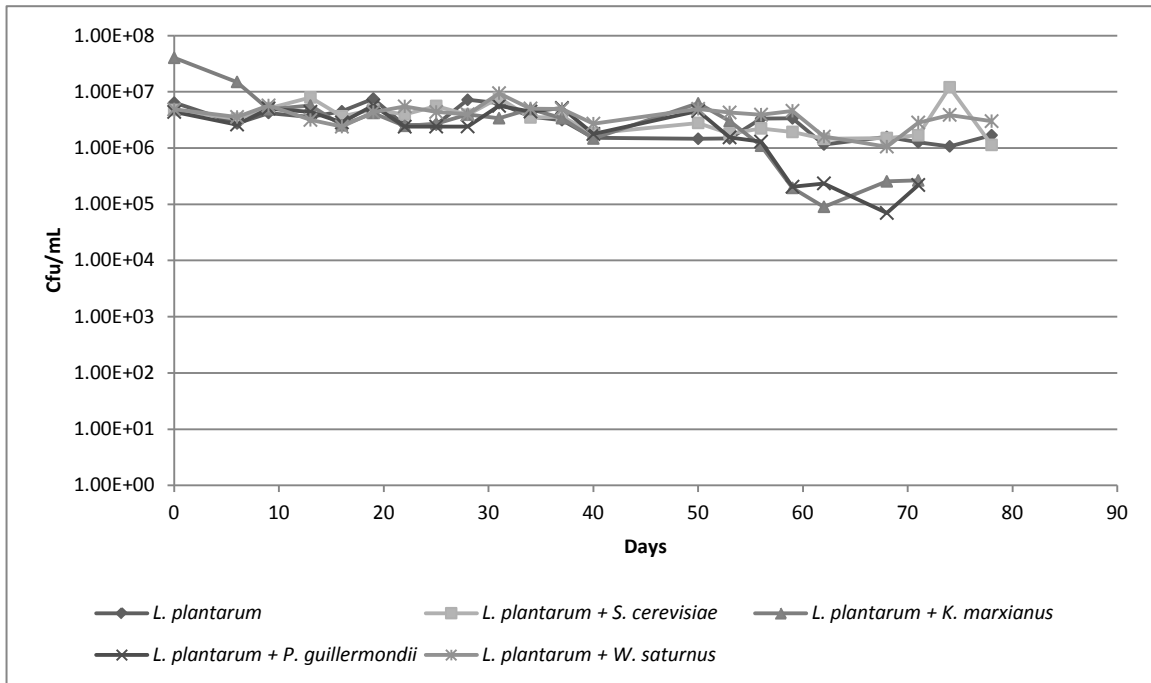


Figure 11. *L. plantarum* WCFS1 growth in yogurt with and without yeasts at 4 °C
 The graph here represents growth curves of *L. plantarum* WCFS1 with and without different yeast species in yogurt kept at 4 °C for eleven weeks.

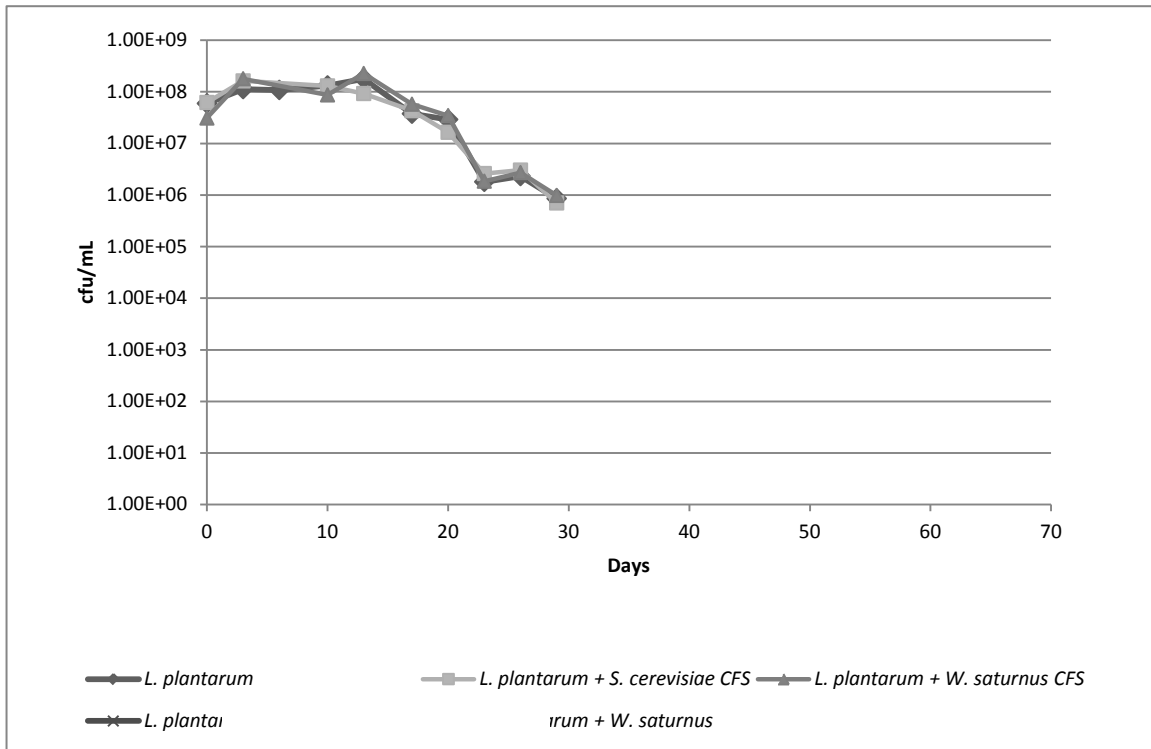


Figure 12. *L. plantarum* WCFS1 growth in yogurt with and without cell free supernatant from yeasts at 30 °C

The graph represents the growth curves of *L. plantarum* WCFS1 in yogurt, at 30 °C, over eleven weeks, with and with the cell free supernatant obtained from *S. cerevisiae* and *W. saturnus* overnight cultures.

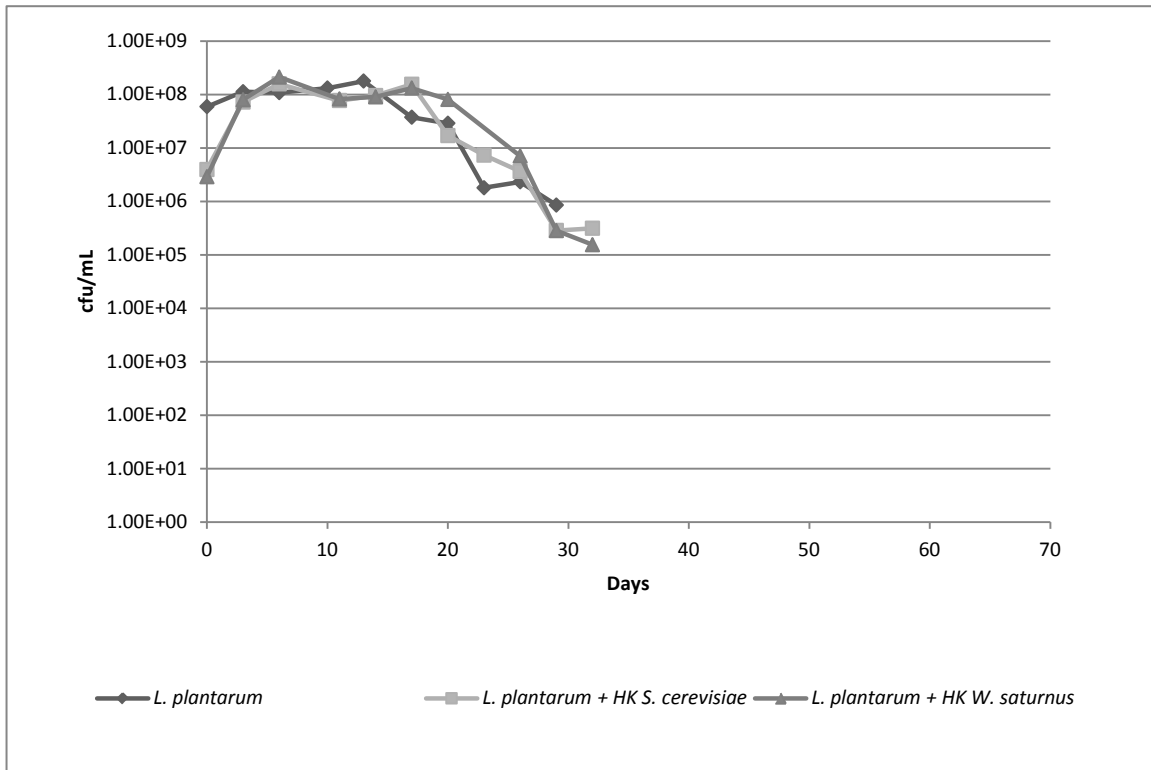


Figure 13. *L. plantarum* WCFS1 growth in yogurt with and without heat killed yeasts at 30 °C

The graph represents the growth curves of *L. plantarum* WCFS1 in yogurt, at 30 °C, over eleven weeks, with and with heat killed *S. cerevisiae* and *W. saturnus*, separately.

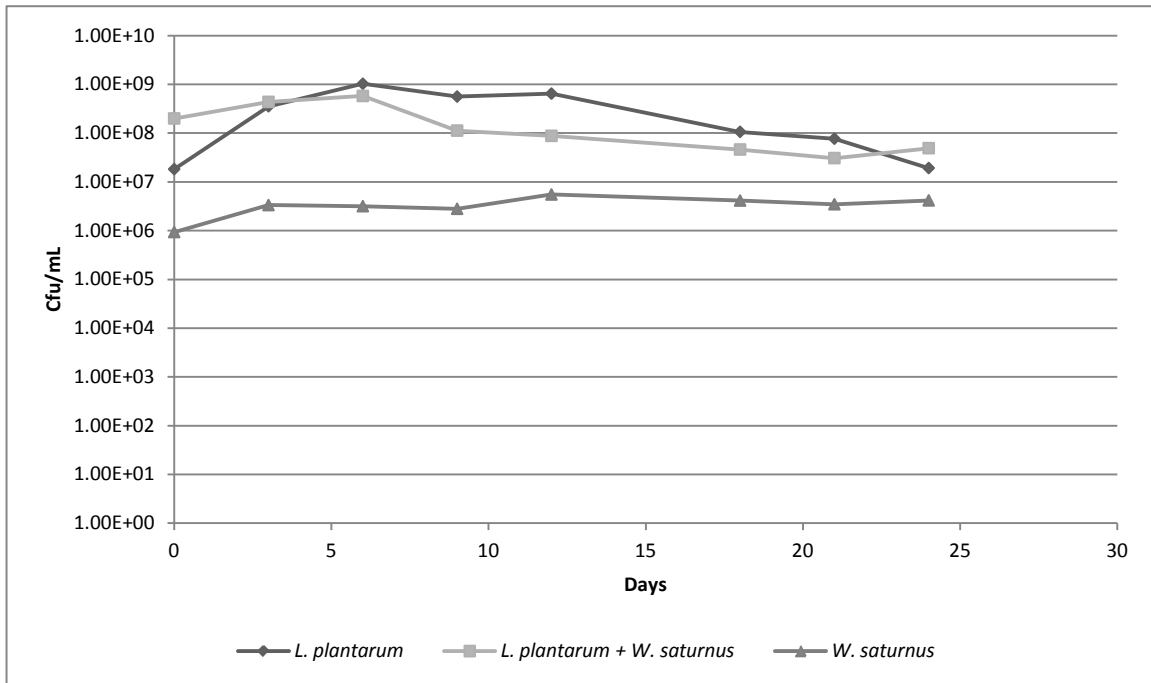


Figure 14. *L. plantarum* WCFS1 growth with and without *W. saturnus* in yogurt at 30 °C
 The graph represents growth curves of *L. plantarum* WCFS1 with and without *W. saturnus* in yogurt kept at 30 °C for 24 days. The growth curve for *W. saturnus* comes from the same flask as the growth curve for *L. plantarum* + *W. saturnus* and were obtained using PDA plates containing kanamycin.

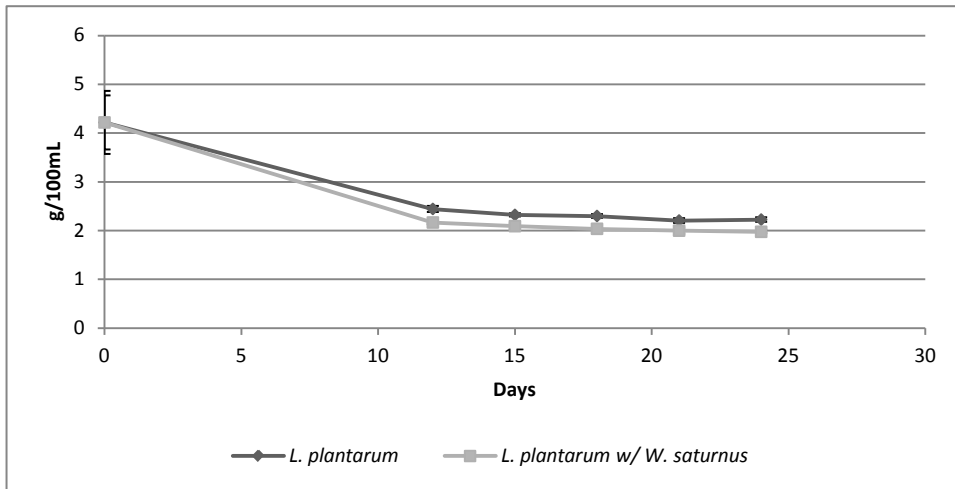


Figure 15. Lactose concentrations (g/100mL) in yogurt containing *L. plantarum* with and without *W. saturnus* during 24 day period at 30 °C.

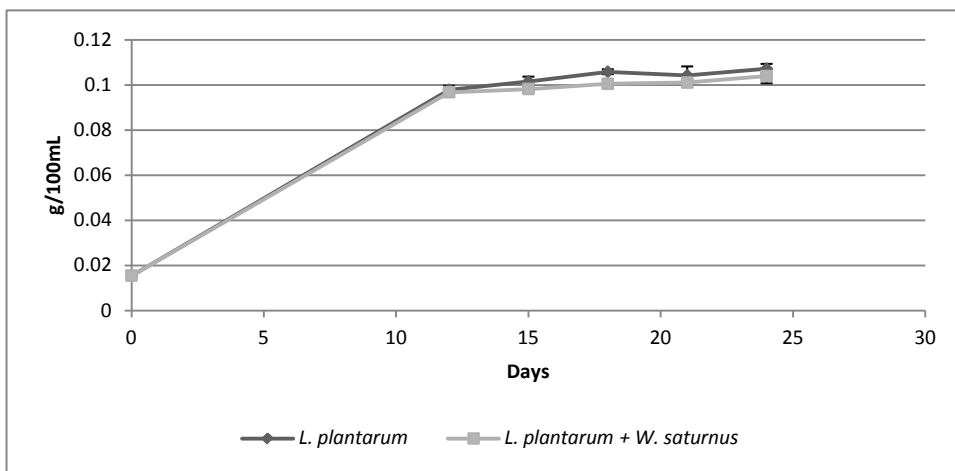


Figure 16. Citric acid concentrations (g/100mL) in yogurt containing *L. plantarum* with and without *W. saturnus* during 24 day period at 30 °C.

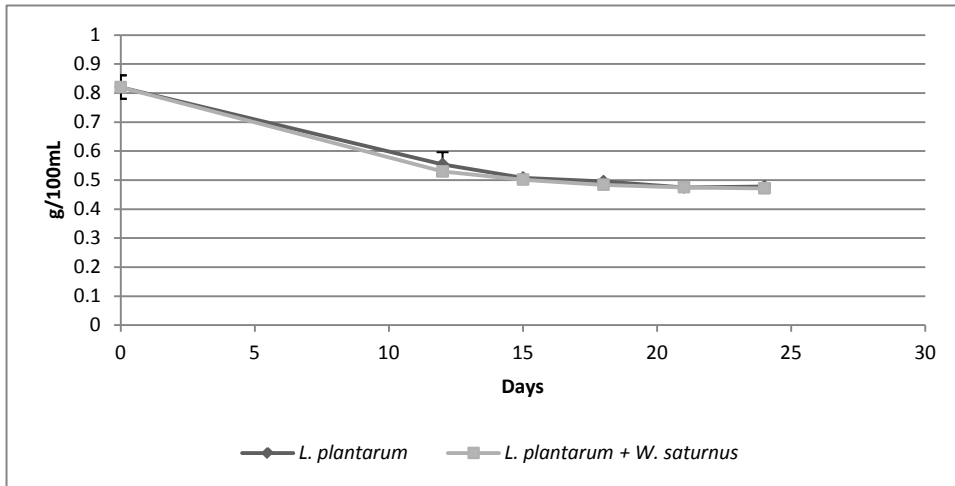


Figure 17. Galactose concentrations (g/100mL) in yogurt containing *L. plantarum* with and without *W. saturnus* during 24 day period at 30 °C.

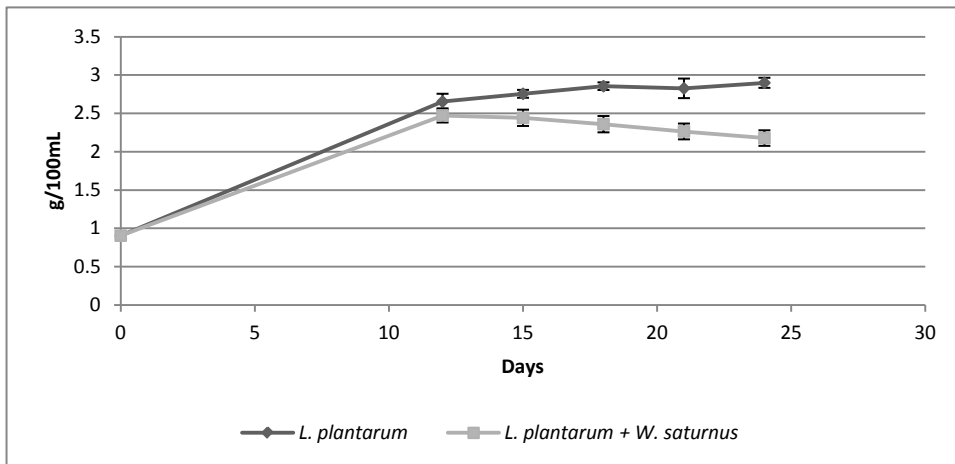


Figure 18. Lactic acid concentrations (g/100mL) in yogurt containing *L. plantarum* with and without *W. saturnus* during 24 day period at 30 °C.

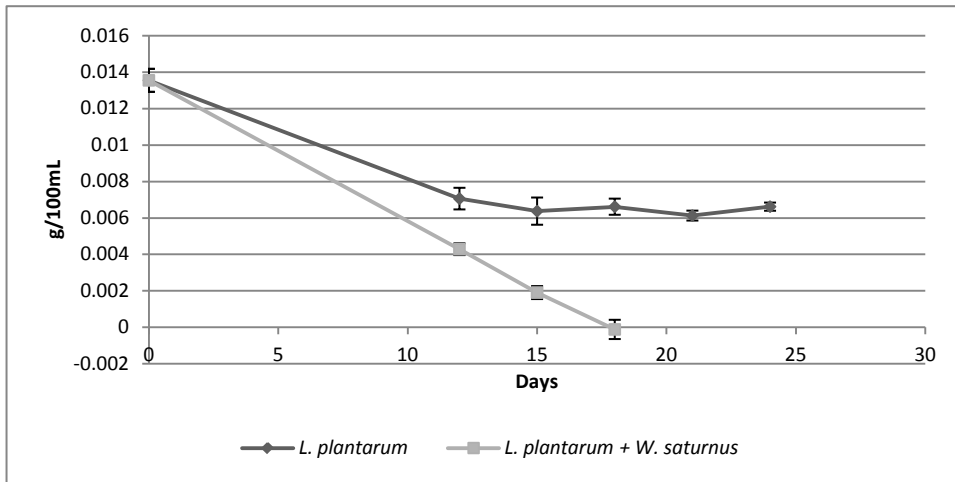


Figure 19. Propionic acid concentrations (g/100mL) in yogurt containing *L. plantarum* with and without *W. saturnus* during 24 day period at 30 °C.

**CHAPTER 3: THE STRESS RESPONSE OF NON-SACCHAROMYCES YEAST
SPECIES TO WEAK ORGANIC ACIDS**

1. Introduction

The majority of the yeasts that we are familiar with come from the diverse phylum *Ascomycota*. Yeasts are a major part of everyday life, from fermenting the beverages we enjoy and producing food ingredients to even the species that spoil the very same commodities. Advances in bioethanol production research has explored yeasts such as *Pichia stipitis*, *Debaryomyces hansenii* and *Spathaspora passalidarum* for their abilities to utilize novel substrates such as sugar cane bagasse and wood (Roberto *et al.*, 1991) (Parajo *et al.*, 1997) (Nguyen *et al.*, 2006) (Vargas and Pereira, 2011). Several examples of such yeasts and their characteristics are compared to the well studied, model eukaryote, *Saccharomyces cerevisiae*, and are summarized in Table 1.

Food preservation via the incorporation of organic acids has been used for many centuries, is commonly practiced today and includes a variety of weak organic acids such as sorbate, benzoic acid, lactic acid, acetic acid and citric acid (Stratford and Anslow, 1996); (Piper *et al.*, 2001). In regards to yeast, the lipophilic properties of different organic acids is one type of determinant of their antimicrobial effect whereby acetic acid is found to be more lipophilic, and consequently more effective than lactic acid (Ray, 2003). Citric acid actually enters through the cell membrane via citrate permeases and by comparison, is less effective than lipophilic acids (Ray, 2003). Therefore, the antimicrobial effect of organic acids is based on the diffusion of the undissociated and uncharged acid across the cell membrane where the acid dissociates into the cytosol of the cell (Piper *et al.*, 2001). Eventually there is an accumulation of the acid anion and protons inside the cell that results in a number of

adverse reactions related to high turgor pressure, free radical production, oxidative stress and inhibition of metabolic functions (Piper *et al.*, 2001).

The response to acidic conditions from yeasts is found to be a part of a response network known as the environmental stress response (ESR) that is common to yeasts of the *Ascomycete* phylum (Gasch, Comparative genomics of the environmental stress response in ascomycete fungi, 2007). Originally discovered in *Saccharomyces cerevisiae*, the ESR offers a competitive advantage to fungi in the environments they inhabit and is found to be well conserved in distant relatives of the model eukaryote. Genomic studies comparing *S. cerevisiae*, *Candida albicans*, and *Schizosaccharomyces pombe* reveal not only the presence of the ESR but also a divergence over time in its response and regulation among each species (Gasch, Comparative genomics of the environmental stress response in ascomycete fungi, 2007) that calls for further investigation. Many of the genes implicated in general stress responses are regulated by stress response elements (STREs) through the transcriptional regulators Msn2p and Msn4p (Görner *et al.*, 1998); (Brul *et al.*, 2008).

Although commonly used in food and beverage production, the use of organic acids has also lead to the resistance of spoilage yeasts, two of the main yeasts being *Saccharomyces cerevisiae* and *Zygosaccharomyces bailii*. Upon exposure to weak acid stress, *S. cerevisiae* relies on the induction of its ATP-binding cassette (ABC) transporter, Pdr12, to export the acid from the cell; a mechanism that works in tandem with the ATP-driven proton efflux pump H⁺-ATPase (Pma1p) that is ultimately ATP taxing on the cell (Piper *et al.*, 2001). The transcription factor, War1p, is responsible for the induction of the *PDR12* gene (Kren *et al.*, 2003)(Mollapour and Piper, 2001b). An alternative response to weak organic acid stress

comes from the integral plasma membrane protein, Hsp30, whereby induction of this protein relieves ATP consumption by the cell during weak-acid stress (Piper *et al.*, 1997). In fact, studies demonstrate that cells lacking the heat shock protein required more time and ATP to adapt to weak acid stress (Piper *et al.*, 1997). Piper and Mollapour (2008) also revealed that resistance to acetic acid in *S. cerevisiae* is achieved by elimination of the Fps1p aquaglyceroporin, the channel by which acetic acid enters the cell, which is targeted by Hog1p MAP kinase for removal from the cell via endocytosis (Figure 39.).

In the case of *Z. bailii*, it relies on a different tactic when under acid stress where action is taken towards minimizing initial diffusion of the acid into the cell, the details of which are still unclear compared to that of *S. cerevisiae* but is thought to be due to a restructuring of the plasma membrane (Piper *et al.*, 2001). *Z. bailii* can trigger oxidative degradation of benzoate and sorbate as well as utilize acetate even in the presence of fermentable sugars via the gene ZbYME2, which happens to share homology with the Yme2p gene in *S. cerevisiae* (Sousa, 1998); (Mollapour and Piper, 2001b); (Mollapour and Piper, 2008).

The purpose of this investigation is to elucidate how well non-*Saccharomyces* yeast species tolerate weak organic acids and how their response compares to that of *Saccharomyces cerevisiae* through gene expression differences. Information from this study will provide insight into the genomes of less explored yeast species.

2. Materials & Methods

2.1 Yeast strains and inoculation culture

Saccharomyces cerevisiae along with seven other non-*Saccharomyces* yeast species were used in this study and are summarized in Table 2. Each yeast was cultured in potato dextrose (PD) broth (BD Scientific, Franklin Lakes, NJ) with 5mM of either acetic, citric or lactic acids (Fisher Scientific, Waltham, MA) as a pretreatment to the acid before the experiment in order to avoid acid shocking cells and to equilibrate starting conditions prior to plate reader experiments.

2.2 Microtiter plate reader experiments

Increasing amounts of each organic acid were used to test the acid tolerance of each yeast. Stock solutions of the different concentrations of the organic acid were made using PD broth and included concentrations of 25 mM, 50 mM, 75 mM and 100 mM. The pH was not adjusted for the organic acid stocks made with potato dextrose broth. These concentrations were chosen based on their occurrence in some foods and beverages. It was observed that at a pH of 4.5 and a concentration between 80 – 150 mM, acetic acid could inhibit *S. cerevisiae* (Piper *et al.*, 2001). The control was the yeast in the pretreatment PD broth which contained 5mM of the organic acid. A 96-well plate was set up to include triplicates of the yeast for each concentration of each organic acid. Hemacytometer counts were used to standardize the number of cells inoculated into each well of the 96-well plate. Once the 96-well plates were set up, they were closed and sealed with parafilm to avoid evaporation. The plate reader system (Synergy HT, BioTek Instruments, In., Winooski, VT) was preheated to 30°C where

the temperature remained for one week. During that week, the plate reader was programmed to take an optical density (OD) reading at 630 nm every two hours with agitation before each read so as to ensure a uniform sample during the reading.

3. Results

In some cases some yeasts grew better, meaning, the amount of time to reach stationary phase was either the same or faster with either the same or greater OD values compared to the respective control. This effect was noted in the following: *D. bruxellensis* 96 (25 mM), *D. bruxellensis* 216 (25 mM and 50 mM) and *Kluyveromyces lactis* (25 mM) in acetic acid; *D. bruxellensis* 73 (25 mM), *D. bruxellensis* 216 (25 mM), *Z. bailii*159 (25mM) and *P. stipitis* (50 mM) in citric acid; *D. bruxellensis* 96 (25 mM and 50 mM), *D. bruxellensis* 216 (25 mM and 50 mM), *Z. bailii* 159 (25 mM and 50 mM), *K. lactis* (25 mM) and *P. stipitis* (25-75 mM) (Figures 1.-3.). When exposed to all three organic acids at increasing concentrations, *D. hansenii* displayed no tolerance.

3.1 Response to Acetic Acid

S. cerevisiae displayed optimal growth in the control and in 25 mM acetic acid where stationary phase was reached by day 1 with OD values around 0.6 and 0.65. Similarly, stationary phase was reached after a day and half in cells exposed to 50 mM but with reduced OD values (0.4). Cells exposed to 75 mM were still able to grow but exhibited an extended lag phase reaching the stationary phase by day 4 with OD values around ~0.48 (Figure 4.). Yeasts exhibiting similar or better growth trends in acetic acid include *D. bruxellensis* 216

and *Z. bailii* 158 (Figures 7. and 10.). *S. passalidarum* and *D. hansenii* displayed the least tolerance to acetic acid as shown by Figures 12 and 14, respectively. The yeasts that yielded an increase in percent growth compared to their respective controls were *D. bruxellensis* 96 and 216 and *K. lactis* (Figure 1.). Some resistance to 50 mM acetic acid was exhibited by *D. bruxellensis* strain 96, however the OD values were reduced compared to those in 25 mM acetic acid (Figure 6).

Although *K. lactis* did not reach stationary phase until a day after its control did, it yielded higher OD values and exponential growth could be observed in as high as 75 mM acetic acid (Figure 11.). *D. bruxellensis* 73 grew well in 25 mM acetic acid and displayed growth in 50 mM and 75 mM concentrations but with reduced OD values; no growth was observed in 100 mM acetic acid (Figure 5.). *P. stipitis* displayed growth and tolerance in concentrations as high as 50 mM acetic acid but became inhibited in 75 mM and 100 mM concentrations (Figure 13.). *Z. rouxii* reached stationary phase after 1.5 days with OD values around 0.5, however in 50 mM acetic acid had an extended lag phase where exponential growth began at day 4 (Figure 8.). *Z. bailii* 159 reached stationary phase after ~2.5 days in 25 mM and 50 mM concentrations with OD values reaching ~0.55 and ~0.70, respectively, however, cells in 50mM entered cell death phase by day ~4.5; cells exposed to 75 mM and 100 mM acetic acid did not grow (Figure 9.).

3.2 Response to Citric Acid

S. cerevisiae cells exhibited no growth or tolerance to citric acid, although, cells grown in the pretreatment (control) reached stationary phase by day 1 with OD values around 1.1 (Figure

15.). Yeasts that grew well and tolerated concentrations of citric acid were *D. bruxellensis* 73 and 216, *S. passalidarum* and *P. stipitis* (Figures 16., 18., 23. and 24., respectively). Yeasts that were inhibited by citric acid concentrations included *Z. rouxii* and *D. hansenii* (Figures 19. and 25., respectively). Yeasts that displayed a percent growth in citric acid concentrations compared to their respective controls were *D. bruxellensis* 73 and 217, *Z. bailii* 159 and *P. stipitis* (Figure 2.). *D. bruxellensis* 96 could tolerate concentrations of 25 mM and 50 mM, where lag phases lasted 3 and ~4.5 days, respectively; cells were inhibited in 75 mM and 100 mM citric acid (Figure 17).

3.3 Response to Lactic Acid

S. cerevisiae reached stationary phase after 1 day where OD values reached ~0.95-1.0 in 25 mM lactic acid (Figure 26.). *S. cerevisiae* cells exposed to 50 mM lactic acid reached stationary phase after 1.5 days with similar OD values as those reached in 25 mM lactic acid, however, growth was slowed in 75 mM lactic acid with stationary phase reached after 3 days with reduced OD values just under 0.6; no growth was observed in 100 mM lactic acid (Figure 26). Yeasts that displayed similar growth trends to *S. cerevisiae* include *D. bruxellensis* 216, *Z. rouxii* and *Z. bailii* 158 (Figures 29., 30. and 32., respectively). An actual increase in percent growth as compared to the control could be observed by *D. bruxellensis* 96 and 216, *Z. bailii* 159, *K. lactis* and *P. stipitis* (Figure 3.). The only yeast inhibited by lactic acid concentrations was *D. hansenii* (Figure 36.). *P. stipitis* displayed greater OD values when exposed to 25 mM, 50 mM and 75 mM lactic acid (~1.0) when compared to its control (~0.5) (Figure 35.).

4. Discussion

Based on the above experiments, it can be observed that there were similarities and differences in the response of the yeasts to the different types and concentrations of weak organic acids. Upon exposure to all of the organic acids *Debaryomyces hansenii* exhibited no sort of tolerance or resistance to the different concentrations which could be reflecting its inability to overcome low pH since the pH of the organic acid concentrations were not adjusted. *S. cerevisiae* displayed the ability to adapt and grow well in acetic and lactic acids and at concentrations as high as 75 mM. Differences were observed among and within yeast species towards each of the different organic acids used. In some instances, a higher concentration of the weak organic acid resulted in improved growth of the yeast whereby stationary phase was reached sooner and with a higher biomass yield as compared to the control. Based on the growth curves from the plate reader experiments, several yeasts were still able to grow but exhibited extended lag phases. In cases where the amount of time to reach stationary phase was unaffected a difference could be observed in the OD values suggesting less biomass yield under higher concentrations of the weak organic acid. This behavior was observed by *S. cerevisiae* and *Z. bailii* 158 in 25 mM acetic acid (Figures 4. and 10., respectively.). This effect was perceived in *D. bruxellensis* 73 and *Z. rouxii* in 25 mM lactic acid (Figures 27. and 30.). Yeasts, excluding *S. cerevisiae*, which tolerated and grew well in concentrations of citric acid, could suggest a difference in response and strategy when exposed to this particular weak acid that has yet to be elucidated.

The yeast *Dekkera/Brettanomyces* has been shown to produce high levels of acetic acid under fermentation conditions that in turn inhibits *S. cerevisiae*, however, exposure of *S.*

cerevisiae to the acetic acid could also protect it by inducing removal of the Fsp1p and action by Pdr12 (Piper *et al.*, 1998). In the same study by Piper and others (1998) the substrates of Pdr12 were all water-soluble carboxylic acids indicating its primary role in removing intracellular carboxylate anions rather than lipophilic molecules.

Many other studies support the pivotal role of Pdr12 in conferring weak organic acid resistance in regards to acetate, benzoate and sorbate, however, additional genes have been reported in response to weak acid stress. For example, the *JEN1* gene found in *S. cerevisiae* encodes a lactate-proton symport (Casal *et al.*, 1999) and Ady2p is responsible for acetic acid transport (Paiva *et al.*, 2004) which, under some circumstances, facilitates the uptake of lactic and acetic acids by the cell in order to fulfill energy and metabolic needs (Kawahata *et al.*, 2006). Based on the results from this study, similar if not the same genes found in these yeasts may be responsible for the survival and adaptation to the organic acids, however, specificity of the genes and their regulation requires further research. Several of the stress genes summarized in Table 2. have also been identified in *K. lactis*, *Z. rouxii* and *Z. bailii* species, where in some cases the genes are different but are thought to be similar in function and purpose.

5. Conclusion

When comparing the growth curves of the different yeast species in different concentrations of weak acids, several yeasts displayed similar response and tolerances to those of *S. cerevisiae* where in some cases growth and adaptation was better. Both *Dekkera/Brettanomyces* and *Zygosaccharomyces* species consistently exhibited tolerance,

and in some cases a percent increase in growth, upon exposure to increasing concentrations of acetic, citric and lactic acids. Although a common spoilage yeast in the production of some fermented foods, *Debaryomyces hansenii* displayed no tolerance to any of the acids and their various concentrations in this study. Out of the weak organic acids used, it appears that citric acid had an overall inhibitory effect towards many of the yeast species. Based on the preliminary findings of this project, it is plausible that many of the yeasts are responding similarly as *S. cerevisiae* during weak acid stress, however, it is still unclear as to how many of these stress genes are regulated and found in the genomes of these yeast species. On the other hand it is very possible that some of these yeast species are utilizing alternate and even novel mechanisms in coping with weak acid stress. Future work with polymerase chain reaction (PCR) and real-time PCR to identify the presence of these genes under weak acid stress from different organic acids will help in elucidating similarities and differences among *S. cerevisiae* and non-*Saccharomyces* yeast species.

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TABLES AND FIGURES

Table 5. Examples of different yeasts and their application in research and/or industry

Yeast	Respiration/ Fermentation	Applications	Other
<i>Saccharomyces cerevisiae</i>	Facultative anaerobe; Crabtree-positive	Baking, brewing, wine, bioethanol production	Eukaryotic model; first eukaryotic genome to be completely sequenced
<i>Dekkera/Brettanomyces</i>	Facultative anaerobe; Crabtree-positive	A major cause of wine spoilage worldwide	Sequenced genome having substantial proportion of genes having orthologs to <i>S. cerevisiae</i>
<i>Zygosaccharomyces</i>	Facultative anaerobe; Crabtree-positive	Major spoilage organism in the food industry	Known for having high tolerance for sugar, ethanol and organic acid concentrations
<i>Kluyveromyceslactis</i>	Obligate aerobe; Crabtree-negative	Commonly used in genetic analysis and in industry for the production of chymosin	Weak organic acid response; poorly defined signal transduction mechanisms; similarities with <i>S. cerevisiae</i>

Table 6. Yeast species and strains used in plate reader experiments

Yeast Species	Assigned Number	CBS	ATCC	Phaff	UCD VEN
<i>Saccharomyces cerevisiae</i>	217	8803	-	-	-
<i>Dekkera bruxellensis</i>	73	-	-	-	2048
	96	-	-	-	2092
	216	2499	-	-	-
<i>Zygosaccharomyces bailii</i>	158	6949	-	-	-
	159	2902	-	-	-
<i>Zygosaccharomyces rouxii</i>	27	-	-	73-31	-
<i>Kluyveromyces lactis</i>	215	683	-	-	-
<i>Spathaspora passalidarum</i>	254	10155	-	-	-
<i>Pichia stipitis</i>	102	6054	-	-	-
<i>Debaryomyces hansenii</i>	13	767	-	-	-

Table 7. Acid stress response genes common in yeasts; compiled using National Center for Biotechnology Information gene bank.

Gene	Function	Gene	Function
<i>ACT1</i>	Actin	<i>JEN1</i>	Lactic acid transport
<i>IPPI</i>	Inorganic phosphatase	<i>PBS2</i>	Osmotic stress
<i>AFT1</i>	Shock and acid adaptation	<i>PDR12</i>	Plasma membrane ABC transporter
<i>ARN1</i>	Metal metabolism	<i>SAP30</i>	Telomere maintenance
<i>ATG22</i>	Vacuolareffluxers	<i>SCW11</i>	Cell wall protein
<i>DSE1</i>	Mating and filamentation pathways	<i>SEDI</i>	Cell wall mannoprotein
<i>HAA1</i>	Transcriptional activator of membrane stress proteins	<i>SUN4</i>	Cell wall protein, septation
<i>HOG1</i>	Osmoregulation	<i>UBC13</i>	Ubiquitin-conjugating enzyme involved in the error-free DNA postreplication repair pathway
<i>HSP30</i>	Heat shock stress induced by ethanol, heat and weak acids	<i>VAC14</i>	Maintenance of vacuole size and acidity

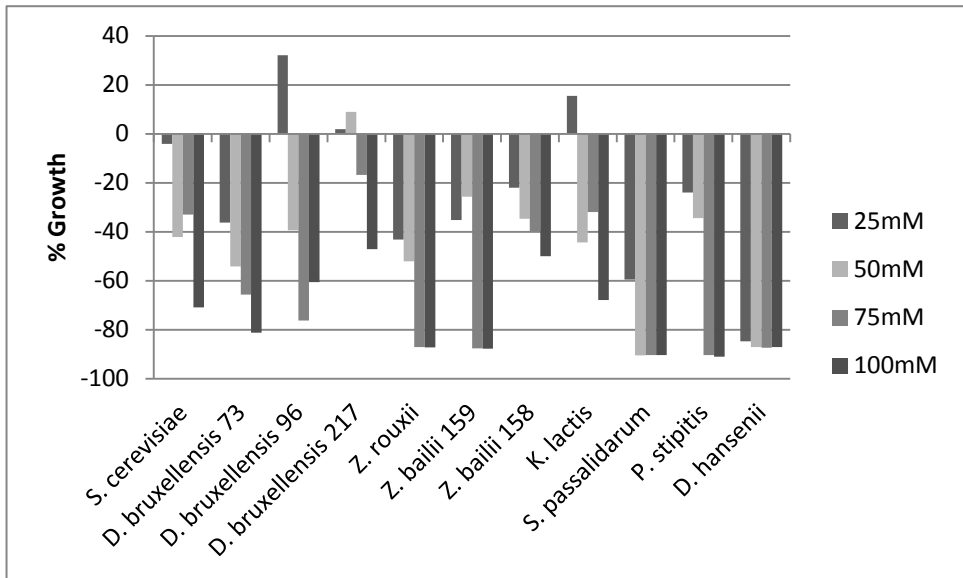


Figure 20. Percent change upon exposure to acetic acid.

The figure represents yeasts that displayed a percent increase and/or decrease in growth compared to its control in varying concentrations of acetic acid. Percent growth was calculated using the maximum optical density (OD) values from each yeast species, which was based on the average of 3 OD readings, when exposed to each of the treatments: control, 25 mM, 50 mM, 75 mM and 100 mM. Using those values, percent growth of the yeast species compared to its respective control in concentrations of 25-100 mM of the acid was calculated by: $\left(\frac{\text{maxOD treatment} - \text{maxOD control}}{\text{maxOD control}}\right) * 100$

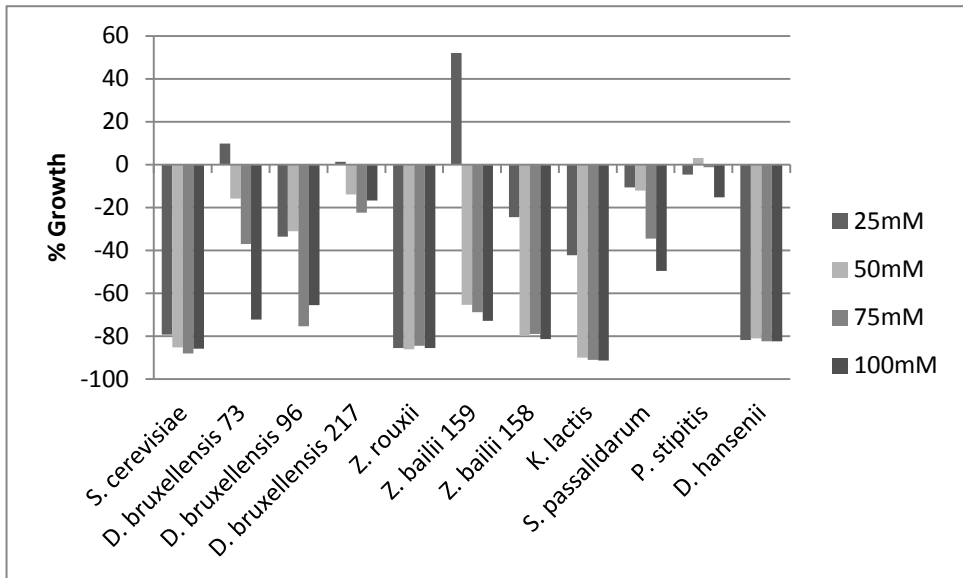


Figure 21. Percent change upon exposure to citric acid.

The figure represents yeasts that displayed a percent increase and/or decrease in growth compared to its control in varying concentrations of citric acid. Percent growth was calculated using the maximum optical density (OD) values from each yeast species, which was based on the average of 3 OD readings, when exposed to each of the treatments: control, 25 mM, 50 mM, 75 mM and 100 mM. Using those values, percent growth of the yeast species compared to its respective control in concentrations of 25-100 mM of the acid was calculated by: $\left(\frac{\text{maxOD treatment} - \text{maxOD control}}{\text{maxOD control}}\right) * 100$

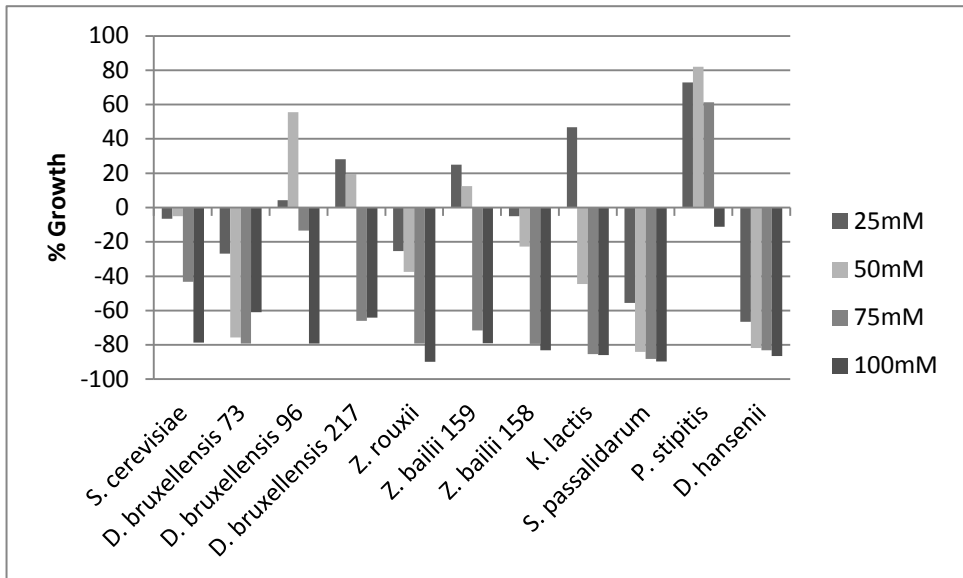


Figure 22. Percent change upon exposure to lactic acid.

The figure represents yeasts that displayed a percent increase and/or decrease in growth compared to its control in varying concentrations of lactic acid. Percent growth was calculated using the maximum optical density (OD) values from each yeast species, which was based on the average of 3 OD readings, when exposed to each of the treatments: control, 25 mM, 50 mM, 75 mM and 100 mM. Using those values, percent growth of the yeast species compared to its respective control in concentrations of 25-100 mM of the acid was calculated by: $\left(\frac{\text{maxOD treatment} - \text{maxOD control}}{\text{maxOD control}}\right) * 100$

Acetic Acid Growth Curves

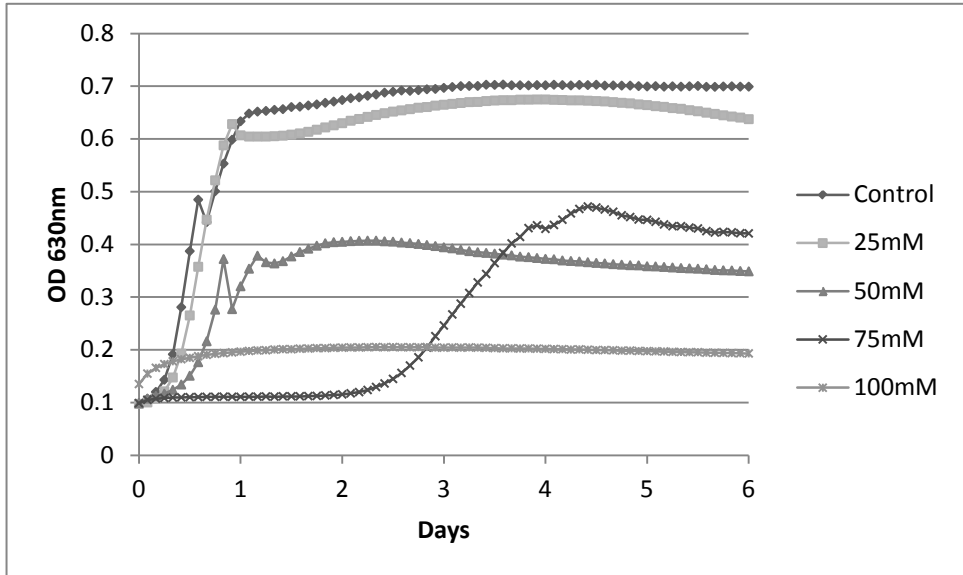


Figure 23. *Saccharomyces cerevisiae* exposed to increasing concentrations of acetic acid. The figure represents growth curves of *Saccharomyces cerevisiae* when exposed to increasing concentrations of acetic acid (25 mM , 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

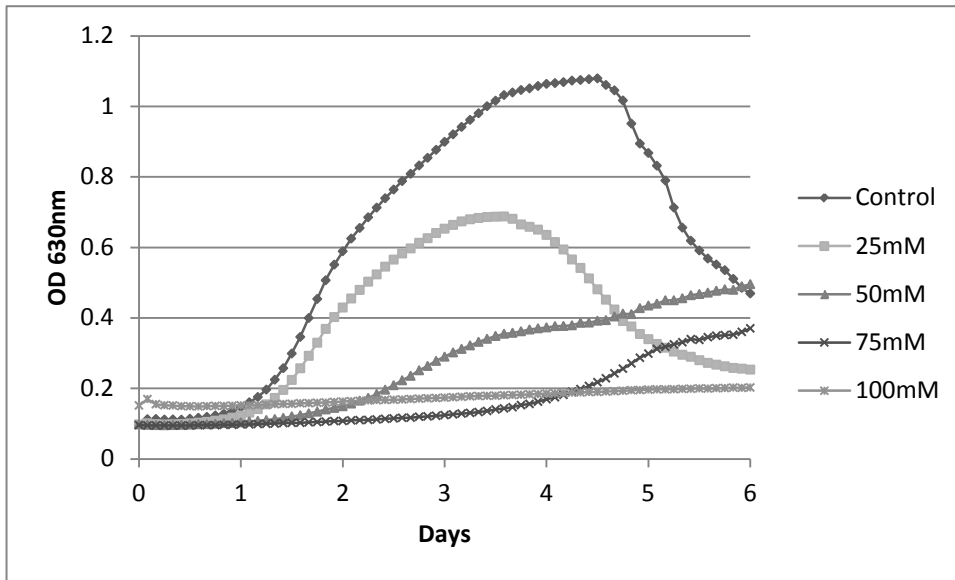


Figure 24. *Dekkera bruxellensis* 73 in increasing concentrations of acetic acid.

The figure represents growth curves of *D. bruxellensis* 73 when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

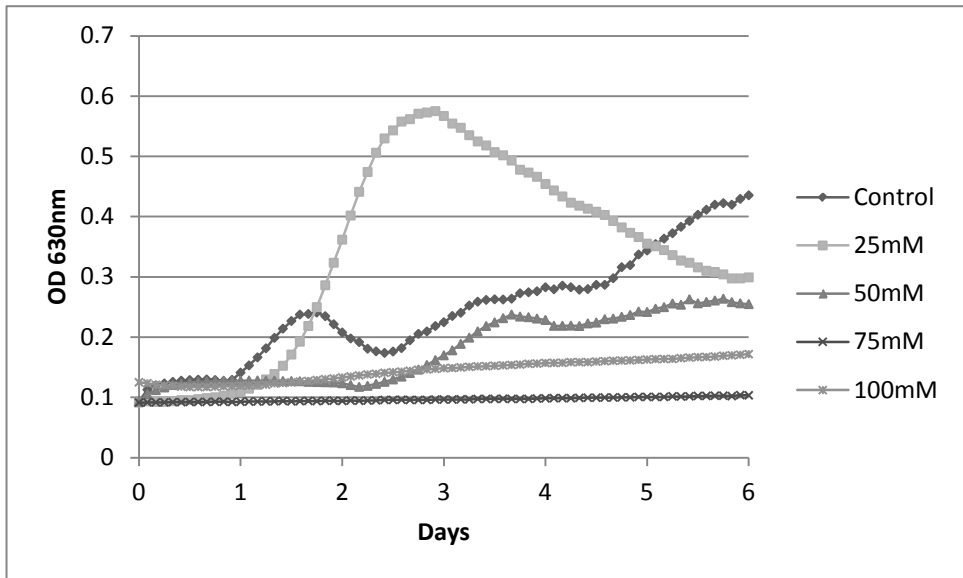


Figure 25. *Dekkera bruxellensis* 96 in increasing concentrations of acetic acid.
 The figure represents growth curves of *D. bruxellensis* 96 when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

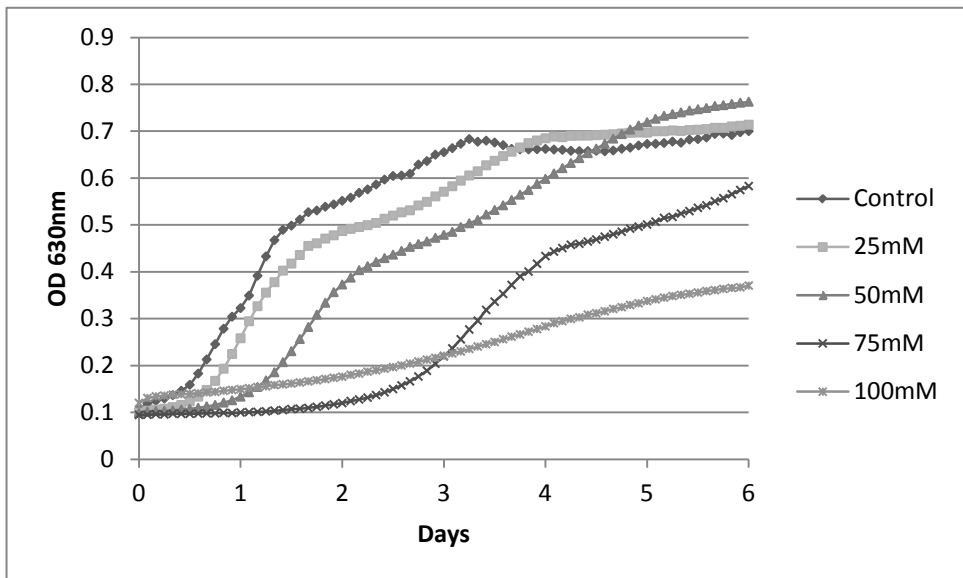


Figure 26. *Dekkera bruxellensis* 216 in increasing concentrations of acetic acid.
 The figure represents growth curves of *D. bruxellensis* 216 when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

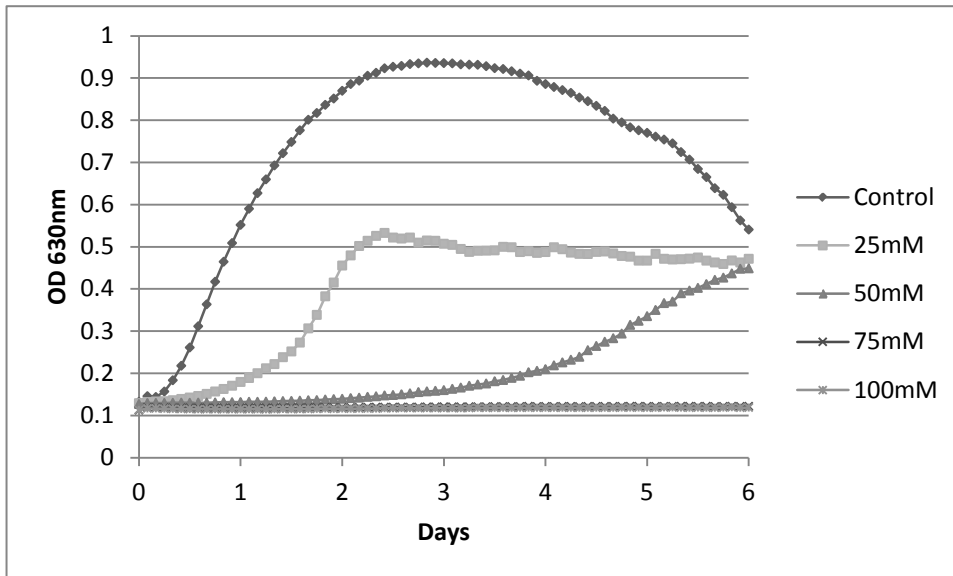


Figure 27. *Zygosaccharomyces rouxii* in increasing concentrations of acetic acid.
 The figure represents growth curves of *Z. rouxii* when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

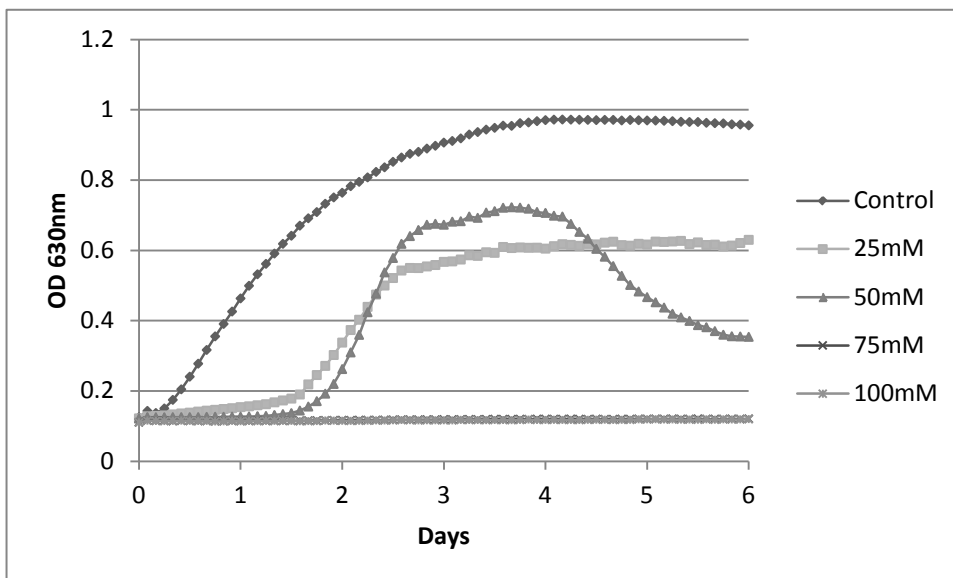


Figure 28. *Zygosaccharomyces bailii* 159 in increasing concentrations of acetic acid.
 The figure represents growth curves of *Z. bailii* 159 when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

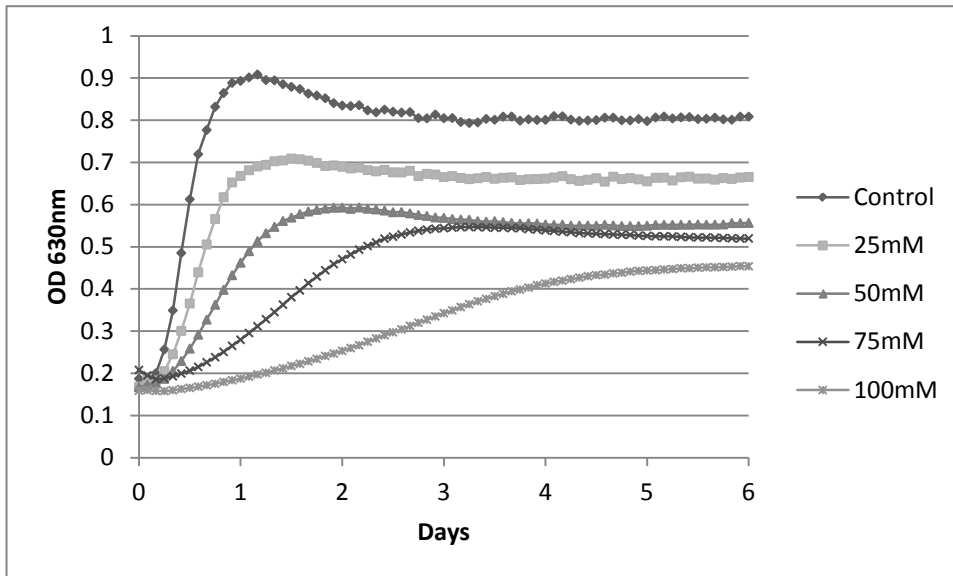


Figure 29. *Zygosaccharomyces bailii* 158 in increasing concentrations of acetic acid.

The figure represents growth curves of *Z. bailii* 158 when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

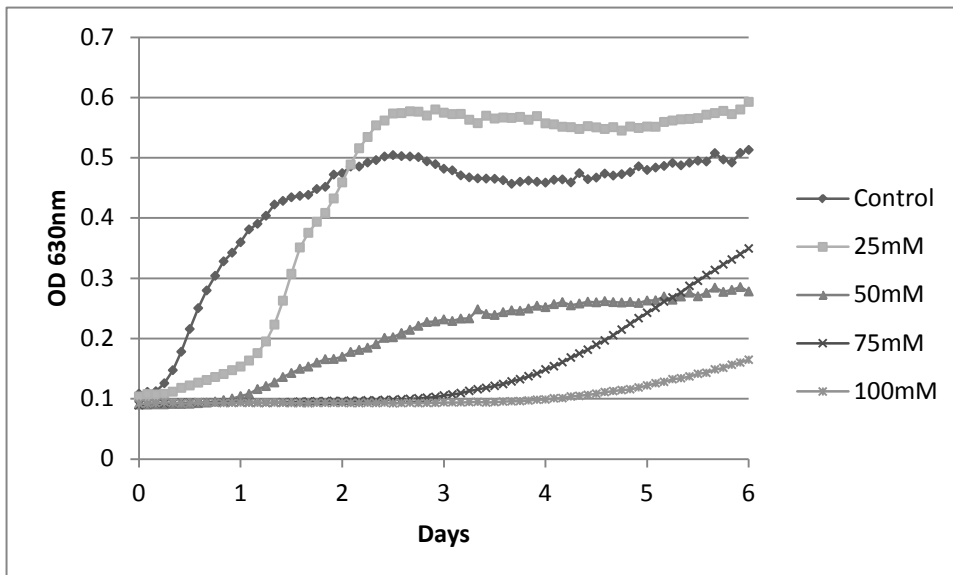


Figure 30. *Kluyveromyces lactis* in increasing concentrations of acetic acid.

The figure represents growth curves of *K. lactis* when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

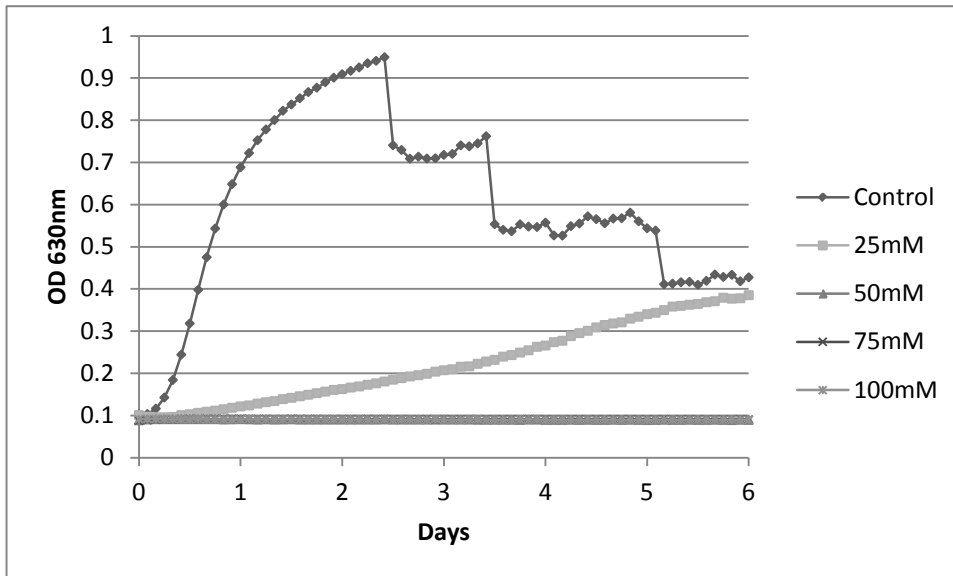


Figure 31. *Spathaspora passalidarum* in increasing concentrations of acetic acid.
 The figure represents growth curves of *S. passalidarum* when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

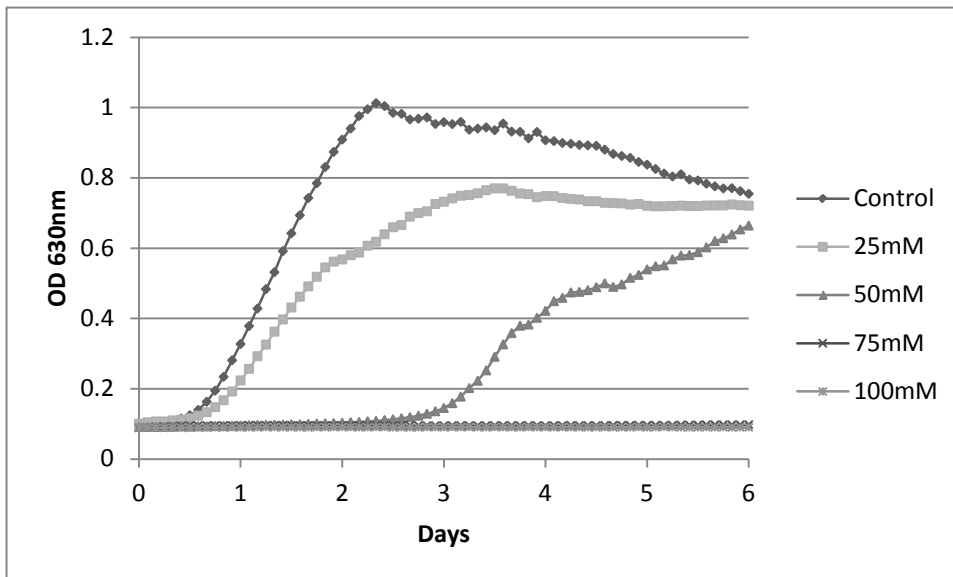


Figure 32. *Pichia stipitis* in increasing concentrations of acetic acid.
 The figure represents growth curves of *P. stipitis* when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

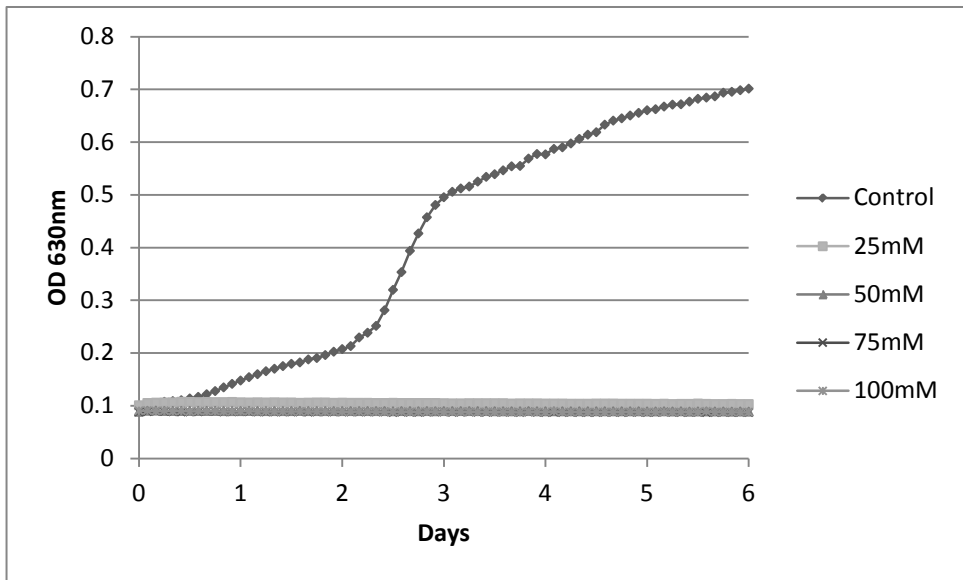


Figure 33. *Debaryomyces hansenii* in increasing concentrations of acetic acid.

The figure represents growth curves of *D. hansenii* when exposed to increasing concentrations of acetic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

Citric Acid Growth Curves

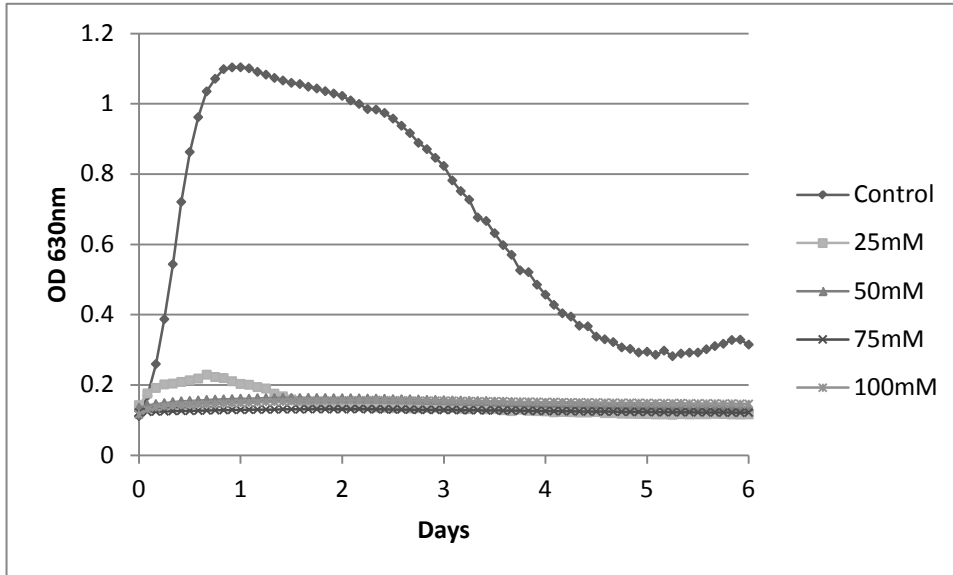


Figure 34. *Saccharomyces cerevisiae* in increasing concentrations of citric acid.

The figure represents growth curves of *S. cerevisiae* when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

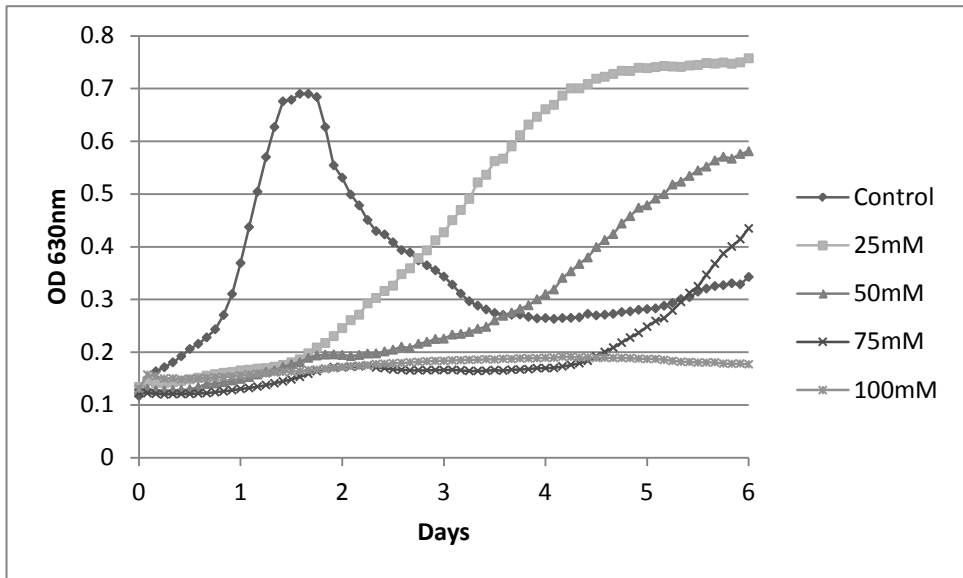


Figure 35. *Dekkera bruxellensis* 73 in increasing concentrations of citric acid.

The figure represents growth curves of *D. bruxellensis* 73 when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

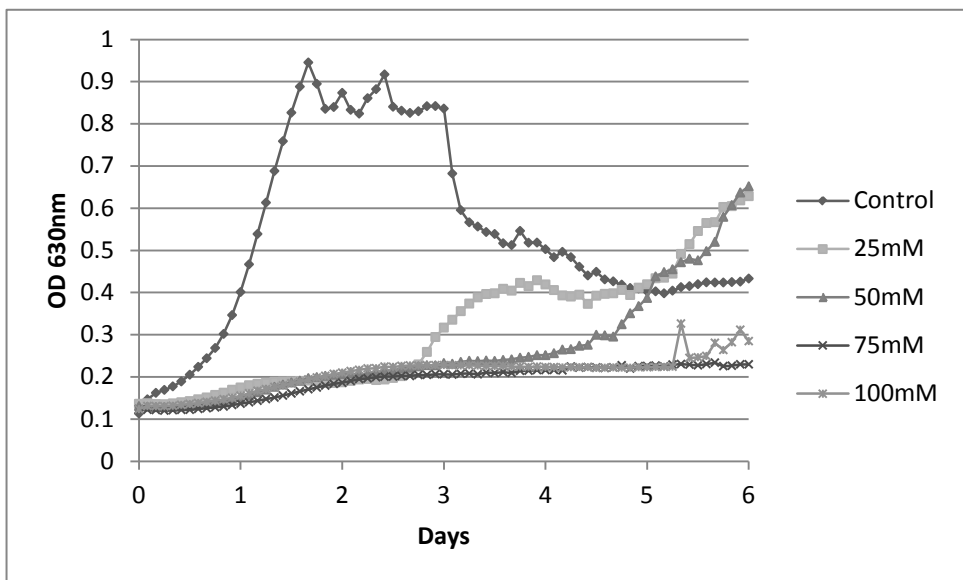


Figure 36. *Dekkera bruxellensis* 96 in increasing concentrations of citric acid.

The figure represents growth curves of *D. bruxellensis* 96 when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

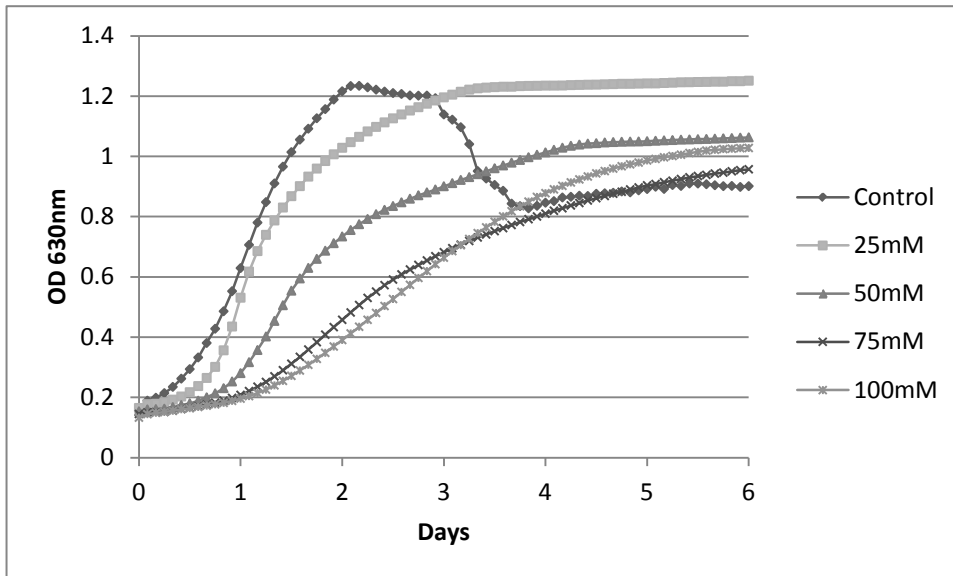


Figure 37. *Dekkera bruxellensis* 216 in increasing concentrations of citric acid.

The figure represents growth curves of *D. bruxellensis* 216 when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

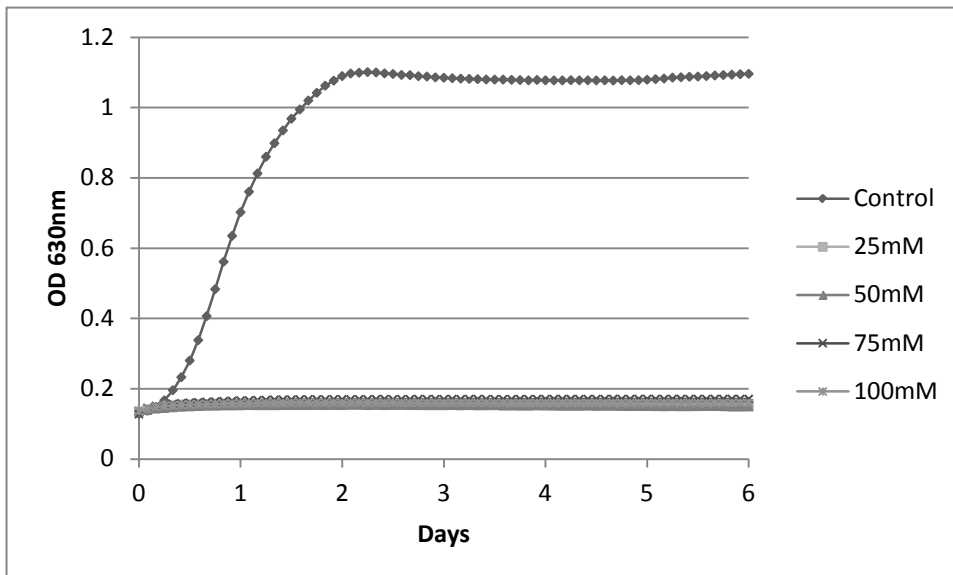


Figure 38. *Zygosaccharomyces rouxii* in increasing concentrations of citric acid.

The figure represents growth curves of *Z. rouxii* when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

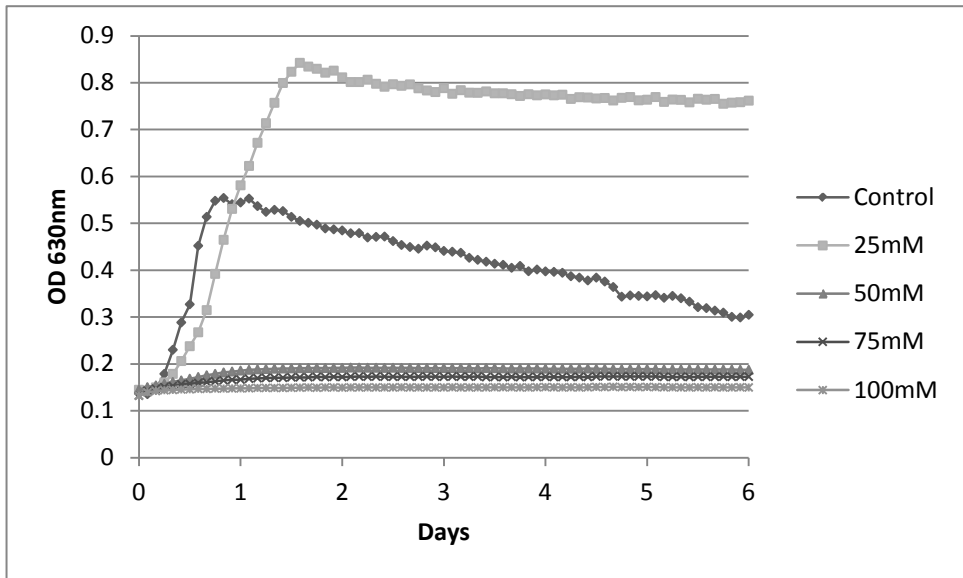


Figure 39. *Zygosaccharomyces bailii* 159 in increasing concentrations of citric acid.
 The figure represents growth curves of *Z. bailii* 159 when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

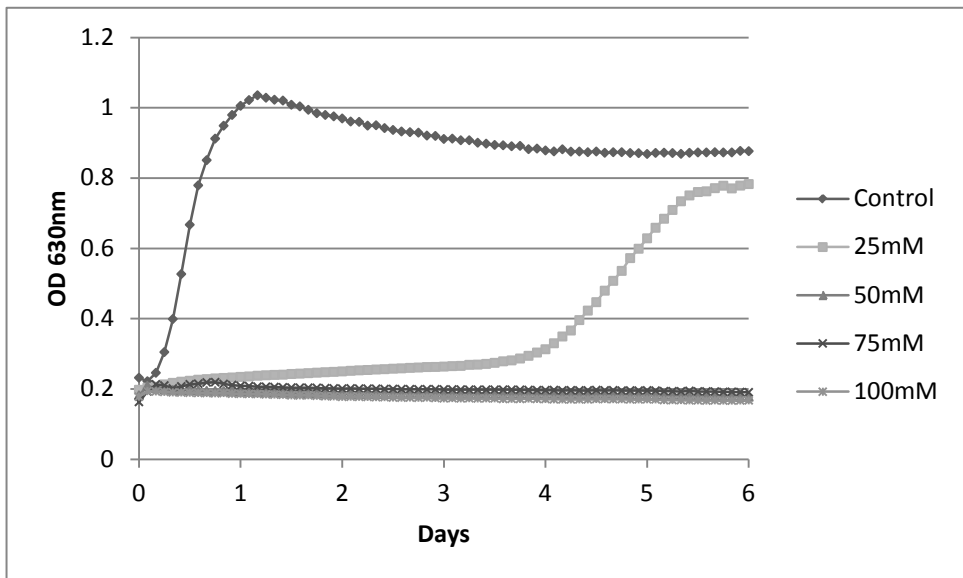


Figure 40. *Zygosaccharomyces bailii* 158 in increasing concentrations of citric acid.
 The figure represents growth curves of *Z. bailii* 158 when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

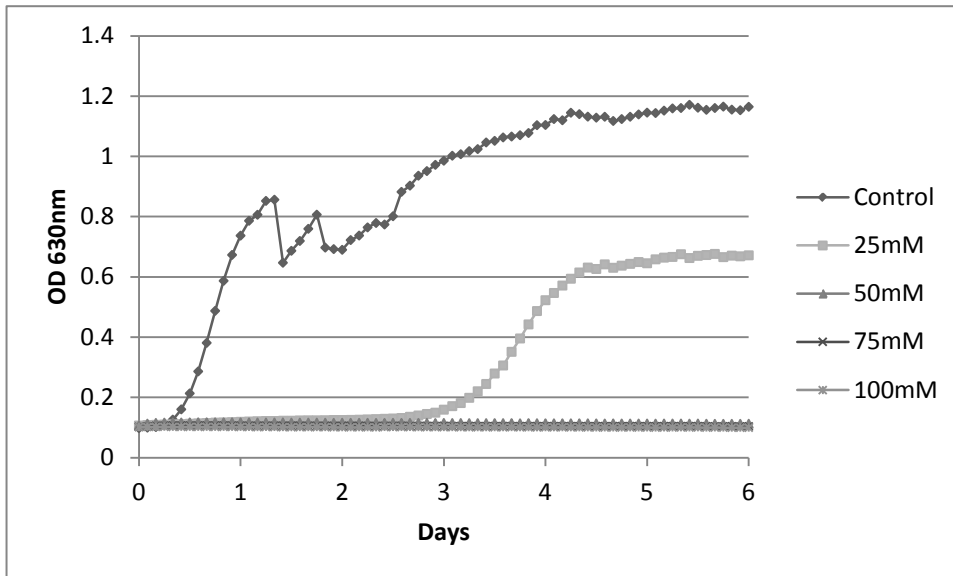


Figure 41. *Kluyveromyces lactis* in increasing concentrations of citric acid.

The figure represents growth curves of *K. lactis* when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

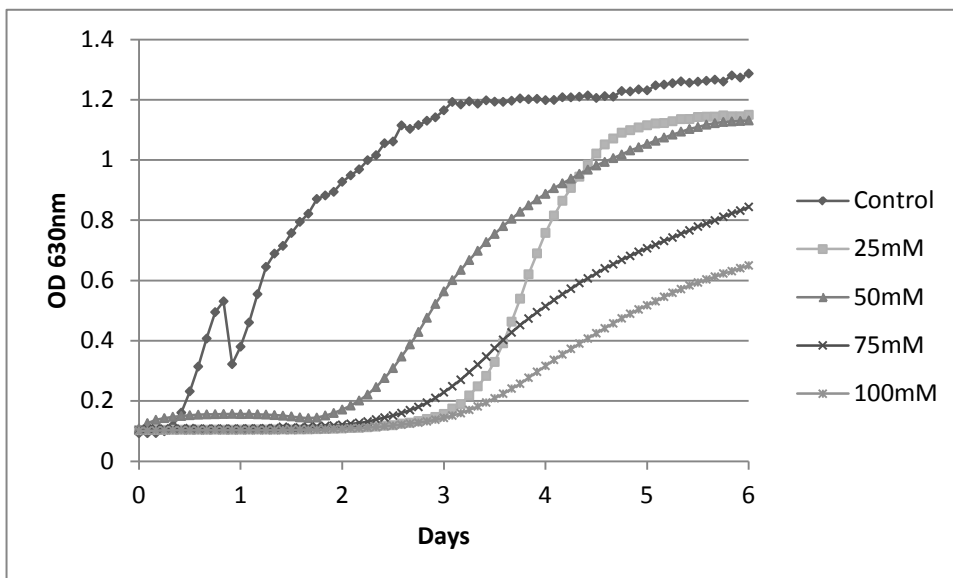


Figure 42. *Spathaspora passalidarum* in increasing concentrations of citric acid.

The figure represents growth curves of *S. passalidarum* when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

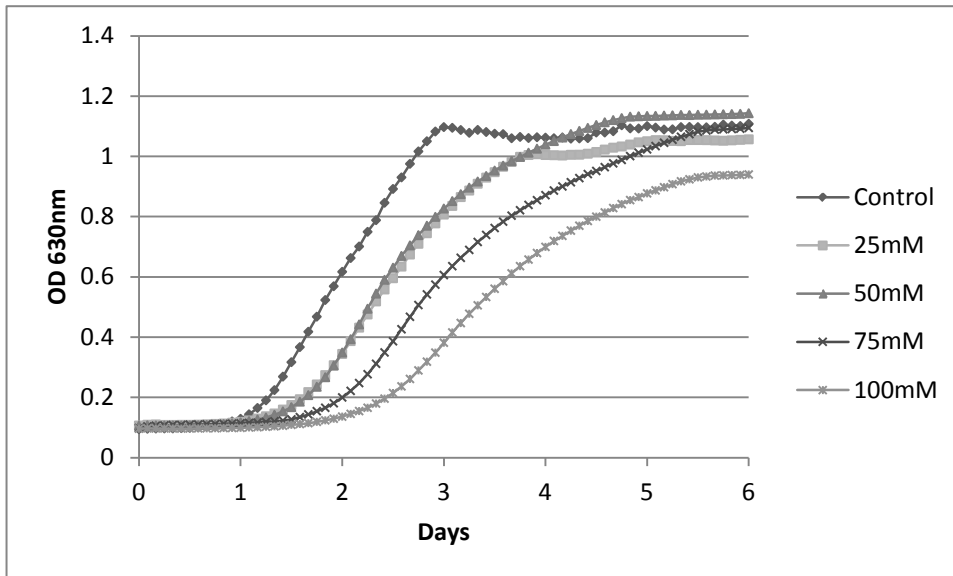


Figure 43. *Pichia stipitis* in increasing concentrations of citric acid.

The figure represents growth curves of *P. stipitis* when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

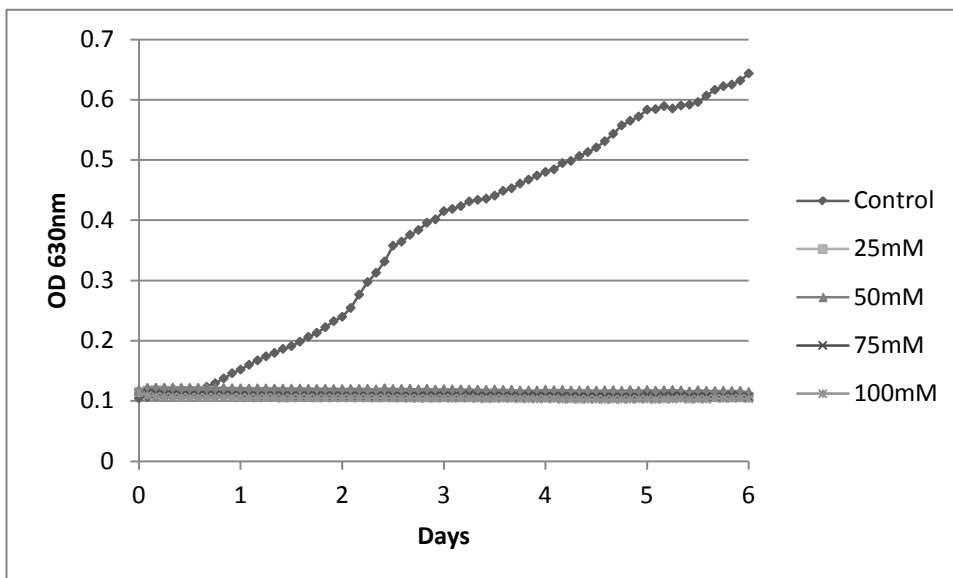


Figure 44. *Debaryomyces hansenii* in increasing concentrations of citric acid.

The figure represents growth curves of *D. hansenii* when exposed to increasing concentrations of citric acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

Lactic Acid Growth Curves

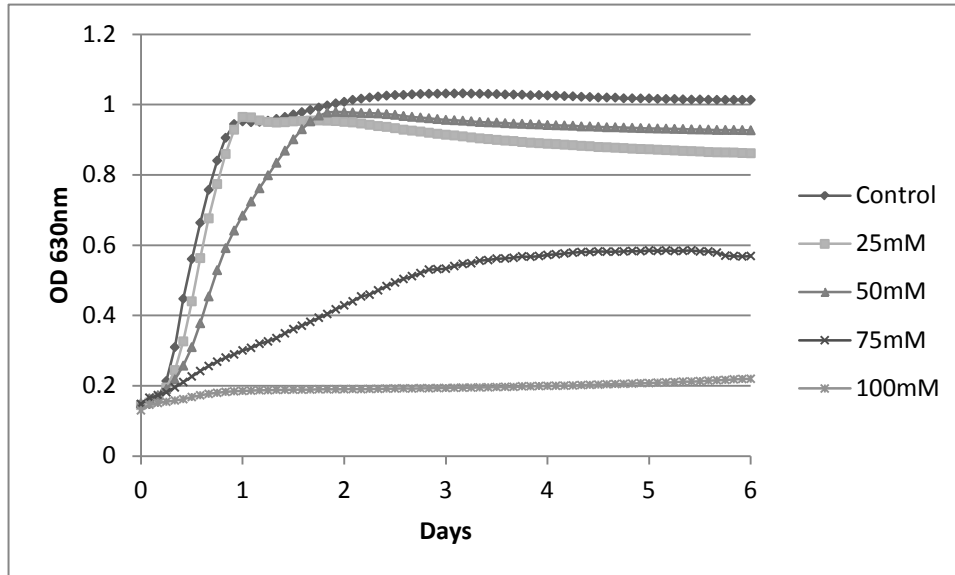


Figure 45. *Saccharomyces cerevisiae* in increasing concentrations of lactic acid.

The figure represents growth curves of *S. cerevisiae* when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

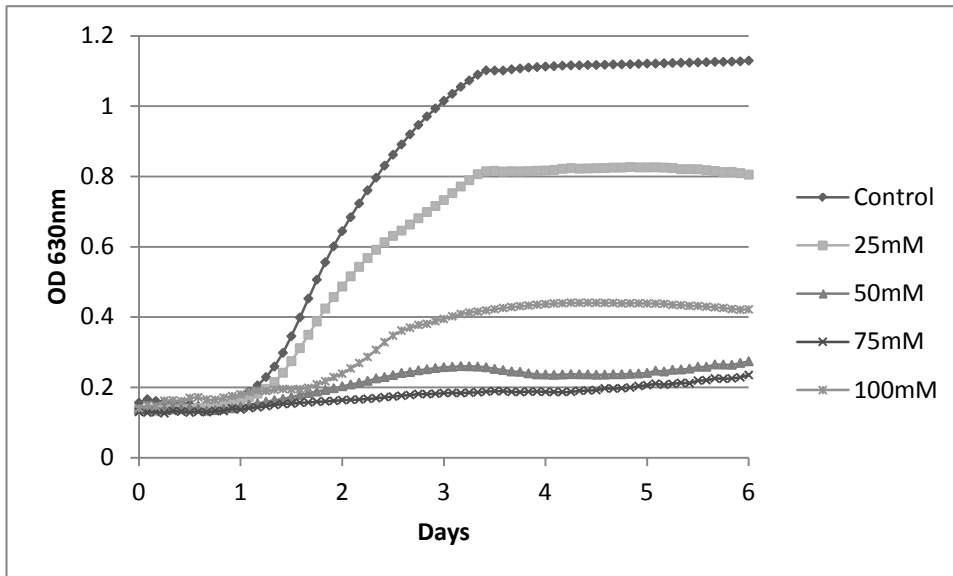


Figure 46. *Dekkera bruxellensis* 73 in increasing concentrations of lactic acid.

The figure represents growth curves of *D. bruxellensis* 73 when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

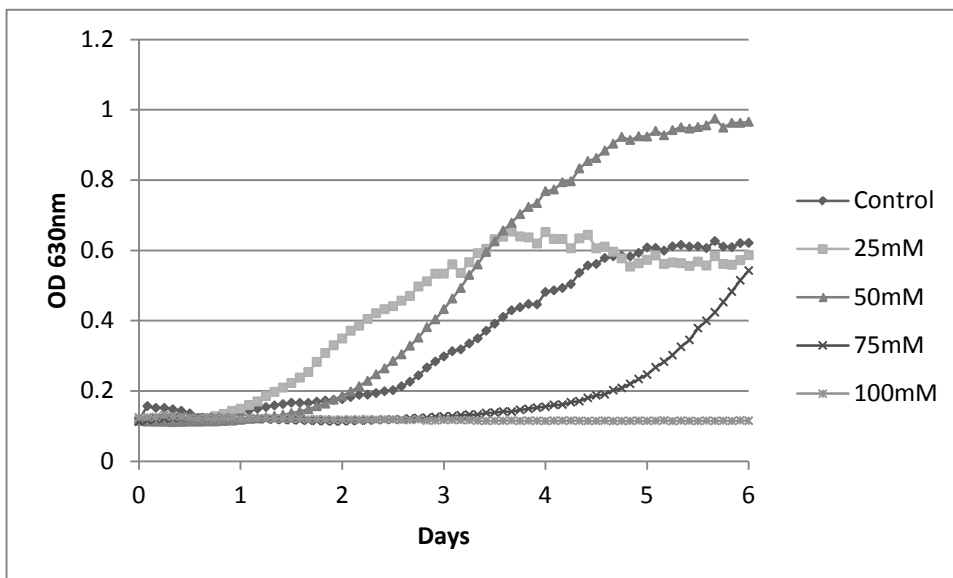


Figure 47. *Dekkera bruxellensis* 96 in increasing concentrations of lactic acid.

The figure represents growth curves of *D. bruxellensis* 96 when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

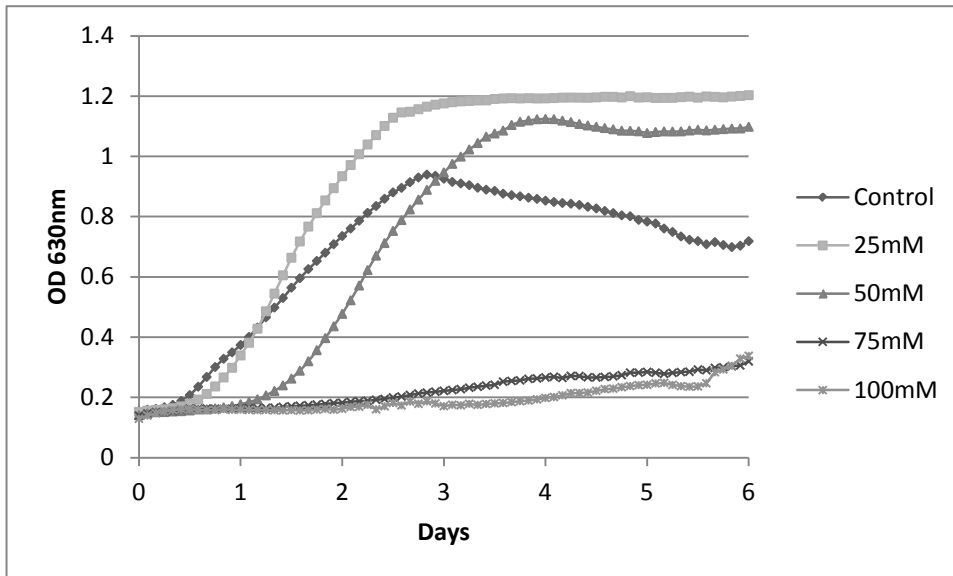


Figure 48. *Dekkera bruxellensis* 216 in increasing concentrations of lactic acid.

The figure represents growth curves of *D. bruxellensis* 216 when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

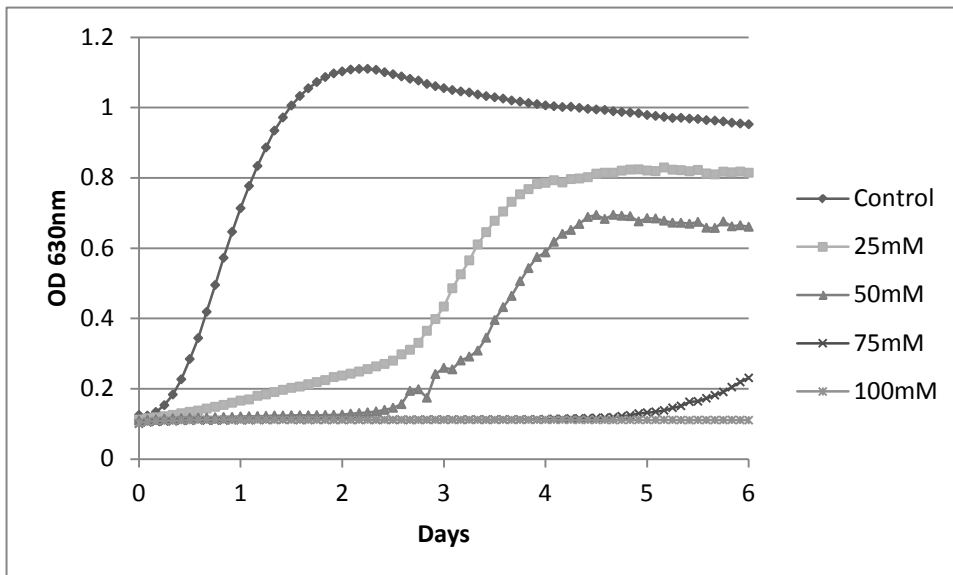


Figure 49. *Zygosaccharomyces rouxii* in increasing concentrations of lactic acid.

The figure represents growth curves of *Z. rouxii* when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

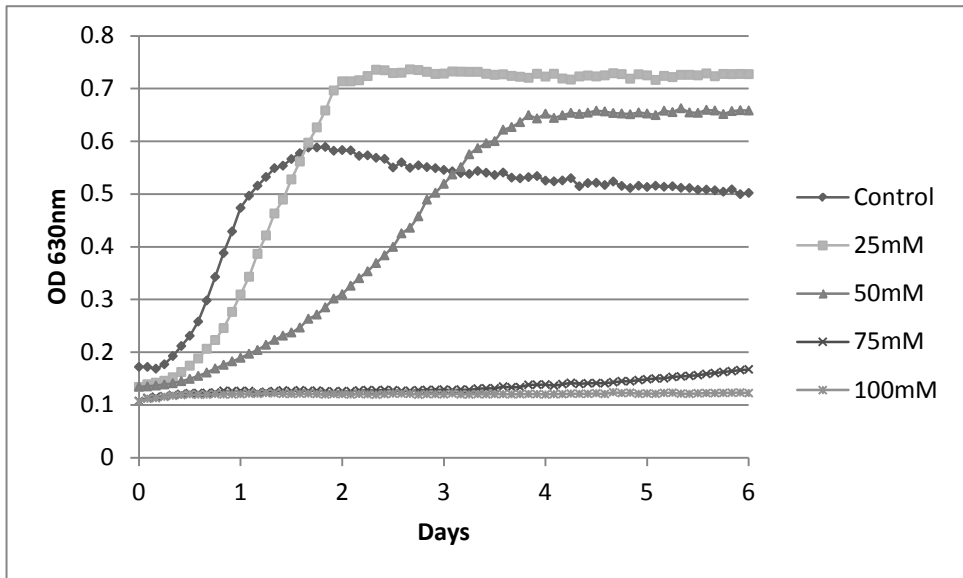


Figure 50. *Zygosaccharomyces bailii* 159 in increasing concentrations of lactic acid.

The figure represents growth curves of *Z. bailii* 159 when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

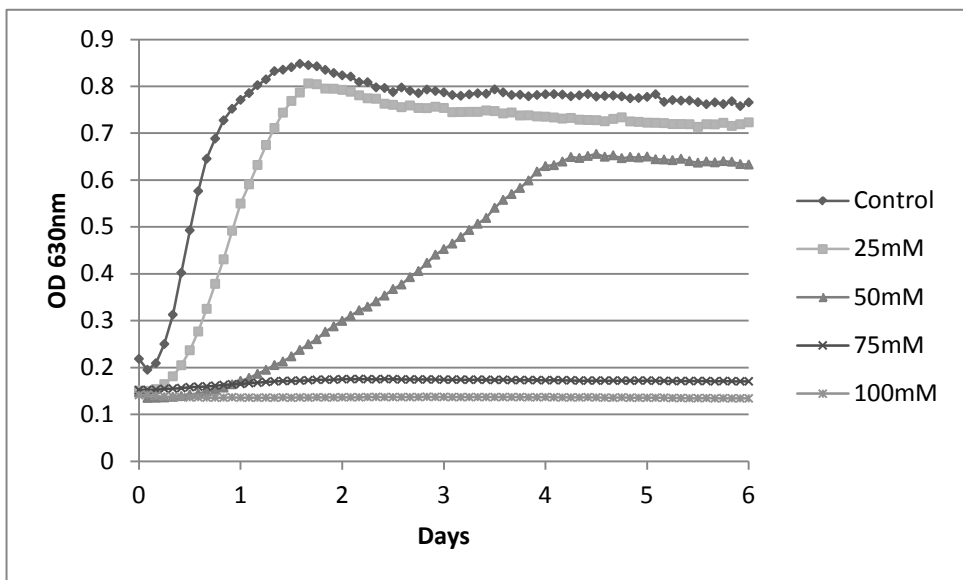


Figure 51. *Zygosaccharomyces bailii* 158 in increasing concentrations of lactic acid.

The figure represents growth curves of *Z. bailii* 158 when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

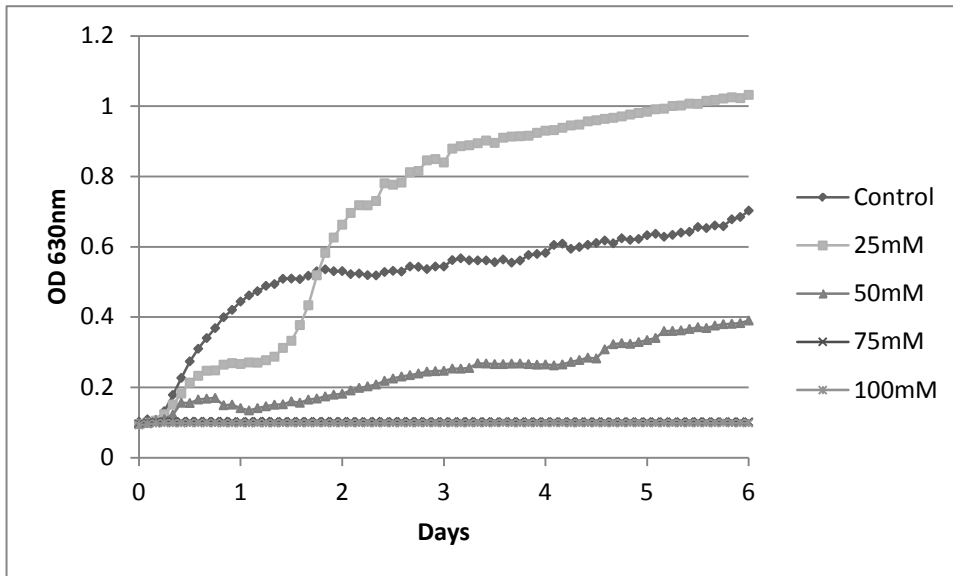


Figure 52. *Kluyveromyces lactis* in increasing concentrations of lactic acid.

The figure represents growth curves of *K. lactis* when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

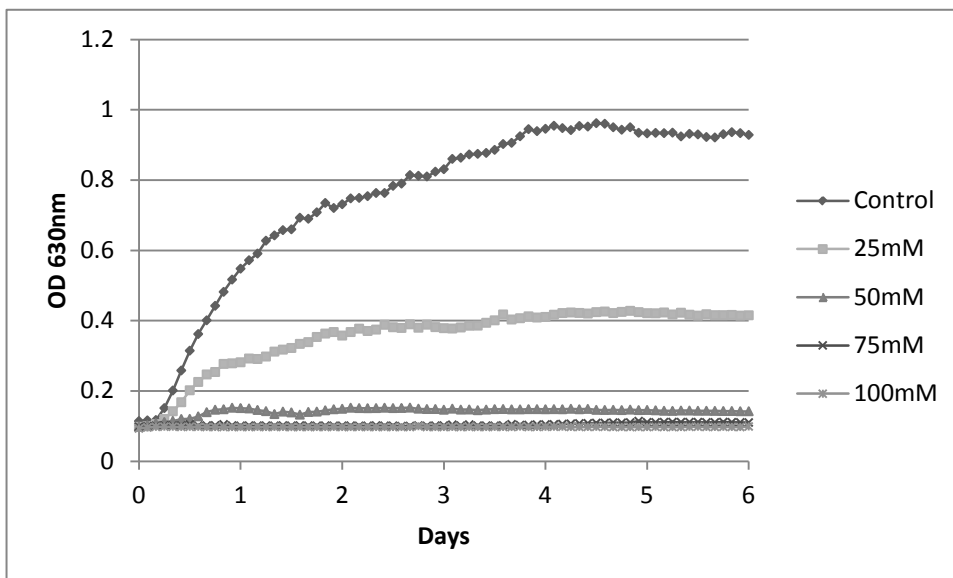


Figure 53. *Spathaspora passalidarum* in increasing concentrations of lactic acid.

The figure represents growth curves of *S. passalidarum* when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

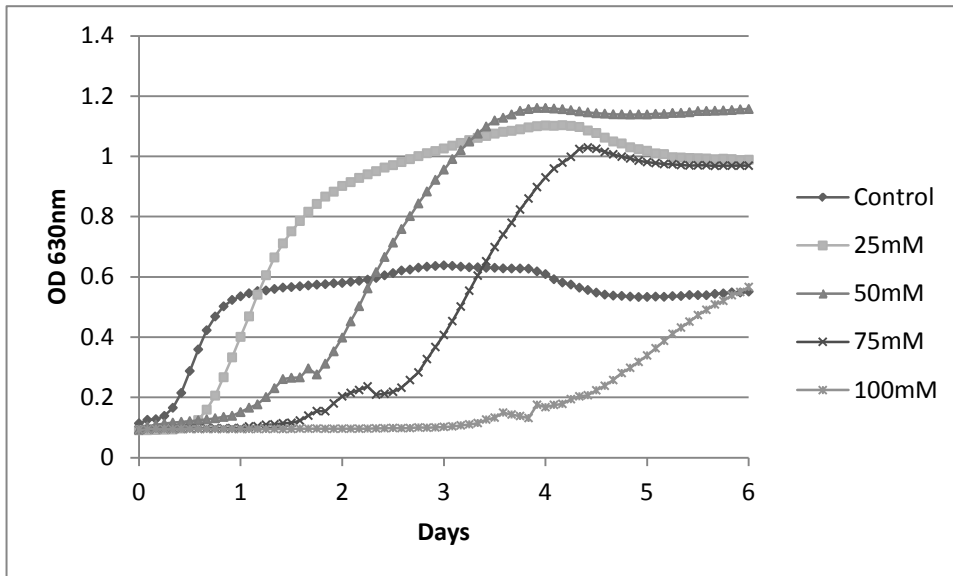


Figure 54. *Pichia stipitis* in increasing concentrations of lactic acid.

The figure represents growth curves of *P. stipitis* when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

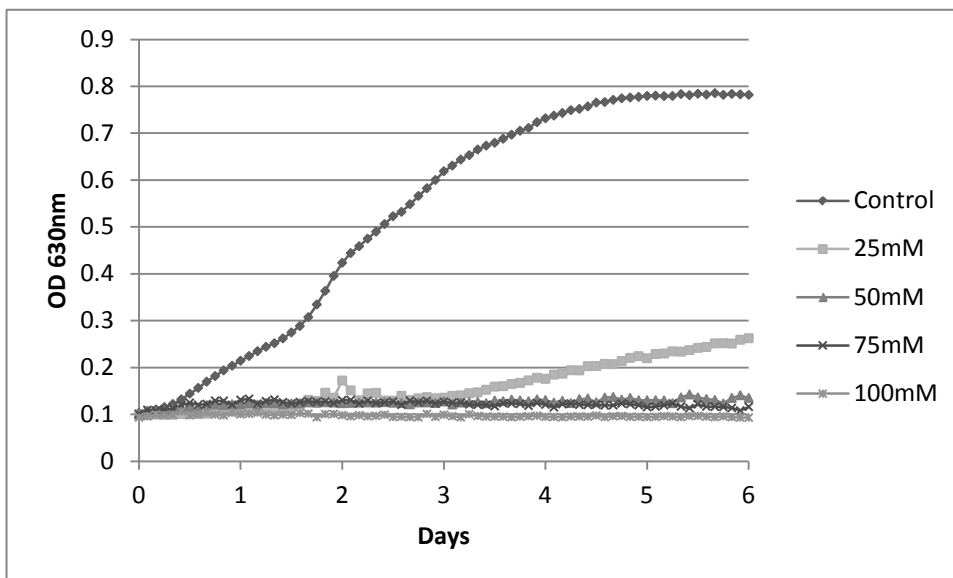


Figure 55. *Debaryomyces hansenii* in increasing concentrations of lactic acid.

The figure represents growth curves of *D. hansenii* when exposed to increasing concentrations of lactic acid (25 mM, 50 mM, 75 mM and 100 mM) or none (control) over a 6 day period. Each point on the graph is an average of 3 optical density (OD) readings taken every 2 hours.

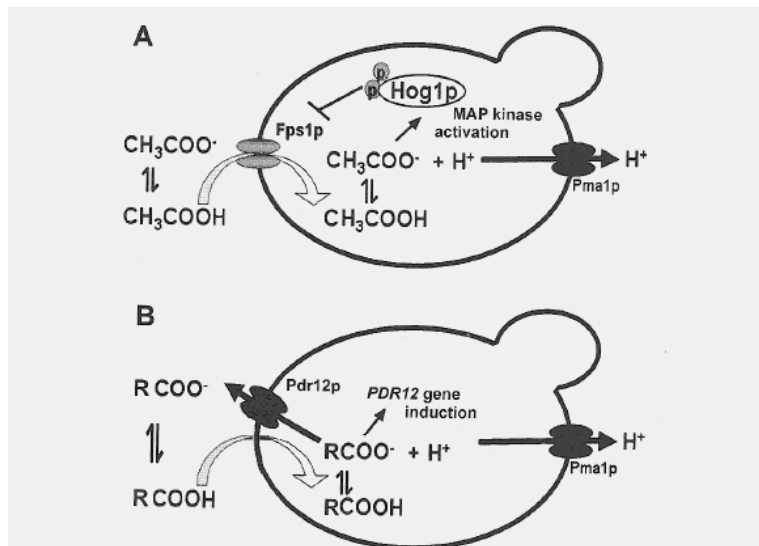


Figure 3 (A) The Fps1p aquaglyceroporin facilitates the initial entry of acetic acid to glucose-repressed *S. cerevisiae*, in this way triggering its own destruction due to the accumulation of an intracellular acetate pool activating the Hog1p that destabilises the open Fps1p channel. Fps1p loss removes the major route of acetic acid entry to the cell, thereby allowing survival in high acetic acid levels. (B) Induction of continuous preservative anion extrusion (Pdr12p) is essential for resistance to weak organic acids more lipophilic than acetic acid.

Figure 56. Function and regulation of Fps1p in *S. cerevisiae* (Mollapour and Piper, 2008)

APPENDICES

APPENDIX A: Raw Data from Chapter 2

Table A8. Cell plate counts of *L. plantarum* WCFS1 with and without *S. cerevisiae* and *K. marxianus* in yogurt at 30°C

Days	<i>L. plantarum</i>			<i>L. plantarum</i> w/ <i>S. cerevisiae</i>			<i>L. plantarum</i> w/ <i>K. marxianus</i>		
	30C	30C	Avg.	30C	30C	Avg.	30C	30C	Avg.
0	5.00E+09	5.00E+06	2.50E+09	8.00E+08	2.00E+06	4.01E+08	2.00E+09	4.00E+06	1.00E+09
6	2.10E+08	2.95E+07	1.20E+08	1.33E+08	1.91E+07	7.61E+07	1.31E+08	4.86E+07	8.98E+07
9	1.90E+08	2.60E+07	1.08E+08	2.44E+08	3.84E+07	1.41E+08	1.81E+08	1.45E+07	9.78E+07
13	1.80E+08	2.50E+07	1.03E+08	2.02E+08	2.10E+07	1.12E+08	1.60E+08	3.51E+07	9.76E+07
16	4.90E+07	1.26E+07	3.08E+07	8.50E+07	5.00E+07	6.75E+07	3.60E+07	9.20E+07	6.40E+07
19	4.70E+07	9.10E+06	2.81E+07	8.80E+07	2.20E+07	5.50E+07	6.90E+07	2.05E+07	4.48E+07
22	1.36E+07	3.70E+06	8.65E+06	2.44E+07	4.70E+06	1.46E+07	1.92E+07	1.16E+07	1.54E+07
25	3.40E+06	1.10E+07	7.20E+06	1.56E+07	2.50E+06	9.05E+06	1.10E+07	6.90E+06	8.95E+06
28	6.00E+05	1.03E+06	8.15E+05	3.70E+06	1.22E+06	2.46E+06	6.40E+06	1.60E+06	4.00E+06
31	0.00E+00	1.50E+05	7.50E+04	5.90E+05	9.10E+05	7.50E+05	1.23E+06	8.70E+05	1.05E+06
34	0.00E+00	6.85E+04	3.43E+04	1.29E+06	1.76E+06	1.53E+06	5.80E+05	3.60E+05	4.70E+05
37	0.00E+00	0.00E+00	0.00E+00	5.50E+05	1.90E+06	1.23E+06	1.00E+06	2.30E+06	1.65E+06
40	0.00E+00	0.00E+00	0.00E+00	7.70E+05	2.78E+06	1.78E+06	1.14E+07	8.00E+05	6.10E+06
50	0.00E+00	0.00E+00	0.00E+00	4.40E+06	1.29E+07	8.65E+06	3.88E+07	1.90E+05	1.95E+07
53	0.00E+00	0.00E+00	0.00E+00	8.40E+06	1.02E+08	5.52E+07	3.36E+07	0.00E+00	1.68E+07
56	0.00E+00	0.00E+00	0.00E+00	1.94E+07	1.16E+08	6.77E+07	2.28E+07	0.00E+00	1.14E+07
59	0.00E+00	0.00E+00	0.00E+00	3.17E+07	4.25E+08	2.28E+08	3.10E+07	0.00E+00	1.55E+07
68	0.00E+00	0.00E+00	0.00E+00	2.66E+07	1.49E+08	8.78E+07	4.80E+07	0.00E+00	2.40E+07
71	0.00E+00	0.00E+00	0.00E+00	2.53E+07	1.12E+08	6.87E+07	5.25E+07	0.00E+00	2.63E+07
74	0.00E+00	0.00E+00	0.00E+00	1.10E+06	9.70E+07	4.91E+07	5.64E+07	0.00E+00	2.82E+07
78	0.00E+00	0.00E+00	0.00E+00	7.30E+06	1.74E+08	9.07E+07	TNTC	0.00E+00	

Table A9. Cell plate counts of *L. plantarum* WCFS1 with and without *P. guillermondii* and *W. saturnus* in yogurt at 30°C

Days	<i>L. plantarum</i> w/ <i>P. guillermondii</i>			<i>L. plantarum</i> w/ <i>W. saturnus</i>		
	30C	30C	Avg.	30C	30C	Avg.
0	2.50E+09	1.30E+06	1.25E+09	2.40E+08	6.30E+07	1.52E+08
6	1.77E+08	3.04E+07	1.04E+08	1.40E+07	1.13E+08	6.35E+07
9	2.18E+08	1.43E+07	1.16E+08	2.57E+08	5.11E+07	1.54E+08
13	1.36E+08	4.23E+07	8.92E+07	5.00E+07	1.91E+08	1.21E+08
16	3.30E+07	4.90E+07	4.10E+07	6.10E+07	2.35E+08	1.48E+08
19	6.70E+07	1.95E+07	4.33E+07	2.12E+08	1.93E+08	2.03E+08
22	1.00E+07	1.56E+07	1.28E+07	1.19E+08	3.51E+08	2.35E+08
25	5.60E+06	1.72E+07	1.14E+07	1.00E+08	1.60E+08	1.30E+08
28	9.40E+06	5.10E+06	7.25E+06	1.97E+08	3.02E+08	2.50E+08
31	1.52E+06	9.80E+06	5.66E+06	1.30E+08	1.72E+08	1.51E+08
34	2.43E+07	5.30E+06	1.48E+07	1.87E+08	1.40E+08	1.64E+08
37	3.82E+07	2.20E+07	3.01E+07	1.32E+08	2.30E+08	1.81E+08
40	1.10E+08	3.57E+07	7.29E+07	1.10E+08	1.99E+08	1.55E+08
50	2.44E+08	2.83E+07	1.36E+08	1.52E+08	9.00E+07	1.21E+08
53	1.99E+08	0.00E+00	9.95E+07	1.81E+08	4.40E+07	1.13E+08
56	1.10E+08	0.00E+00	5.50E+07	1.40E+08	2.30E+07	8.15E+07
59	6.50E+07	0.00E+00	3.25E+07	7.40E+07	1.90E+05	3.71E+07
68	1.14E+07	0.00E+00	5.70E+06	2.76E+07	6.30E+05	1.41E+07
71	6.80E+06	0.00E+00	3.40E+06	4.02E+06	4.70E+04	2.03E+06
74	2.77E+06	0.00E+00	1.39E+06	1.05E+07	0.00E+00	5.25E+06
78	1.10E+06	0.00E+00	5.50E+05	1.95E+06	0.00E+00	9.75E+05

Table A10. Cell plate counts of *L. plantarum* WCFS1 with and without *S. cerevisiae* and *K. marxianus* in yogurt at 4°C

Days	<i>L. plantarum</i>			<i>L. plantarum</i> w/ <i>S. cerevisiae</i>			<i>L. plantarum</i> w/ <i>K. marxianus</i>		
	4C	4C	Avg.	4C	4C	Avg.	4C	4C	Avg.
0	1.20E+0 7	8.00E+0 5	6.40E+0 6	9.30E+0 6	2.00E+0 5	4.75E+0 6	8.00E+0 7	4.00E+0 5	4.02E+0 7
6	2.17E+0 6	3.30E+0 6	2.74E+0 6	2.60E+0 6	4.04E+0 6	3.32E+0 6	2.80E+0 7	1.93E+0 6	1.50E+0 7
9	2.60E+0 6	5.80E+0 6	4.20E+0 6	4.50E+0 6	5.70E+0 6	5.10E+0 6	3.90E+0 6	5.90E+0 6	4.90E+0 6
13	3.60E+0 6	3.50E+0 6	3.55E+0 6	3.60E+0 6	1.23E+0 7	7.95E+0 6	4.10E+0 6	7.30E+0 6	5.70E+0 6
16	1.60E+0 6	7.40E+0 6	4.50E+0 6	2.80E+0 6	4.52E+0 6	3.66E+0 6	1.60E+0 6	3.46E+0 6	2.53E+0 6
19	1.14E+0 7	3.70E+0 6	7.55E+0 6	5.00E+0 6	4.70E+0 6	4.85E+0 6	5.80E+0 6	2.60E+0 6	4.20E+0 6
22	2.50E+0 6	2.60E+0 6	2.55E+0 6	4.40E+0 6	3.50E+0 6	3.95E+0 6	2.80E+0 6	2.16E+0 6	2.48E+0 6
25	2.10E+0 6	3.12E+0 6	2.61E+0 6	3.10E+0 6	8.10E+0 6	5.60E+0 6	1.93E+0 6	3.50E+0 6	2.72E+0 6
28	8.00E+0 6	6.40E+0 6	7.20E+0 6	3.20E+0 6	4.60E+0 6	3.90E+0 6	4.80E+0 6	3.10E+0 6	3.95E+0 6
31	3.03E+0 6	9.50E+0 6	6.27E+0 6	2.60E+0 6	1.30E+0 7	7.80E+0 6	1.68E+0 6	5.10E+0 6	3.39E+0 6
34	1.77E+0 6	5.50E+0 6	3.64E+0 6	4.00E+0 6	2.99E+0 6	3.50E+0 6	5.20E+0 6	4.70E+0 6	4.95E+0 6
37	4.40E+0 6	1.86E+0 6	3.13E+0 6	2.22E+0 6	5.00E+0 6	3.61E+0 6	4.90E+0 6	1.88E+0 6	3.39E+0 6
40	1.65E+0 6	1.39E+0 6	1.52E+0 6	1.76E+0 6	1.90E+0 6	1.83E+0 6	1.90E+0 6	1.05E+0 6	1.48E+0 6
50	1.23E+0 6	1.69E+0 6	1.46E+0 6	2.20E+0 6	3.39E+0 6	2.80E+0 6	1.16E+0 7	8.60E+0 5	6.23E+0 6
53	1.40E+0 6	1.56E+0 6	1.48E+0 6	1.69E+0 6	1.90E+0 6	1.80E+0 6	3.30E+0 6	2.74E+0 6	3.02E+0 6
56	4.50E+0 6	2.20E+0 6	3.35E+0 6	1.78E+0 6	2.69E+0 6	2.24E+0 6	2.10E+0 6	9.50E+0 4	1.10E+0 6
59	4.70E+0 6	2.03E+0 6	3.37E+0 6	2.00E+0 6	1.86E+0 6	1.93E+0 6	0.00E+0 0	3.90E+0 5	1.95E+0 5
62	1.29E+0 6	1.02E+0 6	1.16E+0 6	1.53E+0 6	1.38E+0 6	1.46E+0 6	0.00E+0 0	1.80E+0 5	9.00E+0 4
68	1.08E+0 6	2.07E+0 6	1.58E+0 6	8.40E+0 5	2.17E+0 6	1.51E+0 6	0.00E+0 0	5.10E+0 5	2.55E+0 5
71	1.10E+0 6	1.43E+0 6	1.27E+0 6	1.49E+0 6	1.88E+0 6	1.69E+0 6	0.00E+0 0	5.30E+0 5	2.65E+0 5
74	1.14E+0 6	1.00E+0 6	1.07E+0 6	2.27E+0 7	1.37E+0 6	1.20E+0 7	0.00E+0 0	0.00E+0 0	0.00E+0 0
78	1.78E+0 6	1.60E+0 6	1.69E+0 6	1.38E+0 6	8.90E+0 5	1.14E+0 6	0.00E+0 0	0.00E+0 0	0.00E+0 0

Table A11. Cell plate counts of *L. plantarum* WCFS1 with and without *P. guillermondii* and *W. saturnus* in yogurt at 4°C

Days	<i>L. plantarum</i> w/ <i>P. guillermondii</i>			<i>L. plantarum</i> w/ <i>W. saturnus</i>		
	4C	4C	Average	4C	4C	Average
0	8.60E+06	1.60E+05	4.38E+06	9.40E+06	3.20E+05	4.86E+06
6	1.60E+06	3.63E+06	2.62E+06	4.00E+06	3.13E+06	3.57E+06
9	3.90E+06	6.20E+06	5.05E+06	5.20E+06	6.20E+06	5.70E+06
13	4.60E+06	4.20E+06	4.40E+06	3.90E+06	2.42E+06	3.16E+06
16	2.90E+06	2.81E+06	2.86E+06	2.10E+06	2.70E+06	2.40E+06
19	4.20E+06	7.20E+06	5.70E+06	7.10E+06	1.60E+06	4.35E+06
22	2.80E+06	1.99E+06	2.40E+06	6.50E+06	4.50E+06	5.50E+06
25	1.83E+06	2.98E+06	2.41E+06	6.80E+06	1.95E+06	4.38E+06
28	2.37E+06	2.47E+06	2.42E+06	5.20E+06	2.73E+06	3.97E+06
31	2.04E+06	9.20E+06	5.62E+06	4.90E+06	1.40E+07	9.45E+06
34	5.00E+06	3.90E+06	4.45E+06	6.50E+06	3.60E+06	5.05E+06
37	2.30E+06	8.00E+06	5.15E+06	2.60E+06	7.30E+06	4.95E+06
40	2.40E+06	1.15E+06	1.78E+06	3.40E+06	2.03E+06	2.72E+06
50	7.80E+06	1.30E+06	4.55E+06	6.60E+06	3.32E+06	4.96E+06
53	2.00E+06	1.09E+06	1.55E+06	6.30E+06	2.27E+06	4.29E+06
56	2.00E+06	6.07E+05	1.30E+06	5.00E+06	2.83E+06	3.92E+06
59	0.00E+00	4.10E+05	2.05E+05	7.30E+06	1.87E+06	4.59E+06
62	0.00E+00	4.70E+05	2.35E+05	1.90E+06	1.29E+06	1.60E+06
68	0.00E+00	1.40E+05	7.00E+04	5.80E+05	1.54E+06	1.06E+06
71	0.00E+00	4.40E+05	2.20E+05	4.00E+06	1.67E+06	2.84E+06
74	0.00E+00	0.00E+00	0.00E+00	6.60E+06	1.17E+06	3.89E+06
78	0.00E+00	0.00E+00	0.00E+00	4.60E+06	1.41E+06	3.01E+06

Table A12. Cell plate counts of *L. plantarum* WCFS1 in yogurt at 30°C and 4°C

Days	30C	30C	Avg.	4C	4C	Avg.
0	6.60E+07	5.30E+07	5.95E+07	1.10E+07	3.90E+07	2.50E+07
3	1.45E+08	8.10E+07	1.13E+08	1.05E+07	3.70E+06	7.10E+06
6	9.50E+07	1.22E+08	1.09E+08	6.10E+06	1.42E+07	1.02E+07
10	1.19E+08	1.46E+08	1.33E+08	4.37E+07	2.73E+07	3.55E+07
13	1.30E+08	2.28E+08	1.79E+08	2.50E+07	2.44E+07	2.47E+07
17	6.10E+07	1.43E+07	3.77E+07	5.90E+06	5.40E+06	5.65E+06
20	3.65E+07	2.16E+07	2.91E+07	2.29E+07	2.25E+07	2.27E+07
23	2.20E+06	1.40E+06	1.80E+06	1.04E+07	5.30E+06	7.85E+06
26	1.26E+06	3.40E+06	2.33E+06	2.66E+07	1.21E+07	1.94E+07
29	1.41E+06	3.00E+05	8.55E+05	4.24E+06	3.45E+06	3.85E+06
32	0.00E+00	0.00E+00	1.00E+00	1.80E+07	1.92E+07	1.86E+07
35	0.00E+00	0.00E+00	1.00E+00	2.90E+06	3.70E+06	3.30E+06
40	0.00E+00	0.00E+00	1.00E+00	1.11E+07	2.17E+07	1.64E+07
43	0.00E+00	0.00E+00	1.00E+00	2.45E+07	1.44E+07	1.95E+07
46	0.00E+00	0.00E+00	1.00E+00	1.30E+06	2.46E+06	1.88E+06
49	0.00E+00	0.00E+00	1.00E+00	6.27E+06	6.21E+06	6.24E+06
52	0.00E+00	0.00E+00	1.00E+00	3.96E+06	2.67E+06	3.32E+06
55	0.00E+00	0.00E+00	1.00E+00	5.04E+06	3.30E+06	4.17E+06
58	0.00E+00	0.00E+00	1.00E+00	1.53E+06	2.67E+06	2.10E+06
61	0.00E+00	0.00E+00	1.00E+00	1.44E+06	1.41E+06	1.43E+06
64	0.00E+00	0.00E+00	1.00E+00	1.23E+06	2.16E+06	1.70E+06
70	0.00E+00	0.00E+00	1.00E+00	1.07E+06	1.48E+06	1.28E+06
73	0.00E+00	0.00E+00	1.00E+00	1.22E+05	1.17E+06	6.46E+05
76	0.00E+00	0.00E+00	1.00E+00	1.24E+05	1.50E+05	1.37E+05

Table A13. Cell plate counts of *L. plantarum* WCFS1 with the cell free supernatant from *S. cerevisiae* in yogurt at 30°C and 4°C

Days	30C	30C	Avg.	4C	4C	Avg.
0	7.90E+07	4.50E+07	6.20E+07	1.30E+07	3.30E+07	2.30E+07
3	2.11E+08	1.14E+08	1.63E+08	3.00E+07	7.00E+06	1.85E+07
6	6.04E+08	1.18E+08	3.61E+08	1.51E+07	4.35E+06	9.73E+06
10	1.64E+08	9.60E+07	1.30E+08	2.95E+07	1.15E+07	2.05E+07
13	1.07E+08	7.80E+07	9.25E+07	2.80E+07	4.04E+07	3.42E+07
17	5.30E+07	3.30E+07	4.30E+07	1.67E+07	9.40E+06	1.31E+07
20	2.18E+07	1.10E+07	1.64E+07	3.10E+07	2.01E+07	2.56E+07
23	2.90E+06	2.30E+06	2.60E+06	2.53E+07	2.61E+07	2.57E+07
26	2.17E+06	3.90E+06	3.04E+06	2.80E+07	1.44E+07	2.12E+07
29	6.00E+05	8.00E+05	7.00E+05	4.68E+06	1.11E+07	7.89E+06
32	1.00E+00	1.11E+05	1.00E+00	1.93E+07	6.10E+06	1.27E+07
35	1.00E+00	8.00E+03	1.00E+00	1.17E+06	3.60E+06	2.39E+06
40	1.00E+00	1.00E+00	1.00E+00	3.74E+07	2.45E+07	3.10E+07
43	1.00E+00	1.00E+00	1.00E+00	3.51E+06	2.77E+06	3.14E+06
46	1.00E+00	1.00E+00	1.00E+00	9.60E+06	1.07E+07	1.02E+07
49	1.00E+00	1.00E+00	1.00E+00	5.16E+06	2.91E+06	4.04E+06
52	1.00E+00	1.00E+00	1.00E+00	3.18E+06	2.13E+06	2.66E+06
55	1.00E+00	1.00E+00	1.00E+00	4.56E+06	2.30E+06	3.43E+06
58	1.00E+00	1.00E+00	1.00E+00	2.13E+06	2.67E+06	2.40E+06
64	1.00E+00	1.00E+00	1.00E+00	2.57E+06	1.37E+06	1.97E+06
70	1.00E+00	1.00E+00	1.00E+00	1.48E+06	2.63E+06	2.06E+06
73	1.00E+00	1.00E+00	1.00E+00	2.99E+06	1.32E+06	2.15E+06
76	1.00E+00	1.00E+00	1.00E+00	2.88E+06	5.49E+05	1.71E+06

Table A14. Cell plate counts of *L. plantarum* WCFS1 with the cell free supernatant from *W. saturnus* in yogurt at 30°C and 4°C

Days	30C	30C	Avg.	4C	4C	Avg.
0	1.50E+07	4.70E+07	3.10E+07	3.20E+07	2.70E+07	2.95E+07
3	2.24E+08	1.34E+08	1.79E+08	1.40E+07	1.14E+07	1.27E+07
6	1.35E+08	4.09E+08	2.72E+08	9.80E+07	2.25E+07	6.03E+07
10	6.90E+07	1.05E+08	8.70E+07	1.60E+07	1.00E+07	1.30E+07
13	2.24E+08	2.29E+08	2.27E+08	3.39E+07	1.92E+07	2.66E+07
17	5.40E+07	6.10E+07	5.75E+07	5.10E+06	7.00E+06	6.05E+06
20	3.70E+07	3.22E+07	3.46E+07	4.00E+07	2.43E+07	3.22E+07
23	1.80E+06	1.90E+06	1.85E+06	2.40E+07	1.85E+07	2.13E+07
26	9.40E+05	4.50E+06	2.72E+06	2.56E+07	3.05E+07	2.81E+07
29	9.60E+05	1.00E+06	9.80E+05	1.52E+07	1.05E+07	1.29E+07
32	1.00E+00	1.11E+05	1.00E+00	2.29E+07	1.68E+07	1.99E+07
35	1.00E+00	7.00E+03	1.00E+00	3.23E+06	2.41E+07	1.37E+07
40	1.00E+00	0.00E+00	1.00E+00	8.00E+06	1.54E+07	1.17E+07
43	1.00E+00	0.00E+00	1.00E+00	2.42E+07	2.70E+06	1.35E+07
46	1.00E+00	0.00E+00	1.00E+00	8.30E+06	2.68E+06	5.49E+06
49	1.00E+00	0.00E+00	1.00E+00	8.92E+06	7.10E+06	8.01E+06
52	1.00E+00	0.00E+00	1.00E+00	2.90E+06	3.39E+06	3.15E+06
55	1.00E+00	0.00E+00	1.00E+00	2.66E+06	3.12E+06	2.89E+06
58	1.00E+00	0.00E+00	1.00E+00	1.68E+06	2.37E+06	2.03E+06
64	1.00E+00	0.00E+00	1.00E+00	1.59E+06	1.33E+06	1.46E+06
70	1.00E+00	0.00E+00	1.00E+00	1.13E+06	1.15E+06	1.14E+06
73	1.00E+00	0.00E+00	1.00E+00	1.19E+05	1.35E+06	7.34E+05
76	1.00E+00	0.00E+00	1.00E+00	1.36E+05	1.20E+05	1.28E+05

Table A15. Cell plate counts of *L. plantarum* WCFS1 with heat killed *S. cerevisiae* in yogurt at 30°C and 4°C

Days	30C	30C	Avg.	4C	4C	Avg.
0	6.80E+06	1.10E+06	3.95E+06	3.90E+06	2.80E+06	3.35E+06
3	8.70E+07	5.76E+07	7.23E+07	7.10E+06	7.40E+06	7.25E+06
6	2.32E+08	8.49E+07	1.58E+08	6.60E+06	1.53E+06	4.07E+06
11	8.16E+07	7.30E+07	7.73E+07	9.90E+06	7.20E+06	8.55E+06
14	7.14E+07	1.20E+08	9.57E+07	1.37E+07	1.63E+07	1.50E+07
17	9.20E+07	2.19E+08	1.56E+08	7.00E+06	2.07E+06	4.54E+06
20	1.83E+07	1.58E+07	1.71E+07	1.40E+07	2.30E+06	8.15E+06
23	2.88E+07	1.53E+07	2.21E+07	1.42E+06	1.99E+07	1.07E+07
26	5.10E+06	2.20E+06	3.65E+06	1.89E+06	2.46E+06	2.18E+06
29	9.60E+05	7.59E+05	8.60E+05	1.87E+06	1.16E+06	1.51E+06
32	9.00E+05	1.05E+06	9.75E+05	1.89E+06	1.92E+06	1.91E+06
35	0.00E+00	0.00E+00	1.00E+00	1.65E+06	2.22E+06	1.94E+06
41	0.00E+00	0.00E+00	1.00E+00	1.82E+06	2.33E+06	2.08E+06
44	0.00E+00	0.00E+00	1.00E+00	1.11E+06	1.60E+06	1.35E+06
47	0.00E+00	0.00E+00	1.00E+00	1.83E+06	1.59E+06	1.71E+06
50	0.00E+00	0.00E+00	1.00E+00	4.60E+05	1.41E+06	9.35E+05
53	0.00E+00	0.00E+00	1.00E+00	2.06E+06	1.58E+06	1.82E+06
56	0.00E+00	0.00E+00	1.00E+00	2.53E+06	2.44E+06	2.49E+06
59	0.00E+00	0.00E+00	1.00E+00	1.05E+06	1.99E+05	6.24E+05
65	0.00E+00	0.00E+00	1.00E+00	9.69E+05	1.41E+06	1.19E+06
71	0.00E+00	0.00E+00	1.00E+00	1.17E+06	1.49E+06	1.33E+06
74	0.00E+00	0.00E+00	1.00E+00	1.36E+05	2.06E+05	1.71E+05
77	0.00E+00	0.00E+00	1.00E+00	1.58E+05	1.20E+05	1.39E+05

Table A16. Cell plate counts of *L. plantarum* WCFS1 with heat killed *W. saturnus* in yogurt at 30°C and 4°C

Days	30C	30C	Avg.	4C	4C	Avg.
0	2.20E+06	3.60E+06	2.90E+06	2.90E+06	3.40E+06	3.15E+06
3	6.93E+07	9.03E+07	7.98E+07	1.34E+07	4.70E+06	9.05E+06
6	2.89E+08	1.35E+08	2.12E+08	1.10E+07	1.98E+06	6.49E+06
11	5.85E+07	1.07E+08	8.28E+07	2.24E+06	2.52E+06	2.38E+06
14	8.49E+07	9.60E+07	9.05E+07	9.90E+06	8.90E+06	9.40E+06
17	1.25E+08	1.40E+08	1.33E+08	4.40E+06	2.62E+06	3.51E+06
20	1.17E+08	4.50E+07	8.10E+07	6.50E+06	2.19E+06	4.35E+06
23	1.51E+07	1.39E+07	1.45E+07	1.95E+06	1.71E+06	1.83E+06
26	7.20E+06	7.00E+06	7.10E+06	1.53E+06	1.67E+06	1.60E+06
29	7.80E+05	9.30E+05	8.55E+05	1.11E+06	1.17E+06	1.14E+06
32	6.00E+05	3.30E+05	4.65E+05	5.46E+05	1.05E+06	7.98E+05
35	0.00E+00	0.00E+00	1.00E+00	1.09E+06	1.53E+06	1.31E+06
41	0.00E+00	0.00E+00	1.00E+00	2.92E+06	1.53E+06	2.23E+06
44	0.00E+00	0.00E+00	1.00E+00	1.83E+06	5.70E+05	1.20E+06
47	0.00E+00	0.00E+00	1.00E+00	1.11E+06	1.09E+06	1.10E+06
50	0.00E+00	0.00E+00	1.00E+00	1.57E+06	2.11E+06	1.84E+06
53	0.00E+00	0.00E+00	1.00E+00	2.04E+06	1.97E+06	2.01E+06
56	0.00E+00	0.00E+00	1.00E+00	2.27E+06	2.25E+06	2.26E+06
59	0.00E+00	0.00E+00	1.00E+00	2.00E+06	6.99E+04	1.04E+06
65	0.00E+00	0.00E+00	1.00E+00	1.55E+06	5.49E+05	1.05E+06
71	0.00E+00	0.00E+00	1.00E+00	1.02E+06	1.34E+06	1.18E+06
74	0.00E+00	0.00E+00	1.00E+00	1.34E+05	1.18E+05	1.26E+05
77	0.00E+00	0.00E+00	1.00E+00	8.70E+05	1.10E+05	4.90E+05

Table A17. Cell plate counts of *L. plantarum* WCFS1 in yogurt at 30°C over 24 days in triplicate

Day	A	B	C	Avg.
0	2.80E+07	2.30E+07	3.60E+06	1.82E+07
3	4.85E+08	2.97E+08	2.80E+08	3.54E+08
6	1.08E+09	3.69E+08	1.63E+09	1.03E+09
9	4.41E+08	4.80E+08	7.60E+08	5.60E+08
12	1.84E+08	1.18E+09	5.70E+08	6.45E+08
18	5.50E+07	5.00E+07	2.13E+08	1.06E+08
21	7.90E+07	4.00E+07	1.11E+08	7.67E+07
24	9.00E+06	5.50E+06	4.30E+07	1.92E+07

Table A18. Cell plate counts of *L. plantarum* WCFS1 with *W. saturnus* in yogurt at 30°C over 24 days in triplicate

Day	1	2	3	Avg.
0	7.70E+07	3.35E+08	1.86E+08	1.99E+08
3	3.35E+08	6.16E+08	3.56E+08	4.36E+08
6	6.85E+08	7.41E+08	3.04E+08	5.77E+08
9	1.27E+08	8.30E+07	1.27E+08	1.12E+08
12	8.30E+07	1.02E+08	7.80E+07	8.77E+07
18	5.60E+07	5.50E+07	2.70E+07	4.60E+07
21	4.10E+07	3.00E+07	2.10E+07	3.07E+07
24	5.50E+07	6.30E+07	2.90E+07	4.90E+07

Table A19. Cell plate counts of *W. saturnus* (with *L. plantarum* WCFS1) in yogurt at 30°C over 24 days in triplicate

Day	1	2	3	Avg.
0	1.26E+06	5.00E+05	1.04E+06	9.33E+05
3	6.00E+06	1.80E+06	2.20E+06	3.33E+06
6	3.70E+06	2.70E+06	3.10E+06	3.17E+06
9	1.29E+06	3.40E+06	3.70E+06	2.80E+06
12	8.50E+06	3.90E+06	4.10E+06	5.50E+06
18	5.50E+06	3.20E+06	3.70E+06	4.13E+06
21	3.90E+06	4.20E+06	2.30E+06	3.47E+06
24	2.10E+06	4.14E+06	6.24E+06	4.16E+06

APPENDIX B: Raw Data from Chapter 3

Table B20. Averages of raw data from microtiter plate reader experiments for *S. cerevisiae* in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.098667	0.097333	0.098333	0.098667	0.135
0.107	0.1	0.107333	0.105	0.154667
0.12	0.107333	0.112333	0.107333	0.165667
0.143	0.121	0.116667	0.108333	0.172667
0.191333	0.147333	0.124	0.109333	0.178
0.280667	0.192667	0.134	0.109667	0.182
0.387	0.265	0.150667	0.11	0.184667
0.484667	0.357333	0.176333	0.110333	0.187667
0.442	0.446667	0.216	0.110667	0.190333
0.500667	0.521333	0.276	0.110667	0.192333
0.553	0.587667	0.372	0.111	0.193667
0.598333	0.628	0.277	0.110667	0.195
0.633333	0.606667	0.320333	0.110667	0.196333
0.648	0.604333	0.353667	0.111	0.197667
0.651667	0.604333	0.378333	0.111	0.198667
0.653	0.604333	0.366	0.111333	0.199
0.655	0.605	0.363667	0.111	0.200333
0.656333	0.606	0.368	0.111667	0.201
0.660333	0.608	0.377	0.111667	0.201
0.661	0.610333	0.385333	0.111667	0.202
0.663333	0.613333	0.391667	0.112	0.202333
0.665333	0.617333	0.397333	0.112333	0.203
0.668333	0.621667	0.402	0.113333	0.203
0.670667	0.625667	0.404	0.114333	0.203667
0.673667	0.629667	0.404667	0.115333	0.204
0.677	0.634333	0.406	0.117333	0.204333
0.678667	0.637667	0.406667	0.119667	0.204333
0.681667	0.641667	0.407	0.123667	0.204667
0.684	0.645333	0.407	0.129333	0.205
0.687667	0.648667	0.405667	0.136	0.204667
0.689333	0.651667	0.405	0.144667	0.205
0.691667	0.654	0.403333	0.156	0.204667
0.691	0.656333	0.402333	0.17	0.204667
0.692333	0.659	0.400667	0.185667	0.204667
0.694	0.660333	0.398667	0.204	0.205
0.694667	0.663	0.396667	0.225667	0.204
0.696667	0.664667	0.394333	0.246	0.204
0.698333	0.666333	0.392333	0.267	0.204333
0.7	0.668	0.389667	0.287333	0.204

Table B20. Continued

0.700333	0.669667	0.387	0.307667	0.204333
0.700333	0.67	0.385	0.327667	0.204
0.702667	0.671667	0.383667	0.343667	0.203667
0.703	0.673333	0.380333	0.383667	0.202667
0.701667	0.673333	0.379	0.401667	0.202667
0.701667	0.674333	0.376667	0.414	0.202333
0.701333	0.674333	0.375667	0.430667	0.202333
0.702	0.674667	0.374	0.436	0.202
0.701667	0.674667	0.372333	0.429333	0.201667
0.702667	0.674	0.371667	0.436667	0.201333
0.702	0.673667	0.369333	0.446667	0.201
0.701333	0.673	0.368333	0.458667	0.200333
0.702333	0.673	0.367333	0.467	0.200667
0.702	0.672333	0.366	0.471667	0.2
0.702667	0.671667	0.364667	0.469667	0.199333
0.701	0.671	0.363667	0.466	0.199333
0.701333	0.669667	0.362333	0.461667	0.199
0.701	0.668333	0.361333	0.455	0.198333
0.701	0.667333	0.360333	0.451667	0.198333
0.7	0.665333	0.36	0.447	0.197667
0.699333	0.664	0.358333	0.446333	0.197333
0.7	0.662	0.358	0.442667	0.197
0.699	0.660667	0.357	0.437667	0.196667
0.699667	0.658333	0.356	0.434333	0.196
0.699	0.657	0.355	0.434333	0.195667
0.699667	0.654333	0.354333	0.431667	0.195333
0.700333	0.652333	0.353667	0.43	0.195333
0.698667	0.649667	0.352667	0.425	0.194333
0.698667	0.647333	0.351333	0.422333	0.194333
0.699333	0.644667	0.350667	0.423333	0.194
0.699667	0.642333	0.350333	0.422667	0.193667
0.699	0.640333	0.349333	0.421	0.193333
0.699	0.637333	0.348667	0.420667	0.193

Table B21. Standard deviations of averages of raw data from microtiter plate reader experiments for *S. cerevisiae* in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001528	0.003786	0.000577	0.002517	0.001
0.011358	0.004359	0.004041	0.003	0.001528
0.013856	0.005508	0.006028	0.002517	0.003512
0.016823	0.008718	0.006506	0.003512	0.005033
0.019296	0.014224	0.007	0.002517	0.005568
0.025146	0.02318	0.007	0.003512	0.006245
0.01852	0.036592	0.007024	0.003	0.006658
0.036199	0.050639	0.007767	0.003512	0.006658
0.182261	0.061403	0.009644	0.003512	0.006807
0.211519	0.070614	0.016643	0.003512	0.007767
0.242118	0.077848	0.040509	0.003	0.007371
0.270223	0.076374	0.108296	0.003512	0.007
0.291095	0.065577	0.127806	0.003512	0.006807
0.298518	0.067885	0.146729	0.003	0.007371
0.298198	0.067885	0.161868	0.003	0.006429
0.299351	0.067885	0.14575	0.003512	0.007
0.299414	0.068505	0.146729	0.003	0.006658
0.300503	0.069397	0.151812	0.002082	0.007
0.300503	0.069397	0.158038	0.003512	0.007
0.301975	0.069716	0.165292	0.003512	0.007
0.303192	0.071445	0.170218	0.003606	0.006807
0.304024	0.071445	0.173073	0.003786	0.007
0.306585	0.073494	0.175	0.003786	0.007
0.307801	0.074393	0.175787	0.004619	0.007371
0.307801	0.074393	0.17693	0.004726	0.007
0.310682	0.074969	0.177502	0.006028	0.006658
0.312154	0.076121	0.17693	0.007506	0.006658
0.313052	0.076121	0.17565	0.009018	0.006429
0.314204	0.075798	0.173934	0.01106	0.007
0.31478	0.076892	0.173644	0.012767	0.007234
0.315356	0.076892	0.171572	0.015822	0.007
0.318236	0.077156	0.171669	0.019	0.006429
0.318558	0.076631	0.169359	0.023302	0.006429
0.320608	0.076269	0.167429	0.02635	0.006429
0.320354	0.076579	0.165715	0.031765	0.007
0.32093	0.076269	0.165083	0.037873	0.007
0.32176	0.076846	0.163897	0.042297	0.007
0.322336	0.076579	0.16142	0.04979	0.006658

Table B21. Continued

0.321184	0.077117	0.161221	0.057553	0.007
0.321506	0.076846	0.160262	0.064632	0.006658
0.32093	0.075963	0.157233	0.079664	0.006429
0.32183	0.074809	0.153088	0.103016	0.006429
0.32273	0.074809	0.151757	0.111638	0.006658
0.322406	0.074809	0.150998	0.119102	0.006658
0.322082	0.074232	0.149863	0.119804	0.007
0.322658	0.074232	0.148729	0.115578	0.006429
0.32093	0.073655	0.147595	0.131698	0.006658
0.321184	0.073351	0.147028	0.140632	0.006083
0.321506	0.073655	0.145328	0.144791	0.006658
0.319779	0.073655	0.144383	0.143419	0.006429
0.321184	0.073078	0.14401	0.145946	0.006083
0.320032	0.072473	0.142697	0.142977	0.005859
0.321184	0.072753	0.142497	0.139556	0.005859
0.320608	0.07333	0.141931	0.136181	0.006083
0.320354	0.07305	0.140037	0.133132	0.005859
0.319526	0.072176	0.139848	0.130852	0.005859
0.319526	0.072176	0.138337	0.126083	0.005508
0.320678	0.071882	0.137202	0.125285	0.005859
0.320354	0.071882	0.136635	0.123184	0.005292
0.320354	0.071591	0.135691	0.119684	0.005508
0.319203	0.071305	0.134748	0.119266	0.005292
0.320354	0.071021	0.133806	0.118298	0.005508
0.318304	0.071319	0.132855	0.118593	0.004933
0.318051	0.071319	0.132666	0.120117	0.004933
0.318375	0.069888	0.131356	0.115776	0.004933
0.319203	0.070465	0.131728	0.115154	0.004933
0.317982	0.069888	0.130592	0.113245	0.004359
0.317406	0.069616	0.129847	0.113395	0.004726
0.318558	0.06877	0.130024	0.113767	0.004933
0.31766	0.06877	0.12871	0.113958	0.004359

Table B22. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 73 in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.098	0.098	0.098333	0.096	0.151667
0.112667	0.101	0.096667	0.095	0.169667
0.113333	0.098667	0.096	0.095	0.155333
0.111667	0.097667	0.095667	0.094667	0.152333
0.112	0.098333	0.096	0.094667	0.151667
0.111333	0.099	0.096667	0.094667	0.149667
0.114	0.100667	0.097333	0.094667	0.149333
0.116667	0.102667	0.098333	0.095667	0.149
0.119333	0.105	0.098667	0.095667	0.149667
0.123333	0.108333	0.099667	0.095667	0.150333
0.128333	0.112	0.101667	0.096667	0.150333
0.137	0.117	0.102	0.096667	0.151
0.146333	0.122667	0.103667	0.098	0.152
0.160667	0.131333	0.106333	0.098	0.152
0.175667	0.141333	0.108	0.099	0.152667
0.196667	0.154667	0.110333	0.099667	0.153333
0.224667	0.173	0.113	0.100333	0.155333
0.257333	0.195667	0.116333	0.101667	0.156
0.299	0.224	0.120667	0.102333	0.156333
0.346	0.257	0.124	0.102667	0.158
0.399667	0.292333	0.129333	0.104	0.158333
0.453667	0.329667	0.134	0.104667	0.159333
0.506667	0.368667	0.140333	0.106	0.16
0.551	0.402333	0.144667	0.107333	0.161667
0.589	0.429333	0.149333	0.107667	0.162667
0.625	0.455	0.157	0.109333	0.163667
0.655	0.479333	0.165333	0.11	0.164667
0.685333	0.502667	0.173	0.110667	0.165667
0.712667	0.523333	0.184	0.112	0.166667
0.739333	0.545333	0.196333	0.113667	0.167333
0.764	0.565333	0.209	0.115	0.168
0.788	0.582667	0.223	0.116667	0.168667
0.808667	0.597	0.235667	0.117	0.17
0.832333	0.613	0.251333	0.119667	0.171
0.854	0.626	0.263667	0.120667	0.172
0.876667	0.640667	0.278	0.122333	0.172667
0.899333	0.653	0.29	0.124333	0.174
0.920667	0.663667	0.302	0.126333	0.175
0.941667	0.673667	0.312	0.128667	0.176333

Table B22. Continued

0.961667	0.679667	0.322	0.130667	0.177667
0.980333	0.683333	0.332	0.133	0.178333
1.000333	0.686	0.340667	0.136	0.179
1.039333	0.681	0.357667	0.146667	0.181333
1.046333	0.665	0.362	0.152667	0.182
1.051	0.658333	0.367	0.156	0.183333
1.057667	0.650333	0.370333	0.162333	0.183667
1.063667	0.635333	0.373	0.169333	0.185333
1.066	0.615	0.376667	0.175	0.185667
1.068667	0.594	0.377	0.181667	0.186667
1.073	0.565667	0.379	0.191	0.188
1.074667	0.541667	0.386	0.198	0.188667
1.077	0.512	0.386667	0.207	0.189667
1.079333	0.481	0.392	0.217667	0.19
1.060667	0.451667	0.393667	0.228667	0.191333
1.045333	0.423667	0.404	0.242667	0.192
1.016667	0.391	0.412	0.256	0.193333
0.951	0.375667	0.410667	0.271	0.195
0.894333	0.354333	0.427667	0.287	0.195333
0.867667	0.339667	0.435	0.298667	0.196667
0.831667	0.326	0.440333	0.312	0.197333
0.789667	0.315333	0.45	0.318	0.197333
0.713	0.304333	0.45	0.325	0.197667
0.656	0.295333	0.455667	0.331	0.198667
0.619	0.289667	0.464333	0.339667	0.199
0.591333	0.28	0.467667	0.337667	0.2
0.568333	0.272333	0.471667	0.345333	0.199667
0.551333	0.267333	0.477	0.349333	0.200667
0.535333	0.262667	0.481	0.351333	0.201
0.510667	0.258	0.479667	0.352333	0.202333
0.485333	0.256	0.489667	0.360333	0.201667
0.469333	0.253333	0.495667	0.370333	0.202667

Table B23. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 73 in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001732	0.001	0.002082	0.001	0.005508
0.001528	0.004359	0.001528	0.001732	0.010116
0.000577	0.001155	0.001	0.001732	0.008505
0.001155	0.001155	0.001155	0.001155	0.008083
0.001	0.000577	0.001	0.001155	0.008622
0.001528	0.001	0.001155	0.001155	0.008622
0.001	0.001155	0.001528	0.001155	0.008083
0.001528	0.001155	0.001528	0.001155	0.00755
0.000577	0.001	0.001155	0.001155	0.008622
0.000577	0.001528	0.001155	0.001155	0.008505
0.001528	0.001732	0.000577	0.001155	0.009074
0.001	0.002646	0.001732	0.001155	0.008544
0.001155	0.002887	0.001155	0.001	0.008544
0.002082	0.004041	0.001528	0.001	0.008544
0.002887	0.004933	0.001732	0.001	0.009018
0.004041	0.006429	0.001528	0.001155	0.009074
0.006028	0.008888	0.001	0.000577	0.009074
0.011015	0.01124	0.001155	0.001155	0.009539
0.016093	0.014731	0.001528	0.001528	0.010066
0.018083	0.01833	0.001732	0.001155	0.009539
0.021825	0.022189	0.002082	0.001	0.010066
0.02444	0.026102	0.002646	0.001155	0.010066
0.026274	0.031005	0.003786	0.001732	0.009539
0.027404	0.03453	0.004041	0.001528	0.010017
0.028792	0.038214	0.004619	0.001155	0.011015
0.031432	0.040951	0.005292	0.001528	0.011015
0.033151	0.043004	0.006028	0.001	0.011015
0.035105	0.045081	0.007211	0.001528	0.011015
0.036254	0.047014	0.009	0.002	0.012014
0.038553	0.049702	0.009504	0.001528	0.012503
0.03995	0.049521	0.011136	0.001	0.01253
0.041677	0.05116	0.012124	0.001528	0.013051
0.043155	0.051157	0.013577	0.002	0.013528
0.043822	0.051971	0.01464	0.001528	0.013528
0.045211	0.052	0.014189	0.002517	0.013528
0.046608	0.054418	0.012	0.002082	0.014048
0.04818	0.053019	0.01	0.002887	0.014107
0.050143	0.054243	0.009644	0.003055	0.0151

Table B23. Continued

0.051965	0.054427	0.01044	0.003215	0.015177
0.051965	0.054921	0.012124	0.003215	0.015275
0.054372	0.050507	0.017898	0.004583	0.016371
0.054994	0.051971	0.021825	0.005508	0.017214
0.055175	0.056471	0.022113	0.006028	0.017776
0.054745	0.06133	0.022113	0.00755	0.017954
0.056323	0.067471	0.023459	0.008505	0.01893
0.055411	0.075049	0.024021	0.007095	0.019502
0.05656	0.077672	0.024583	0.009165	0.019858
0.054418	0.066573	0.026287	0.010599	0.020648
0.054836	0.066003	0.025159	0.010149	0.020881
0.053687	0.060468	0.024434	0.01179	0.021385
0.053019	0.046508	0.022368	0.014422	0.022234
0.054096	0.038197	0.021932	0.018717	0.022517
0.055609	0.042442	0.024826	0.020429	0.023692
0.064609	0.043547	0.028844	0.020207	0.024331
0.103852	0.036346	0.022869	0.019925	0.025482
0.166502	0.040067	0.028308	0.019925	0.026058
0.23749	0.036501	0.026727	0.019079	0.027429
0.278299	0.03365	0.027785	0.015144	0.028572
0.280001	0.032741	0.026312	0.017349	0.029297
0.25957	0.032332	0.025357	0.004583	0.030238
0.223242	0.034559	0.019925	0.002646	0.030616
0.203664	0.034559	0.022368	0.007211	0.031786
0.201522	0.038214	0.022143	0.013429	0.031953
0.202806	0.039038	0.021221	0.016862	0.031953
0.20204	0.039501	0.01823	0.022279	0.032316
0.199054	0.04055	0.018083	0.023629	0.033081
0.191286	0.041681	0.018735	0.023861	0.032512
0.164807	0.037643	0.016921	0.020257	0.03365
0.132198	0.039395	0.019858	0.021221	0.033081
0.126184	0.042595	0.018771	0.020033	0.033858

Table B24. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 96 in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.093333	0.091333	0.092667	0.091333	0.125
0.112667	0.093333	0.105333	0.091667	0.123333
0.12	0.092333	0.112	0.091667	0.120667
0.123	0.092333	0.116333	0.091667	0.119667
0.125667	0.093667	0.120333	0.092	0.119333
0.127667	0.095333	0.122333	0.092	0.117667
0.128667	0.095333	0.124333	0.092333	0.117
0.129333	0.097	0.125333	0.092333	0.117
0.129667	0.098667	0.126333	0.092333	0.117
0.128667	0.1	0.126667	0.092667	0.117667
0.127	0.102333	0.127667	0.092667	0.118
0.129	0.105	0.127333	0.092333	0.118667
0.141	0.109	0.127667	0.092667	0.119333
0.153	0.114333	0.128	0.093	0.119667
0.166333	0.120667	0.128	0.093	0.120667
0.181333	0.129667	0.127667	0.093333	0.121
0.198667	0.138667	0.127667	0.093333	0.123
0.214	0.152333	0.127	0.094	0.123667
0.226667	0.171	0.127	0.093333	0.124667
0.237333	0.192333	0.126667	0.093667	0.126
0.238333	0.218333	0.125667	0.094	0.127
0.240667	0.249667	0.125333	0.093667	0.128667
0.234667	0.286	0.125	0.094333	0.13
0.221333	0.323333	0.124667	0.094333	0.131333
0.207667	0.361667	0.123333	0.094	0.133
0.197667	0.401667	0.120333	0.094667	0.134667
0.191667	0.441	0.117333	0.094333	0.136333
0.180667	0.474	0.119	0.094667	0.138
0.176333	0.506	0.122333	0.095	0.139
0.173667	0.529667	0.125667	0.095667	0.140667
0.176	0.543	0.129667	0.095667	0.141667
0.181667	0.557667	0.134333	0.096	0.142667
0.194667	0.561667	0.140333	0.095667	0.144
0.205333	0.570667	0.146	0.095667	0.145667
0.209333	0.572667	0.153667	0.095667	0.146333
0.218333	0.575	0.161667	0.096333	0.147333
0.224667	0.567	0.169667	0.096333	0.148333
0.235	0.554333	0.178	0.096333	0.148667
0.240333	0.547333	0.188667	0.096667	0.149667

Table B24. Continued

0.252333	0.535	0.199	0.096667	0.150667
0.258667	0.524667	0.209333	0.097333	0.151333
0.261667	0.518	0.218333	0.097333	0.151667
0.263667	0.493	0.237333	0.097333	0.153667
0.272667	0.477667	0.234	0.097333	0.154333
0.274333	0.473	0.233	0.097333	0.155667
0.276	0.466	0.230667	0.098	0.156
0.282667	0.454	0.228333	0.098333	0.157
0.279333	0.443333	0.218667	0.098667	0.157
0.285333	0.433333	0.218667	0.098667	0.157333
0.282667	0.423	0.219	0.098667	0.158333
0.278667	0.418	0.218333	0.099	0.158333
0.279667	0.413	0.222667	0.099333	0.158333
0.286667	0.408	0.224	0.099333	0.159333
0.286667	0.402667	0.229667	0.099667	0.16
0.297667	0.392667	0.230667	0.099667	0.160667
0.316	0.382	0.233667	0.1	0.161
0.319333	0.373	0.236667	0.1	0.161333
0.337	0.366	0.242333	0.100667	0.162
0.343667	0.355	0.241667	0.100667	0.162667
0.354333	0.350667	0.247	0.100667	0.163333
0.363333	0.344333	0.249667	0.100667	0.163667
0.372333	0.336	0.255667	0.101667	0.163667
0.383	0.327	0.253667	0.101333	0.165
0.392667	0.323333	0.262667	0.101667	0.166
0.403	0.315667	0.256	0.102333	0.166667
0.411333	0.31	0.258333	0.102333	0.167
0.419667	0.308	0.260667	0.102667	0.167667
0.422333	0.304	0.263667	0.102667	0.169
0.419667	0.297333	0.258	0.102	0.169667
0.429333	0.297333	0.256	0.103667	0.170667
0.435333	0.299	0.254667	0.103333	0.171667

Table B25. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 96 in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.000577	0.001155	0.002082	0.000577	0.002
0.026274	0.001155	0.023965	0.000577	0.003215
0.039	0.001528	0.035511	0.000577	0.003786
0.045902	0.001528	0.043016	0.000577	0.003055
0.048789	0.002082	0.048211	0.001	0.002517
0.048789	0.001155	0.051675	0.001	0.002517
0.046199	0.001528	0.05428	0.001155	0.002
0.040427	0.001732	0.056012	0.001155	0.002
0.032347	0.001155	0.056871	0.001155	0.002
0.019399	0.002646	0.057449	0.000577	0.002517
0.002646	0.002517	0.057449	0.001528	0.002646
0.014177	0.002646	0.056012	0.001155	0.002517
0.020421	0.003606	0.054857	0.000577	0.003055
0.026458	0.004163	0.054562	0.001	0.002517
0.032884	0.004726	0.05283	0.001	0.002517
0.040821	0.004619	0.051394	0.001155	0.002646
0.051984	0.007638	0.048789	0.001155	0.002646
0.06077	0.010066	0.045924	0.001	0.003215
0.068537	0.012767	0.043313	0.001155	0.003215
0.077022	0.017243	0.041004	0.001528	0.003464
0.080308	0.02248	0.037541	0.001	0.003464
0.083429	0.026951	0.033501	0.001528	0.004041
0.077468	0.033422	0.029462	0.001155	0.003464
0.069816	0.038553	0.025423	0.001155	0.003786
0.060748	0.042712	0.019655	0.001	0.004359
0.051791	0.047721	0.011846	0.001528	0.004163
0.043432	0.054286	0.002517	0.001155	0.004726
0.03479	0.059808	0.001	0.001528	0.005292
0.031565	0.064861	0.001528	0.001732	0.005292
0.030288	0.066425	0.001528	0.001528	0.005859
0.033719	0.071021	0.002517	0.001528	0.005859
0.018037	0.075798	0.003786	0.001732	0.005859
0.01159	0.076291	0.005508	0.001528	0.006245
0.011504	0.078704	0.008185	0.001528	0.006807
0.015373	0.083152	0.010066	0.001528	0.007371
0.017039	0.089202	0.012662	0.002082	0.007371
0.021127	0.102235	0.016042	0.002082	0.007371
0.015395	0.115214	0.018	0.002082	0.007767

Table B25. Continued

0.010017	0.121397	0.020033	0.001528	0.007767
0.017388	0.121211	0.022517	0.001528	0.008505
0.018717	0.116863	0.022053	0.002082	0.008737
0.018583	0.120785	0.026102	0.002082	0.008327
0.021455	0.122202	0.024583	0.002517	0.008888
0.019655	0.122094	0.018717	0.002082	0.008737
0.023692	0.109473	0.012288	0.002082	0.009292
0.022368	0.101946	0.008544	0.002082	0.009713
0.018028	0.097155	0.008083	0.002646	0.010149
0.024194	0.091995	0.008083	0.002082	0.010149
0.02203	0.081249	0.009609	0.002517	0.011136
0.033946	0.076265	0.012702	0.002517	0.010599
0.032593	0.068637	0.014731	0.002517	0.01159
0.034034	0.065552	0.013868	0.003	0.01159
0.037421	0.066091	0.014503	0.003055	0.01159
0.039879	0.062554	0.013	0.003055	0.01159
0.044859	0.059869	0.009074	0.003512	0.01253
0.056146	0.05551	0.008622	0.003512	0.013051
0.07184	0.048125	0.011676	0.002646	0.013528
0.07257	0.042036	0.006658	0.003	0.014012
0.072395	0.041146	0.006506	0.003512	0.014526
0.070493	0.038354	0.00611	0.003512	0.015503
0.071066	0.037314	0.001	0.003512	0.015503
0.068296	0.034819	0.008386	0.003512	0.01701
0.066531	0.034699	0.013577	0.003512	0.01701
0.064552	0.033061	0.010116	0.004041	0.017521
0.066576	0.029956	0.011372	0.003512	0.020075
0.066551	0.028184	0.016093	0.004041	0.020133
0.070812	0.024331	0.020133	0.004509	0.021656
0.072707	0.018358	0.018502	0.004509	0.021733
0.071668	0.017692	0.026006	0.004509	0.023259
0.069292	0.018009	0.021517	0.003606	0.024338
0.073799	0.019502	0.023643	0.004509	0.025968
0.073201	0.021166	0.026006	0.005132	0.026312

Table B26. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 216 in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.107333	0.099667	0.098667	0.094333	0.12
0.119	0.103333	0.101667	0.094667	0.130333
0.124333	0.105667	0.102667	0.096	0.134
0.129333	0.107667	0.103	0.095333	0.135667
0.136667	0.111	0.104333	0.097	0.137667
0.146	0.115667	0.106	0.096667	0.138333
0.158667	0.123333	0.107333	0.096667	0.139333
0.182667	0.133333	0.109667	0.097333	0.140667
0.212667	0.147667	0.112667	0.097667	0.142333
0.245333	0.167	0.115667	0.097667	0.143667
0.278333	0.193	0.120667	0.099	0.146
0.304	0.224333	0.125667	0.098333	0.147667
0.322333	0.258	0.133333	0.099667	0.149333
0.349	0.294333	0.142667	0.100333	0.151333
0.391333	0.326333	0.154	0.101	0.153667
0.432667	0.355333	0.168	0.102	0.155333
0.467333	0.377667	0.185333	0.103667	0.158
0.489333	0.402333	0.207	0.104667	0.159667
0.498333	0.417333	0.230333	0.107	0.161333
0.511333	0.435667	0.256333	0.107667	0.163667
0.527	0.455	0.282	0.109333	0.166
0.530667	0.460667	0.308333	0.111667	0.168333
0.538667	0.470667	0.333667	0.114333	0.171
0.543667	0.477667	0.356333	0.117	0.173667
0.551333	0.486667	0.372667	0.119667	0.176
0.558	0.491333	0.387333	0.124	0.18
0.568333	0.495333	0.403333	0.127333	0.182667
0.575667	0.499333	0.411667	0.131333	0.186667
0.586	0.504	0.420667	0.136667	0.189667
0.596667	0.513	0.429	0.142667	0.193
0.604333	0.519667	0.436333	0.149667	0.196333
0.605333	0.526667	0.444333	0.157333	0.2
0.609	0.531	0.453	0.166	0.204
0.628667	0.541333	0.459	0.176333	0.208333
0.636	0.549	0.464667	0.188667	0.212333
0.649667	0.560667	0.472333	0.203667	0.216
0.655	0.570667	0.478667	0.219333	0.220667
0.663667	0.582333	0.485	0.236333	0.225667
0.673	0.594333	0.495333	0.255667	0.23

Table B26. Continued

0.683	0.605333	0.503333	0.276667	0.235333
0.677333	0.614333	0.510667	0.295333	0.240333
0.679667	0.627	0.522	0.318333	0.245333
0.675667	0.636667	0.531667	0.336	0.25
0.67	0.646667	0.541667	0.352667	0.256
0.662	0.656	0.553	0.371667	0.261333
0.661	0.665	0.564333	0.39	0.266333
0.661	0.674333	0.574333	0.400333	0.272
0.661333	0.68	0.587333	0.417	0.277667
0.662	0.684667	0.598	0.433333	0.283333
0.660667	0.688333	0.609667	0.443	0.290333
0.66	0.687	0.621	0.450333	0.294667
0.658	0.69	0.632	0.457333	0.299333
0.657333	0.690333	0.642333	0.459667	0.302667
0.657333	0.690333	0.653	0.464333	0.308333
0.658	0.691333	0.662667	0.468667	0.311333
0.657	0.692333	0.673	0.474667	0.315667
0.658667	0.693333	0.684	0.48	0.320667
0.662333	0.695	0.693667	0.485333	0.324333
0.664667	0.696333	0.703333	0.492	0.329
0.669333	0.697	0.712	0.496	0.332667
0.672667	0.696667	0.719	0.500667	0.337333
0.673	0.699667	0.726333	0.506667	0.341
0.674667	0.699667	0.732667	0.514667	0.344667
0.677667	0.701333	0.736333	0.517	0.348
0.675333	0.700333	0.74	0.524	0.350667
0.682	0.702333	0.744	0.529333	0.353
0.683	0.703	0.746667	0.536333	0.355667
0.686333	0.704333	0.749333	0.541667	0.358667
0.694	0.707	0.753667	0.550333	0.360667
0.694667	0.707	0.755333	0.557	0.363333
0.691667	0.71	0.758	0.565333	0.365333
0.697667	0.711333	0.760667	0.574333	0.366667
0.7	0.713667	0.762667	0.582667	0.370333

Table B27. Standard deviation of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 216 in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001528	0.000577	0.000577	0.000577	0.004
0.01044	0.000577	0.000577	0.000577	0.005033
0.015308	0.000577	0.000577	1.7E-17	0.005
0.016197	0.000577	0.001	0.000577	0.004509
0.015044	0.001	0.001155	0.001	0.004509
0.008718	0.001155	0.001	0.001155	0.005033
0.001155	0.001528	0.001155	0.000577	0.005033
0.005859	0.001528	0.001528	0.000577	0.004509
0.010116	0.002082	0.001528	0.001155	0.005033
0.015948	0.002	0.001528	0.000577	0.005508
0.022942	0.002646	0.001528	0.001	0.005568
0.028931	0.002082	0.001528	0.000577	0.005508
0.026652	0.002646	0.001528	0.000577	0.006028
0.020664	0.002082	0.001528	0.000577	0.006028
0.012503	0.000577	0.002	0.001	0.00611
0.043466	0.001155	0.002	0.001	0.006028
0.064825	0.004163	0.001528	0.000577	0.006557
0.068413	0.003215	0.001	0.000577	0.007095
0.057977	0.005033	0.000577	0.001	0.006658
0.050954	0.005132	0.000577	0.001528	0.007767
0.05009	0.00755	0.002	0.001155	0.007937
0.046918	0.005033	0.001528	0.001528	0.008327
0.045633	0.008622	0.001528	0.001528	0.008718
0.044837	0.01193	0.000577	0.002	0.009292
0.045742	0.009866	0.000577	0.002517	0.009539
0.04668	0.010066	0.003786	0.002	0.010392
0.048645	0.012662	0.004726	0.003055	0.011015
0.055896	0.010504	0.001155	0.004041	0.01193
0.063553	0.009165	0.005859	0.004509	0.012858
0.068061	0.010392	0.003	0.005508	0.014177
0.072542	0.010017	0.00611	0.006506	0.015535
0.059878	0.01159	0.007572	0.008021	0.016371
0.050388	0.010149	0.00781	0.009539	0.01833
0.071515	0.010504	0.009644	0.01159	0.020133
0.068724	0.012	0.007234	0.014048	0.022121
0.066531	0.011719	0.004933	0.017039	0.024062
0.065046	0.014572	0.004619	0.019009	0.026026
0.063516	0.017616	0.002646	0.022008	0.028501

Table B27. Continued

0.062386	0.016258	0.003055	0.023029	0.031
0.062746	0.015631	0.001528	0.024502	0.033501
0.063516	0.016093	0	0.024111	0.039552
0.059341	0.015503	0.001155	0.024637	0.041581
0.054065	0.016258	0.003512	0.020526	0.045133
0.04564	0.015133	0.004583	0.019296	0.047648
0.040632	0.015524	0.008327	0.020952	0.050639
0.043555	0.015011	0.006028	0.017214	0.054249
0.043753	0.015524	0.008327	0.012166	0.056146
0.044193	0.014189	0.008185	0.007638	0.058757
0.041405	0.015948	0.007767	0.002646	0.063319
0.043555	0.013748	0.007211	0.003055	0.06426
0.043863	0.014107	0.007937	0.005859	0.064733
0.042477	0.012342	0.008327	0.012503	0.066252
0.043753	0.010693	0.007211	0.017098	0.065607
0.044933	0.010693	0.006658	0.022143	0.067159
0.049244	0.010693	0.007	0.027209	0.068245
0.047899	0.009713	0.007	0.034699	0.069673
0.054123	0.010583	0.007572	0.041284	0.069716
0.053003	0.010408	0.007371	0.046861	0.07076
0.057492	0.009539	0.006928	0.053731	0.071808
0.061232	0.009609	0.007211	0.057501	0.071863
0.060308	0.009074	0.005508	0.059349	0.072333
0.056607	0.007638	0.006028	0.065432	0.072803
0.061436	0.008083	0.004933	0.06691	0.071924
0.052205	0.009074	0.005292	0.068637	0.071396
0.060308	0.007506	0.006557	0.071122	0.071526
0.059573	0.008	0.005033	0.071234	0.070401
0.063011	0.009074	0.00611	0.07365	0.06901
0.065818	0.006	0.005132	0.072954	0.068017
0.066726	0.006	0.005686	0.075147	0.068091
0.062613	0.006557	0.006245	0.079286	0.066493
0.064532	0.005508	0.005132	0.079286	0.064663
0.06463	0.005774	0.006658	0.080525	0.06376

Table B28. Averages of raw data from microtiter plate reader experiments for *Z. rouxii* in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.132333	0.129	0.127	0.112333	0.113
0.145667	0.131667	0.129333	0.118667	0.116667
0.143667	0.133	0.129667	0.118667	0.116667
0.156667	0.133667	0.129667	0.118333	0.116
0.183333	0.136	0.13	0.118	0.115667
0.217667	0.139	0.130333	0.118	0.115333
0.261	0.142333	0.13	0.118	0.115
0.311333	0.146	0.130333	0.118	0.114667
0.363333	0.151	0.130333	0.118	0.114667
0.417	0.156667	0.130667	0.118	0.114667
0.464333	0.162667	0.131333	0.118	0.114667
0.508667	0.170333	0.131333	0.118	0.114667
0.551667	0.179333	0.131667	0.118	0.114667
0.59	0.188667	0.132333	0.118	0.114667
0.627	0.2	0.132333	0.118	0.114667
0.659667	0.211667	0.132667	0.118	0.114333
0.692667	0.221667	0.133333	0.118	0.114667
0.721667	0.238	0.134	0.118333	0.115333
0.748333	0.251667	0.134333	0.118333	0.115
0.776	0.272667	0.135	0.118	0.115
0.801	0.306333	0.136	0.118667	0.115333
0.817	0.338333	0.136333	0.118667	0.115667
0.836333	0.382333	0.137667	0.119	0.116333
0.851333	0.415	0.138667	0.118667	0.115667
0.869667	0.455333	0.139333	0.118667	0.116333
0.885667	0.479333	0.141	0.118667	0.116
0.893667	0.501667	0.142	0.119	0.116333
0.905333	0.514	0.144	0.119333	0.116333
0.912333	0.525667	0.145333	0.119667	0.116333
0.923	0.532667	0.147333	0.119667	0.117
0.926667	0.521667	0.148333	0.119667	0.117
0.928667	0.519333	0.15	0.12	0.117333
0.933	0.521667	0.152333	0.119667	0.117333
0.934667	0.509667	0.155333	0.12	0.117333
0.936333	0.514667	0.157	0.120333	0.117333
0.935667	0.514	0.158333	0.120333	0.117333
0.935333	0.507	0.16	0.120667	0.117333
0.934667	0.504333	0.163	0.120333	0.117333
0.932333	0.494667	0.166	0.120333	0.117333

Table B28. Continued

0.931667	0.487667	0.170333	0.120667	0.117667
0.931333	0.490333	0.173333	0.120667	0.118333
0.928	0.490667	0.175667	0.120667	0.118
0.923333	0.491333	0.181	0.121	0.118
0.921333	0.499667	0.184	0.121	0.118333
0.916	0.498667	0.189	0.121	0.118
0.910333	0.487333	0.194	0.121	0.118333
0.906	0.489333	0.202333	0.121667	0.118333
0.893333	0.485333	0.205667	0.121	0.118333
0.885667	0.487333	0.209667	0.121333	0.118333
0.878667	0.498667	0.218667	0.121	0.118333
0.871333	0.494	0.225667	0.121333	0.118333
0.864667	0.486	0.232	0.121333	0.118333
0.853667	0.483	0.239	0.121	0.118333
0.845	0.482667	0.254667	0.121333	0.118333
0.834	0.487667	0.264667	0.121333	0.118333
0.822	0.488667	0.274667	0.121333	0.118333
0.803667	0.484	0.283	0.121333	0.118333
0.794667	0.478	0.294	0.121333	0.118667
0.783	0.476333	0.314667	0.121667	0.118667
0.776	0.467	0.324333	0.121667	0.118667
0.77	0.467	0.335333	0.121333	0.118333
0.761	0.483	0.35	0.121333	0.118333
0.754	0.471333	0.366333	0.121333	0.119
0.745	0.469667	0.37	0.121333	0.119
0.724333	0.470333	0.389667	0.121667	0.118667
0.706667	0.471667	0.396	0.121667	0.118333
0.684333	0.474333	0.402333	0.121333	0.118667
0.665	0.467	0.411333	0.121667	0.118333
0.638667	0.462667	0.421333	0.121	0.118333
0.623	0.459	0.426667	0.121333	0.118667
0.593667	0.467333	0.436667	0.121667	0.119333
0.562333	0.462667	0.447667	0.121333	0.118333
0.540667	0.471333	0.448667	0.121667	0.118667

Table B29. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. rouxii* in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.008145	0.001	0.001	0.002082	0.001732
0.010504	0.002517	0.002309	0.001155	0.000577
0.007638	0.002	0.002887	0.001155	0.000577
0.007234	0.002517	0.003786	0.001528	0.001
0.009609	0.003	0.003464	0.001	0.000577
0.015308	0.003	0.004041	0.001	0.001155
0.027404	0.003055	0.003464	0.001	0.001
0.043684	0.003	0.004041	0.001	0.000577
0.062963	0.003	0.004041	0.001	0.000577
0.082177	0.003512	0.003786	0.001	0.000577
0.101298	0.003512	0.004041	0.001	0.000577
0.119182	0.003055	0.004041	0.001	0.000577
0.134894	0.002887	0.003786	0.001	0.000577
0.149452	0.003215	0.003215	0.001	0.000577
0.159772	0.001732	0.004041	0.001	0.000577
0.170177	0.003512	0.003786	0.001	0.001155
0.178001	0.004041	0.003215	0.001	0.000577
0.183849	0.006	0.003464	0.001528	0.001155
0.186688	0.005686	0.003215	0.001528	0.001
0.192829	0.01159	0.003606	0.001	0.001
0.200651	0.01193	0.003606	0.001528	0.001155
0.203044	0.010214	0.003215	0.001528	0.000577
0.210324	0.010017	0.003055	0.001	0.001155
0.216181	0.021284	0.003055	0.001528	0.000577
0.218893	0.020429	0.003512	0.001528	0.001155
0.217571	0.022301	0.003	0.001528	0.001
0.221848	0.024007	0.003	0.001	0.001155
0.227601	0.033045	0.003	0.001528	0.001155
0.230877	0.03782	0.003055	0.001528	0.001155
0.231145	0.044298	0.003055	0.001528	0.001
0.234913	0.052729	0.003055	0.001528	0.001
0.237877	0.050954	0.003	0.001	0.001155
0.240932	0.059366	0.003786	0.001528	0.001155
0.245133	0.071738	0.003786	0.002	0.001155
0.248689	0.074628	0.003464	0.001528	0.001155
0.248065	0.067978	0.004041	0.001528	0.001155
0.249963	0.061262	0.003464	0.001528	0.001155
0.251669	0.048387	0.003606	0.001528	0.001155

Table B29. Continued

0.251915	0.046307	0.005292	0.001528	0.001155
0.250999	0.045369	0.005132	0.001528	0.001528
0.250078	0.043776	0.003512	0.001528	0.001
0.248898	0.039552	0.007	0.002	0.001
0.249584	0.034501	0.008888	0.002	0.001155
0.248574	0.038527	0.013	0.002	0.001
0.247148	0.032332	0.017349	0.002	0.001155
0.245379	0.038527	0.019732	0.001528	0.001155
0.244978	0.037581	0.017786	0.002	0.001155
0.245017	0.033005	0.028885	0.002082	0.001155
0.247011	0.033005	0.034933	0.002	0.001155
0.243019	0.028618	0.03213	0.002082	0.001155
0.244933	0.027	0.032696	0.002082	0.001155
0.247658	0.029309	0.040841	0.002	0.001155
0.250126	0.030827	0.044859	0.002082	0.001155
0.252846	0.024786	0.056518	0.002082	0.001155
0.256766	0.032146	0.060871	0.002082	0.001155
0.268519	0.034044	0.065962	0.002082	0.001155
0.271399	0.029309	0.07015	0.002082	0.001528
0.276051	0.025658	0.079198	0.002517	0.001528
0.281235	0.021932	0.082984	0.002517	0.001528
0.285154	0.024434	0.081819	0.002082	0.001155
0.291902	0.023431	0.089404	0.002082	0.001155
0.291851	0.027099	0.093607	0.002082	0.001732
0.291012	0.03296	0.083211	0.002082	0.001732
0.274504	0.027006	0.093725	0.002517	0.001528
0.263381	0.035698	0.086029	0.002517	0.001155
0.246281	0.03139	0.077022	0.002082	0.001528
0.232858	0.030447	0.073009	0.002517	0.001155
0.202574	0.032868	0.067122	0.002646	0.001155
0.187305	0.032419	0.064733	0.002082	0.001528
0.153644	0.033561	0.057951	0.002517	0.001155
0.115855	0.036638	0.053613	0.002082	0.001155
0.088822	0.042028	0.055582	0.002517	0.001528

Table B23. Averages of raw data from microtiter plate reader experiments for *Z. bailii* 159 in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.125	0.121667	0.121333	0.110333	0.110333
0.143	0.127667	0.125333	0.115667	0.115333
0.137	0.128667	0.125	0.115333	0.114333
0.15	0.13	0.125	0.115	0.114
0.174333	0.133	0.125333	0.114	0.114667
0.204333	0.135667	0.125333	0.115	0.115333
0.240333	0.138	0.125333	0.114667	0.114667
0.277333	0.141	0.125333	0.114333	0.114333
0.316333	0.143667	0.126	0.114333	0.114667
0.355	0.146	0.126333	0.114	0.113
0.390333	0.148333	0.126333	0.114	0.113333
0.425667	0.150667	0.126667	0.114667	0.114667
0.463	0.153667	0.126667	0.114333	0.113667
0.499	0.156	0.127333	0.114667	0.114333
0.531667	0.159	0.128	0.115	0.114
0.561333	0.162	0.128667	0.114667	0.114667
0.590667	0.167333	0.131333	0.114667	0.114667
0.618333	0.172667	0.134	0.115	0.114667
0.641333	0.178	0.136667	0.115	0.114667
0.67	0.189667	0.144	0.115	0.113667
0.691	0.218333	0.155333	0.115333	0.114
0.708667	0.245	0.170667	0.115667	0.114
0.732333	0.271	0.192	0.116	0.115667
0.750333	0.302	0.219667	0.116333	0.115333
0.763667	0.337333	0.262	0.116667	0.115
0.782333	0.373	0.309333	0.116333	0.114667
0.794667	0.402333	0.359333	0.117	0.115
0.807333	0.439	0.423667	0.117	0.115333
0.823	0.474	0.476667	0.117	0.116
0.836	0.499667	0.537	0.117333	0.115667
0.851667	0.521	0.578	0.117667	0.116333
0.864	0.542333	0.618333	0.118	0.117
0.874333	0.549667	0.640333	0.118	0.116667
0.88	0.549333	0.657667	0.118	0.116
0.889333	0.554	0.672667	0.118333	0.116333
0.897333	0.558	0.675333	0.118	0.116333
0.906333	0.567	0.672667	0.118667	0.116333
0.911	0.568333	0.681333	0.118333	0.116
0.918333	0.573667	0.682667	0.118667	0.117333

Table B30. Continued

0.929333	0.585667	0.696	0.119	0.117
0.936333	0.584	0.692333	0.118667	0.117
0.943333	0.594333	0.707333	0.119	0.116667
0.948333	0.592667	0.711333	0.119667	0.117
0.954667	0.609333	0.721	0.119333	0.117
0.954	0.606333	0.722333	0.119333	0.116667
0.961667	0.608	0.721333	0.119667	0.117333
0.963667	0.607	0.718333	0.119333	0.118333
0.967333	0.607333	0.709	0.12	0.117333
0.970333	0.604667	0.706333	0.12	0.117333
0.971667	0.611667	0.698333	0.119667	0.117667
0.972	0.617333	0.696	0.119667	0.117333
0.971667	0.615333	0.675	0.12	0.117333
0.971333	0.612667	0.652333	0.119667	0.117
0.971	0.618	0.633	0.119333	0.117667
0.970333	0.616667	0.604	0.12	0.118
0.971	0.621667	0.581667	0.119333	0.118
0.971	0.624333	0.555	0.119333	0.117333
0.969333	0.614667	0.527333	0.12	0.117667
0.970667	0.613	0.501333	0.119667	0.117667
0.97	0.618333	0.482667	0.120333	0.119
0.969333	0.616333	0.466667	0.12	0.119
0.969	0.624667	0.452	0.120333	0.119333
0.968333	0.623667	0.437	0.12	0.118667
0.967333	0.625	0.419333	0.120667	0.118667
0.965667	0.626667	0.409	0.12	0.118333
0.965	0.617667	0.399	0.12	0.118333
0.965	0.622333	0.387	0.120667	0.118
0.962667	0.615	0.381	0.12	0.119
0.961667	0.616	0.37	0.12	0.118
0.961	0.610667	0.359667	0.12	0.119
0.958333	0.613333	0.355333	0.120333	0.118667
0.957667	0.620667	0.354667	0.12	0.119
0.955333	0.629667	0.353667	0.120667	0.119667

Table B31. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. bailii* 159 in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.008544	0.001528	0.000577	0.001528	0.002517
0.010817	0.002517	0.001155	0.002309	0.001155
0.006557	0.002517	0.001732	0.001155	0.002082
0.007	0.002	0.001	0.001732	0.002
0.007638	0.002	0.001155	0.001732	0.001528
0.010017	0.001528	0.001155	0.001732	0.001155
0.014224	0.001732	0.001155	0.001528	0.001528
0.020207	0.001	0.001155	0.002082	0.001155
0.025482	0.001528	0.001732	0.002082	0.001528
0.032357	0.001	0.001155	0.001732	0.002
0.039879	0.001155	0.001155	0.001732	0.000577
0.048014	0.000577	0.001528	0.001528	0.001528
0.057088	0.000577	0.001528	0.001155	0.001155
0.066144	0	0.002082	0.001528	0.001155
0.074299	0.001	0.001732	0.001732	0.001
0.083578	0.002646	0.002517	0.001528	0.001528
0.089718	0.005132	0.003512	0.001528	0.001528
0.094786	0.007371	0.005568	0.001732	0.001528
0.100724	0.010583	0.005508	0.001732	0.001155
0.10143	0.014189	0.009539	0.001732	0.001155
0.108296	0.030436	0.01601	0.001155	0.002
0.120101	0.037323	0.021548	0.001528	0.002
0.117006	0.048073	0.029	0.001732	0.001528
0.123087	0.055326	0.040067	0.002082	0.001528
0.134575	0.06704	0.046033	0.002517	0.002
0.13415	0.079051	0.065516	0.002082	0.001528
0.14311	0.090257	0.06704	0.001732	0.002
0.14609	0.091537	0.072707	0.001732	0.001528
0.142313	0.083648	0.06901	0.002646	0.002
0.146809	0.075434	0.056507	0.002887	0.001528
0.14311	0.056824	0.047508	0.002309	0.001528
0.146666	0.041199	0.02616	0.002646	0.001
0.149614	0.028024	0.010786	0.002646	0.001155
0.15883	0.029569	0.01464	0.002646	0.002
0.16088	0.019157	0.015567	0.002887	0.001528
0.162608	0.007	0.024583	0.002646	0.001528
0.15992	0.026514	0.02829	0.003215	0.001528
0.165629	0.021502	0.028148	0.002082	0.002

Table B31. Continued

0.165053	0.036295	0.024786	0.002309	0.001528
0.158083	0.035105	0.025981	0.002646	0.002
0.154623	0.045545	0.01701	0.002646	0.002082
0.152893	0.050846	0.021962	0.002309	0.002
0.151428	0.068369	0.026287	0.002887	0.002
0.15866	0.072266	0.019348	0.002887	0.002082
0.15054	0.081902	0.030746	0.002309	0.001528
0.152271	0.082274	0.031786	0.002082	0.001155
0.1485	0.089985	0.032187	0.002646	0.001528
0.146732	0.097007	0.036692	0.002646	0.001528
0.145308	0.103549	0.037634	0.002309	0.002082
0.142965	0.116749	0.039357	0.002309	0.001528
0.14008	0.126342	0.041761	0.002646	0.001528
0.137195	0.128461	0.047078	0.002309	0.002
0.134309	0.1348	0.058506	0.002082	0.002082
0.13112	0.134794	0.058207	0.002646	0.002
0.128234	0.139005	0.067099	0.002082	0.002
0.125654	0.143235	0.066813	0.002082	0.001528
0.123346	0.141033	0.065684	0.002646	0.002082
0.120155	0.141989	0.071808	0.002517	0.002082
0.116966	0.149323	0.059011	0.002082	0.001
0.114657	0.153461	0.053818	0.002	0.001732
0.112623	0.162439	0.060622	0.002887	0.002082
0.111168	0.157637	0.05866	0.002	0.001155
0.109436	0.154793	0.053613	0.002309	0.001155
0.108841	0.154872	0.060399	0.002	0.001528
0.107392	0.141938	0.056454	0.002	0.001528
0.10566	0.150736	0.056719	0.002309	0.002
0.105368	0.144503	0.05656	0.002	0.001732
0.102768	0.141743	0.058284	0.002	0.001732
0.103058	0.14008	0.054885	0.002	0.001
0.105078	0.1345	0.059543	0.002082	0.001155
0.105368	0.135593	0.053985	0.002	0.001
0.107686	0.135964	0.059231	0.002309	0.001528

Table B32. Averages of raw data from microtiter plate reader experiments for *Z. bailii* 158 in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.187	0.168	0.166667	0.207667	0.158667
0.177667	0.187667	0.172667	0.194667	0.16
0.2	0.183	0.177333	0.186	0.158
0.256333	0.205	0.186667	0.188	0.157667
0.349	0.245	0.205333	0.192667	0.159667
0.485	0.300333	0.229	0.199333	0.162667
0.612333	0.365333	0.258333	0.206333	0.165333
0.719333	0.439333	0.291333	0.215	0.168333
0.776667	0.505333	0.327	0.226	0.171667
0.831667	0.565667	0.362333	0.238	0.175
0.864333	0.617333	0.397667	0.250667	0.179333
0.888333	0.652333	0.432333	0.265	0.183333
0.893	0.667667	0.462	0.279333	0.187333
0.901333	0.681333	0.489333	0.295333	0.192
0.908333	0.690333	0.513	0.311333	0.197
0.895	0.694	0.532	0.328	0.201
0.894333	0.702667	0.547	0.345	0.206667
0.885333	0.704333	0.561	0.362667	0.211667
0.879	0.709	0.569	0.380333	0.217333
0.873667	0.707333	0.577333	0.396333	0.222333
0.863	0.704	0.583333	0.413667	0.228333
0.858333	0.698667	0.587333	0.429333	0.234
0.852	0.691333	0.590333	0.444	0.241
0.840333	0.692667	0.592333	0.458667	0.246667
0.834667	0.689333	0.592667	0.470667	0.253
0.833333	0.685667	0.589667	0.481667	0.259667
0.835333	0.687333	0.593	0.493	0.266333
0.823333	0.681667	0.59	0.501667	0.274667
0.818667	0.678667	0.588333	0.51	0.282667
0.825	0.682	0.585667	0.519	0.29
0.82	0.676333	0.581667	0.523667	0.297
0.818	0.676	0.582	0.529	0.304
0.819	0.68	0.579	0.534	0.312333
0.805	0.667333	0.575333	0.537667	0.319667
0.804333	0.672667	0.573	0.540667	0.327
0.813333	0.671	0.569333	0.542667	0.334667
0.804667	0.665	0.568333	0.544	0.342333
0.805	0.667333	0.565667	0.545333	0.349
0.795667	0.663	0.564333	0.546333	0.357

Table B32. Continued

0.793333	0.660333	0.564	0.546667	0.363667
0.794667	0.662333	0.560667	0.546333	0.370667
0.803	0.665333	0.559333	0.546	0.376333
0.801	0.661	0.560667	0.545	0.382667
0.808333	0.663333	0.558333	0.545333	0.388
0.808667	0.664333	0.556333	0.544	0.394333
0.798667	0.658	0.554667	0.544	0.398333
0.802	0.66	0.555667	0.541667	0.403
0.800333	0.660333	0.554667	0.540667	0.408667
0.800667	0.661333	0.552667	0.538667	0.412667
0.809667	0.664	0.551667	0.537333	0.416667
0.809333	0.667333	0.552333	0.535667	0.419667
0.801333	0.66	0.55	0.534667	0.423333
0.798333	0.656	0.55	0.532333	0.426667
0.799333	0.658667	0.550333	0.531667	0.43
0.800333	0.662333	0.549667	0.531	0.432667
0.806	0.654333	0.552	0.53	0.434
0.806	0.666	0.550333	0.529	0.436667
0.799667	0.660333	0.549	0.528333	0.438333
0.799333	0.662667	0.549	0.528	0.441
0.802667	0.659667	0.548667	0.526333	0.442667
0.797667	0.655	0.549667	0.525667	0.443667
0.806333	0.663333	0.551667	0.524667	0.444333
0.808667	0.663667	0.552	0.524667	0.446
0.804	0.657	0.551667	0.524333	0.447
0.806667	0.664667	0.552	0.523333	0.449
0.807333	0.666	0.552	0.522667	0.449
0.802667	0.661333	0.552667	0.522	0.450333
0.803333	0.661667	0.552333	0.522	0.451
0.806	0.659	0.552333	0.521333	0.451333
0.802	0.662667	0.552667	0.520667	0.452
0.801	0.660667	0.556	0.52	0.452667
0.808333	0.664	0.556	0.519333	0.454
0.808333	0.665333	0.556333	0.519667	0.453667

Table B33. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. bailii* 158 in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.011533	0.009849	0.010693	0.001528	0.010408
0.003786	0.020429	0.007234	0.006506	0.005568
0.003606	0.004583	0.005859	0.003	0.004
0.007234	0.004359	0.005686	0.001732	0.004041
0.013454	0.006083	0.004933	0.002517	0.003786
0.020664	0.006429	0.003464	0.003786	0.002887
0.023072	0.010017	0.002517	0.004619	0.003215
0.027319	0.010786	0.003055	0.006083	0.003215
0.034078	0.01193	0.002	0.00781	0.003055
0.042618	0.013577	0.002517	0.009539	0.003
0.049003	0.016166	0.004163	0.011015	0.002517
0.052205	0.009018	0.004041	0.013077	0.002517
0.060655	0.01124	0.001	0.013317	0.002517
0.06133	0.007572	0.004726	0.014224	0.002646
0.064516	0.007095	0.006557	0.014224	0.002646
0.06	0.002646	0.009644	0.014933	0.002646
0.059011	0.006028	0.007	0.015875	0.002082
0.060044	0.003512	0.008185	0.015503	0.002082
0.057507	0.008185	0.006557	0.01701	0.001528
0.056536	0.009452	0.009609	0.015535	0.001528
0.054	0.014526	0.008021	0.015695	0.001528
0.05252	0.01097	0.008963	0.015308	0.001
0.051565	0.006351	0.007371	0.014177	0.001732
0.050083	0.010599	0.006807	0.014012	0.001528
0.053013	0.009713	0.00611	0.014012	0.002
0.054501	0.01222	0.004163	0.013317	0.003055
0.050003	0.011015	0.004	0.012767	0.003215
0.046501	0.008622	0.004359	0.013317	0.004619
0.051052	0.01159	0.004041	0.012767	0.005508
0.048693	0.009539	0.006658	0.01249	0.006083
0.052	0.008386	0.007024	0.013051	0.006083
0.051682	0.008888	0.006245	0.014422	0.006245
0.049508	0.008888	0.004	0.014177	0.00611
0.05012	0.008505	0.007572	0.014978	0.007371
0.041549	0.008145	0.005196	0.014012	0.008888
0.049014	0.011358	0.005774	0.014742	0.008145
0.045501	0.006245	0.005132	0.015395	0.009452
0.044034	0.008737	0.009018	0.013614	0.009644

Table B33. Continued

0.047173	0.004583	0.008505	0.015535	0.010583
0.042099	0.007767	0.009849	0.014742	0.012423
0.042036	0.009292	0.008505	0.015133	0.01365
0.04613	0.011358	0.010066	0.015875	0.012503
0.046058	0.013317	0.00611	0.01701	0.013
0.05056	0.008505	0.007767	0.017578	0.01193
0.039425	0.014731	0.008505	0.017578	0.01365
0.037	0.008185	0.010693	0.019858	0.012166
0.040501	0.010116	0.011504	0.019732	0.013317
0.050053	0.015044	0.009292	0.021572	0.013279
0.046318	0.008185	0.009609	0.022942	0.013279
0.04055	0.010693	0.008737	0.02409	0.013279
0.046737	0.008	0.008185	0.025736	0.013577
0.042852	0.010392	0.009849	0.025482	0.014154
0.04087	0.010017	0.009713	0.026633	0.013856
0.044242	0.018009	0.009074	0.027875	0.013429
0.049122	0.014364	0.01179	0.027785	0.014731
0.047149	0.012124	0.010116	0.029513	0.014154
0.04319	0.017502	0.009849	0.029838	0.013577
0.045015	0.014978	0.011136	0.031321	0.013856
0.041789	0.015373	0.010693	0.033292	0.014154
0.036226	0.01833	0.010693	0.034443	0.013279
0.041549	0.018148	0.010786	0.035346	0.012741
0.041004	0.016921	0.010536	0.037072	0.013077
0.042509	0.019	0.01124	0.039311	0.013077
0.043004	0.019732	0.01249	0.039311	0.012288
0.032021	0.018358	0.012767	0.040464	0.012288
0.037072	0.01914	0.013614	0.041617	0.01115
0.031974	0.016653	0.01115	0.042462	0.011533
0.03061	0.019053	0.013317	0.042771	0.011372
0.033779	0.018148	0.013868	0.043039	0.012288
0.039509	0.023116	0.015133	0.045078	0.011719
0.03107	0.02358	0.016643	0.045347	0.011358
0.037687	0.024194	0.017098	0.045622	0.012662

Table B34. Averages of raw data from microtiter plate reader experiments for *K. lactis* in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.108333	0.103667	0.090333	0.089333	0.091667
0.111333	0.107667	0.090333	0.091	0.091667
0.112333	0.107	0.090667	0.092	0.092667
0.125667	0.108	0.090667	0.092333	0.094333
0.147333	0.111667	0.091333	0.092667	0.093333
0.178	0.118	0.091333	0.093333	0.092333
0.215667	0.122	0.091667	0.093333	0.092333
0.250333	0.126667	0.092667	0.093333	0.094333
0.279667	0.131	0.093667	0.094	0.093333
0.304	0.136	0.095333	0.093667	0.093333
0.328	0.141	0.097667	0.093667	0.092667
0.342333	0.147333	0.100333	0.093667	0.093
0.359667	0.153333	0.104333	0.094	0.093333
0.381	0.163333	0.108	0.094	0.093
0.390333	0.175667	0.116	0.093333	0.093
0.403667	0.195	0.121	0.093	0.093333
0.422333	0.223	0.127	0.093333	0.093333
0.428333	0.262667	0.136	0.094	0.093
0.434333	0.307333	0.142667	0.094333	0.092667
0.436667	0.351	0.149667	0.095	0.092667
0.438333	0.375333	0.153333	0.095333	0.092333
0.448	0.393667	0.16	0.095667	0.093
0.451667	0.408333	0.165667	0.096	0.093
0.472	0.432333	0.166	0.096333	0.093
0.474333	0.459	0.169667	0.096	0.093
0.485333	0.488667	0.177667	0.096667	0.092667
0.485333	0.515667	0.181	0.096333	0.092667
0.492	0.534333	0.184667	0.097333	0.093
0.496	0.553667	0.190667	0.097	0.092667
0.502	0.561667	0.201	0.098	0.093333
0.504333	0.573333	0.202	0.098	0.092333
0.502667	0.574	0.209	0.099	0.092667
0.502	0.577	0.214333	0.099667	0.093333
0.501	0.576333	0.221	0.100667	0.092667
0.494	0.57	0.227333	0.101667	0.093
0.489333	0.58	0.228333	0.103	0.093
0.481667	0.574667	0.231667	0.105333	0.094
0.479	0.572333	0.229	0.107	0.094
0.470667	0.572667	0.233	0.109333	0.094

Table B34. Continued

0.467333	0.563	0.233333	0.113	0.094333
0.465667	0.557333	0.248333	0.115667	0.094667
0.465333	0.569667	0.240667	0.118	0.093667
0.465	0.565	0.239	0.121333	0.094333
0.462667	0.566667	0.243667	0.124333	0.095333
0.456667	0.566	0.246667	0.128667	0.095667
0.46	0.567667	0.246	0.132333	0.096
0.462	0.563	0.249667	0.137333	0.097
0.46	0.569	0.254333	0.141667	0.098333
0.458667	0.557	0.252	0.148667	0.098667
0.463333	0.555333	0.257	0.154	0.100667
0.464	0.551333	0.260333	0.160667	0.101
0.459	0.550667	0.255	0.168333	0.103667
0.474333	0.547667	0.258	0.175	0.104667
0.464333	0.552333	0.261	0.181333	0.106333
0.467	0.550333	0.26	0.189667	0.108333
0.473667	0.547667	0.262	0.196667	0.111
0.470333	0.550667	0.260333	0.205333	0.112667
0.472667	0.545	0.259667	0.214667	0.114333
0.476	0.551667	0.260667	0.224667	0.115667
0.485667	0.549333	0.259	0.233667	0.118667
0.479667	0.551667	0.263	0.242667	0.122
0.483667	0.551333	0.263333	0.251	0.125667
0.486333	0.559333	0.269667	0.261333	0.128
0.491333	0.561667	0.264333	0.268	0.132333
0.487333	0.563667	0.269667	0.276333	0.134
0.491667	0.564333	0.276	0.287333	0.137
0.495	0.565667	0.27	0.295667	0.141333
0.493667	0.571333	0.275667	0.305333	0.143
0.507667	0.574	0.284333	0.313667	0.148667
0.497	0.577667	0.277333	0.323	0.151333
0.492	0.572333	0.280667	0.331	0.156333
0.508	0.58	0.285333	0.34	0.16
0.513	0.592667	0.278	0.349333	0.164667

Table B35. Standard deviation of averages of raw data from microtiter plate reader experiments for *K. lactis* in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.000577	0.000577	0.001528	0.000577	0.002082
0.000577	0.000577	0.001155	0.003464	0.002082
0.000577	0.001	0.001528	0.005196	0.003786
0.000577	0.001	0.001528	0.005774	0.006658
0.002082	0.000577	0.001155	0.006351	0.004933
0.005196	0.001	0.001155	0.006658	0.003215
0.01115	0.001732	0.001528	0.006658	0.003215
0.016073	0.000577	0.001528	0.006658	0.005774
0.01893	0.001	0.001528	0.006083	0.004163
0.023516	0	0.002082	0.005508	0.003215
0.026	0	0.001528	0.004619	0.003055
0.024542	0.000577	0.002082	0.003786	0.002646
0.026633	0.000577	0.001528	0.003464	0.003215
0.031193	0.000577	0.002646	0.002646	0.002646
0.021939	0.002309	0.003606	0.001528	0.002646
0.015308	0.004	0.003464	0.001	0.002517
0.008386	0.010817	0.003606	0.000577	0.002517
0.005132	0.019035	0.003	1.7E-17	0.002646
0.008737	0.024111	0.003786	0.000577	0.002082
0.01106	0.024021	0.005033	1.7E-17	0.002082
0.020257	0.017786	0.005132	0.000577	0.001528
0.028355	0.021385	0.004583	0.000577	0.002
0.025423	0.024664	0.005686	1.7E-17	0.001
0.028618	0.035105	0.005292	0.000577	0.001
0.034443	0.044238	0.007234	0.001	0.001
0.041138	0.050895	0.006658	0.000577	0.001528
0.047721	0.056146	0.008718	0.000577	0.001528
0.051507	0.05577	0.008963	0.001155	0.001
0.053777	0.048211	0.007638	0.001	0.000577
0.055462	0.038695	0.009165	0.001732	0.001528
0.05783	0.033201	0.006083	0.001732	0.001155
0.061849	0.021	0.005568	0.002646	0.000577
0.06393	0.012288	0.007095	0.002082	0.001155
0.063174	0.003215	0.007	0.004509	0.000577
0.066091	0.006557	0.011372	0.004726	0.001
0.063319	0.014177	0.012662	0.005	0.001
0.055175	0.019348	0.015567	0.008083	1.7E-17
0.051029	0.026727	0.013454	0.010149	1.7E-17

Table B35. Continued

0.046715	0.030665	0.011269	0.012662	0.001
0.035726	0.039837	0.015011	0.0151	0.000577
0.019732	0.050521	0.020551	0.022271	0.001155
0.011269	0.057158	0.015133	0.026407	0.000577
0.012662	0.066154	0.018009	0.029687	0.002082
0.022121	0.070164	0.020033	0.033171	0.001528
0.028355	0.079154	0.019519	0.036611	0.002646
0.040951	0.078937	0.022368	0.041187	0.003
0.043093	0.082286	0.019553	0.047721	0.002517
0.046694	0.087504	0.022338	0.052558	0.004041
0.055474	0.089779	0.019287	0.059573	0.004509
0.058284	0.091544	0.024846	0.065493	0.006557
0.057472	0.099902	0.025239	0.071898	0.007638
0.069974	0.100759	0.019157	0.079038	0.008622
0.069587	0.105462	0.022716	0.085114	0.009074
0.077485	0.111447	0.022113	0.09192	0.011676
0.083171	0.112077	0.025865	0.096775	0.012124
0.082597	0.119001	0.022189	0.104577	0.01222
0.089779	0.123843	0.028006	0.112117	0.011372
0.090266	0.129342	0.027755	0.117628	0.013429
0.097511	0.127962	0.027055	0.124102	0.014572
0.089768	0.136346	0.028844	0.128204	0.014
0.096997	0.136552	0.027791	0.132367	0.015144
0.101633	0.145225	0.035218	0.133886	0.016462
0.099168	0.147582	0.028537	0.135967	0.016289
0.102725	0.151018	0.035218	0.13699	0.019287
0.109144	0.158197	0.039887	0.13699	0.019157
0.11212	0.159657	0.029866	0.135149	0.020257
0.109244	0.163467	0.034356	0.134113	0.023065
0.122859	0.168083	0.042712	0.131804	0.024007
0.113767	0.173615	0.031943	0.127307	0.027062
0.110145	0.172097	0.03782	0.122523	0.029687
0.119578	0.177654	0.038475	0.11628	0.031796
0.121248	0.182582	0.031512	0.109646	0.032868

Table B36. Averages of raw data from microtiter plate reader experiments for *S. passalidarum* in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.102667	0.100667	0.088333	0.088	0.091
0.103333	0.097	0.090333	0.089	0.091333
0.116	0.095667	0.091	0.09	0.091333
0.142333	0.095667	0.091	0.090333	0.091
0.184	0.096333	0.091	0.090333	0.091
0.244	0.100667	0.091	0.091333	0.090667
0.318	0.102667	0.091	0.091667	0.090667
0.397667	0.106	0.091	0.091667	0.091667
0.475	0.108667	0.091	0.091667	0.090333
0.543	0.111333	0.091	0.091667	0.090333
0.6	0.114667	0.090333	0.091667	0.090667
0.648333	0.118	0.090667	0.092	0.090667
0.688333	0.121333	0.091	0.091667	0.090333
0.722	0.123667	0.090667	0.091667	0.091667
0.752333	0.128	0.09	0.091333	0.090333
0.778	0.131333	0.090667	0.091333	0.090333
0.800333	0.134	0.09	0.091	0.090333
0.822333	0.138667	0.090333	0.091	0.090333
0.837333	0.141667	0.090667	0.091667	0.090333
0.852	0.145333	0.09	0.091333	0.090333
0.866667	0.149	0.09	0.091333	0.090333
0.877	0.152667	0.09	0.091333	0.090333
0.89	0.156333	0.09	0.091	0.090333
0.900667	0.160333	0.09	0.091	0.090333
0.909	0.162333	0.09	0.091333	0.090333
0.917	0.166	0.09	0.090667	0.089667
0.925	0.168667	0.09	0.091	0.090333
0.935	0.172667	0.09	0.091333	0.09
0.940667	0.176	0.09	0.091	0.09
0.949333	0.180333	0.090333	0.091333	0.090333
0.740333	0.184667	0.09	0.090667	0.089667
0.729333	0.188333	0.09	0.091	0.09
0.708667	0.192333	0.09	0.090667	0.09
0.713333	0.195333	0.09	0.090667	0.089667
0.709	0.198667	0.09	0.091	0.089667
0.709667	0.203667	0.09	0.090667	0.091
0.717667	0.207	0.09	0.091	0.09
0.72	0.209333	0.09	0.090667	0.089667
0.740333	0.215333	0.09	0.090667	0.089333

Table B36. Continued

0.738	0.216333	0.09	0.091	0.090333
0.745	0.222333	0.089667	0.090667	0.090667
0.762	0.227667	0.089667	0.090667	0.089667
0.553333	0.231667	0.089667	0.090333	0.089667
0.54	0.239333	0.089667	0.090667	0.089333
0.536667	0.243	0.089667	0.090667	0.089333
0.553	0.249	0.089333	0.091	0.090333
0.547667	0.254333	0.09	0.091	0.089667
0.546667	0.262667	0.09	0.091	0.090667
0.557	0.265667	0.089333	0.090667	0.089333
0.526667	0.273667	0.089333	0.090333	0.089667
0.526333	0.277	0.089333	0.090667	0.09
0.548667	0.288	0.089667	0.090667	0.089333
0.555	0.295	0.089333	0.090667	0.089333
0.572	0.300667	0.089667	0.090667	0.09
0.565333	0.308667	0.089333	0.090667	0.089333
0.555667	0.314333	0.089333	0.090667	0.089667
0.566667	0.318	0.089667	0.090667	0.089333
0.567667	0.320667	0.089333	0.090667	0.089333
0.580667	0.329333	0.089667	0.090667	0.089333
0.560333	0.334	0.089333	0.090667	0.089333
0.543667	0.34	0.089	0.090667	0.089333
0.538333	0.343333	0.089333	0.090333	0.089333
0.411	0.349667	0.089667	0.091	0.089667
0.412333	0.358	0.089333	0.090667	0.089667
0.415667	0.359667	0.089333	0.090667	0.089333
0.416667	0.362333	0.089667	0.090667	0.089333
0.409667	0.364333	0.089333	0.090667	0.089667
0.419	0.368333	0.089333	0.090333	0.089333
0.434	0.370667	0.089667	0.090333	0.089333
0.428333	0.379	0.089333	0.090333	0.089333
0.433333	0.376667	0.089	0.090333	0.089667
0.418	0.377667	0.089667	0.090667	0.089333
0.427333	0.385	0.089333	0.09	0.089333

Table B37. Standard deviations of averages of raw data from microtiter plate reader experiments for *S. passalidarum* in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001528	0.001155	0.000577	0.001	0.001732
0.001155	1.7E-17	0.000577	0.002	0.001528
0.001732	0.000577	0.001	0.002	0.000577
0.003055	0.000577	0.001	0.001528	0.001
0.005196	0.000577	0.001	0.001528	0.001
0.011533	0.001155	0.001	0.003215	0.001155
0.021932	0.001155	0.001	0.003786	0.000577
0.031786	0.001732	0.001	0.002887	0.001155
0.042154	0.002887	0.001	0.002887	0.000577
0.04979	0.004163	0.001	0.002887	0.000577
0.054945	0.004619	0.001528	0.002887	0.000577
0.058731	0.005196	0.001528	0.003606	0.001155
0.062067	0.006658	0.001	0.002887	0.000577
0.06691	0.007234	0.001528	0.002887	0.002082
0.071445	0.007937	0.001	0.003215	0.000577
0.076315	0.008505	0.001528	0.003215	0.000577
0.08177	0.007937	0.001	0.002646	0.000577
0.08954	0.010786	0.001528	0.002646	0.000577
0.093002	0.010786	0.001528	0.002887	0.000577
0.097041	0.01193	0.001	0.003215	0.000577
0.10462	0.014	0.001	0.003215	0.000577
0.108282	0.015044	0.001	0.003215	0.000577
0.116065	0.015503	0.001	0.002646	0.000577
0.122769	0.017214	0.001	0.002646	0.000577
0.12733	0.016289	0.001	0.003215	0.000577
0.131636	0.017578	0.001	0.002887	0.001155
0.136832	0.017786	0.001	0.002646	0.000577
0.140296	0.018583	0.001	0.003215	0.001
0.147805	0.018358	0.001	0.002646	1.7E-17
0.152775	0.019858	0.001155	0.003215	0.001155
0.320828	0.020429	0.001	0.002887	0.001155
0.352724	0.019732	0.001	0.002646	1.7E-17
0.390016	0.021572	0.001	0.002887	0.001
0.39524	0.020648	0.001	0.002887	0.000577
0.402955	0.020306	0.001	0.002646	0.000577
0.414373	0.02203	0.001	0.002887	0.002646
0.409077	0.020224	0.001	0.002646	0.001
0.418459	0.021455	0.001	0.002887	0.000577

Table B37. Continued

0.398559	0.02318	0.001	0.002887	0.000577
0.412186	0.019732	0.001	0.002646	0.000577
0.396458	0.021939	0.001528	0.002887	0.000577
0.20635	0.021939	0.001528	0.002309	0.000577
0.213586	0.023094	0.001528	0.002887	0.000577
0.214556	0.026	0.001528	0.002887	0.000577
0.22524	0.027713	0.001155	0.002646	0.001528
0.232011	0.026633	0.001	0.002646	0.000577
0.231522	0.028937	0.001	0.002646	0.001528
0.211026	0.028006	0.001155	0.002887	0.000577
0.23829	0.029738	0.001155	0.002309	0.000577
0.233252	0.031193	0.001155	0.002887	0.001
0.212241	0.035595	0.001528	0.002887	0.000577
0.206487	0.038223	0.001155	0.002887	0.000577
0.177008	0.039311	0.001528	0.002887	0.001
0.180093	0.039273	0.001155	0.002887	0.000577
0.188288	0.041308	0.001155	0.002887	0.001155
0.178786	0.045967	0.001528	0.002887	0.000577
0.177455	0.047078	0.001155	0.002887	0.000577
0.161407	0.050063	0.001528	0.002887	0.000577
0.185511	0.053926	0.001155	0.002887	0.000577
0.19958	0.05557	0.001	0.002887	0.000577
0.204823	0.060385	0.001155	0.002309	0.000577
0.073532	0.060178	0.001528	0.003464	0.000577
0.12454	0.067735	0.001155	0.002887	0.000577
0.172236	0.073419	0.001155	0.002887	0.000577
0.177272	0.079952	0.001528	0.002887	0.000577
0.174517	0.079739	0.001155	0.002887	0.001155
0.187933	0.083393	0.001155	0.002309	0.000577
0.190229	0.09149	0.001528	0.002309	0.000577
0.188057	0.101769	0.001155	0.002309	0.000577
0.203738	0.100848	0.001	0.002309	0.001155
0.1878	0.109601	0.001528	0.002887	0.000577
0.194408	0.117987	0.001155	0.001732	0.000577

Table B38. Averages of raw data from microtiter plate reader experiments for *P. stipitis* in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.098333	0.100333	0.091333	0.088667	0.089333
0.102	0.104333	0.091	0.09	0.089333
0.103333	0.106667	0.091	0.091333	0.089
0.105	0.106667	0.091	0.092	0.088667
0.108333	0.109667	0.091333	0.093	0.089667
0.114667	0.111667	0.093	0.094	0.088667
0.124333	0.116	0.092	0.094333	0.089
0.139333	0.123	0.093	0.094667	0.089333
0.162667	0.133	0.093	0.095	0.089333
0.194333	0.147333	0.093667	0.095	0.089667
0.233667	0.167	0.094	0.095	0.089333
0.280667	0.192	0.094667	0.095333	0.09
0.327	0.223333	0.095333	0.095333	0.089667
0.378	0.256333	0.096	0.095667	0.09
0.428	0.292333	0.096667	0.095667	0.089667
0.483	0.325333	0.097	0.095667	0.090667
0.531333	0.362	0.097333	0.095667	0.09
0.591333	0.397	0.098	0.096	0.09
0.642	0.431	0.098667	0.095667	0.09
0.693333	0.461667	0.099	0.095333	0.09
0.742333	0.491	0.1	0.095333	0.089667
0.784333	0.518333	0.100667	0.095667	0.090333
0.830667	0.545	0.101333	0.095333	0.090333
0.873667	0.561333	0.102	0.095333	0.090667
0.908667	0.567667	0.103	0.095333	0.090667
0.94	0.579667	0.104333	0.095	0.090333
0.975667	0.587	0.105	0.094667	0.09
0.995	0.606667	0.107	0.094667	0.09
1.012333	0.618	0.108333	0.094667	0.090667
1.004	0.639333	0.110667	0.095333	0.090667
0.984667	0.659333	0.112667	0.094333	0.089667
0.982	0.665667	0.115667	0.095	0.09
0.966	0.689333	0.118667	0.095	0.089667
0.968	0.699667	0.123	0.095	0.089667
0.971667	0.704667	0.128667	0.094667	0.090667
0.953	0.725333	0.135667	0.094667	0.090333
0.958333	0.731667	0.145	0.094667	0.090333
0.952667	0.741333	0.158667	0.095	0.090333
0.959	0.748667	0.177333	0.095	0.090333

Table B38. Continued

0.936667	0.751	0.201667	0.095	0.090667
0.94	0.756	0.222333	0.094667	0.09
0.943333	0.764667	0.252	0.095	0.09
0.935333	0.769667	0.290667	0.095	0.090667
0.954333	0.769667	0.326	0.095	0.090333
0.931333	0.763	0.358	0.095	0.09
0.930667	0.755333	0.379	0.095	0.09
0.912333	0.753333	0.382333	0.095333	0.090667
0.930333	0.744667	0.401667	0.095	0.090333
0.906667	0.748	0.421333	0.094667	0.090333
0.904333	0.747667	0.449	0.095	0.09
0.899	0.742333	0.458333	0.095	0.090333
0.896667	0.74	0.473667	0.095333	0.090333
0.893333	0.738333	0.475333	0.095	0.09
0.892333	0.733333	0.480333	0.095333	0.09
0.891	0.733333	0.488667	0.095	0.09
0.88	0.728667	0.499667	0.095333	0.090333
0.867667	0.728	0.489667	0.095667	0.09
0.862	0.727	0.496667	0.095667	0.09
0.856667	0.723667	0.515333	0.095667	0.09
0.845	0.725333	0.523667	0.096	0.090667
0.837333	0.720333	0.539333	0.096	0.089667
0.825	0.718667	0.548333	0.096	0.09
0.812	0.719	0.550667	0.096	0.091333
0.803667	0.719667	0.568	0.096	0.090333
0.81	0.720667	0.578667	0.096667	0.09
0.795	0.719667	0.58	0.096667	0.089667
0.792333	0.719667	0.588333	0.096667	0.09
0.783	0.721	0.602	0.097333	0.090333
0.775667	0.721333	0.62	0.097333	0.09
0.769667	0.721333	0.628	0.097333	0.090333
0.770333	0.724	0.638667	0.097333	0.089667
0.762	0.722	0.653	0.097333	0.09
0.754333	0.720667	0.664	0.097667	0.09

Table B39. Standard deviations of averages of raw data from microtiter plate reader experiments for *P. stipitis* in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.000577	0.000577	0.000577	0.000577	0.000577
0.001	0.001155	1.7E-17	0.001732	0.001528
0.000577	0.002082	1.7E-17	0.003215	0.001
0.001	0.000577	1.7E-17	0.005196	0.001155
0.001528	0.002082	0.000577	0.006083	0.001155
0.001528	0.000577	0.001732	0.006928	0.001155
0.001528	0.001	1.7E-17	0.007506	0.001
0.002517	0.001	1.7E-17	0.008083	0.000577
0.003055	0.001	1.7E-17	0.00781	0.001528
0.004163	0.001528	0.000577	0.00781	0.001155
0.004726	0.002	1.7E-17	0.00781	0.001528
0.007371	0.003	0.000577	0.007506	0.001732
0.006	0.002517	0.000577	0.007506	0.001155
0.008888	0.002517	1.7E-17	0.007234	0.001732
0.00781	0.002082	0.000577	0.007234	0.001155
0.008185	0.003055	0.001	0.007234	0.001528
0.009866	0.001	0.001155	0.007234	0.001
0.004163	0.001732	0.001	0.006928	0.001
0.004359	0.004	0.000577	0.006351	0.001732
0.01193	0.004041	0.001	0.005774	0.001732
0.01914	0.012166	0.001	0.005774	0.001155
0.025891	0.015373	0.001528	0.005508	0.001528
0.031374	0.020421	0.001155	0.004933	0.001528
0.03402	0.020599	0.001	0.004933	0.002082
0.039311	0.023245	0.001	0.004933	0.001155
0.044978	0.028537	0.001528	0.004359	0.001528
0.044792	0.028054	0.001732	0.003786	0.001732
0.051971	0.034078	0.001732	0.003786	0.001732
0.03894	0.033601	0.002309	0.003786	0.001528
0.034073	0.036896	0.002082	0.003215	0.001155
0.032005	0.041633	0.003055	0.003215	0.001155
0.033808	0.039804	0.003512	0.002646	0.001732
0.030643	0.047163	0.005508	0.002646	0.001155
0.032078	0.048563	0.006557	0.002646	0.001155
0.049541	0.047648	0.009713	0.002082	0.001155
0.035	0.053678	0.013051	0.002082	0.001528
0.035852	0.054812	0.017578	0.002082	0.001528
0.047427	0.057553	0.025929	0.001732	0.001528

Table B39. Continued

0.041388	0.062389	0.036747	0.001732	0.001528
0.053267	0.063411	0.050817	0.001	0.001155
0.03499	0.072954	0.075478	0.001	0.001732
0.054684	0.077861	0.094129	0.001	0.001155
0.03139	0.085676	0.106579	0.001	0.001528
0.048211	0.092795	0.115182	0.001	0.001732
0.046918	0.087523	0.103058	0.001	0.001732
0.056889	0.091282	0.083429	0.001155	0.001155
0.039716	0.088093	0.082887	0.001	0.001528
0.058825	0.086366	0.078309	0.000577	0.001528
0.064825	0.092143	0.081099	0.001	0.001732
0.057974	0.095929	0.079977	0.001	0.001528
0.05802	0.09286	0.082887	0.000577	0.001528
0.069867	0.093751	0.076304	0.001	0.001732
0.062003	0.093168	0.073501	0.000577	0.001732
0.06149	0.097388	0.080848	0.001	0.001732
0.06879	0.096366	0.083213	0.000577	0.001528
0.065455	0.098656	0.062644	0.001155	0.001732
0.07494	0.098788	0.070117	0.000577	0.001732
0.068806	0.099932	0.057934	0.001155	0.001732
0.069735	0.098434	0.061493	0.001	0.001155
0.063217	0.100152	0.055293	0.001	0.001155
0.067357	0.10429	0.062979	0.001	0.001732
0.066144	0.103407	0.080476	0.001	0.000577
0.068806	0.101402	0.074719	0.001	0.001528
0.071715	0.104844	0.079576	0.000577	0.001732
0.070314	0.101293	0.103262	0.000577	0.001155
0.073935	0.103929	0.115626	0.001528	0.001732
0.072959	0.105219	0.118823	0.001155	0.001528
0.074312	0.104069	0.111853	0.001155	0.001732
0.074782	0.107612	0.121347	0.001155	0.001528
0.078053	0.111396	0.126271	0.001155	0.001155
0.079775	0.107852	0.124012	0.001155	0.001732
0.077983	0.105462	0.124012	0.001528	0.001732

Table B40. Averages of raw data from microtiter plate reader experiments for *D. hansenii* in acetic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.099	0.100667	0.088333	0.088333	0.090333
0.104	0.105	0.090333	0.088667	0.090667
0.105	0.105667	0.090667	0.089	0.089667
0.107333	0.106	0.09	0.089	0.090333
0.108667	0.106333	0.09	0.088333	0.089333
0.110333	0.107333	0.09	0.088	0.09
0.113667	0.107	0.09	0.088	0.088667
0.116667	0.106667	0.09	0.088333	0.089667
0.121667	0.107	0.09	0.089	0.089333
0.127667	0.106667	0.09	0.089	0.089667
0.134667	0.106667	0.089667	0.088	0.089
0.141333	0.107	0.089667	0.088333	0.089
0.147667	0.106333	0.089667	0.088667	0.089333
0.154	0.106	0.09	0.088333	0.089333
0.159667	0.106333	0.089667	0.088	0.088667
0.165333	0.106	0.089667	0.088	0.089
0.17	0.106333	0.089667	0.088	0.088667
0.175	0.106	0.089667	0.088	0.088667
0.179333	0.106	0.089667	0.088	0.089
0.182	0.105333	0.09	0.088	0.088667
0.187667	0.105667	0.089667	0.087667	0.089
0.190333	0.106	0.089667	0.088	0.088667
0.196	0.106	0.089667	0.088	0.088667
0.202333	0.105333	0.089667	0.088	0.088667
0.207333	0.105667	0.089667	0.088	0.088333
0.213	0.105333	0.089667	0.088	0.088333
0.229333	0.105333	0.089667	0.088	0.088667
0.238333	0.105333	0.089667	0.088	0.088667
0.251333	0.105	0.089667	0.088	0.088333
0.281	0.105	0.089667	0.088	0.088333
0.319667	0.105333	0.089333	0.087	0.088
0.353333	0.105	0.089667	0.087667	0.088667
0.393667	0.105	0.089667	0.087333	0.087667
0.426667	0.105	0.089333	0.087333	0.088333
0.457333	0.105	0.089667	0.087667	0.088333
0.480667	0.105	0.089333	0.088	0.088667
0.495333	0.104667	0.089667	0.088	0.088
0.505667	0.104333	0.089667	0.087333	0.088
0.512	0.104333	0.089667	0.087667	0.088

Table B40. Continued

0.515667	0.104667	0.089667	0.088	0.088333
0.525	0.104667	0.089667	0.087333	0.087667
0.534	0.104667	0.089667	0.087333	0.088
0.539	0.104667	0.089333	0.087667	0.088
0.546333	0.104667	0.089333	0.087667	0.087667
0.554	0.104	0.089333	0.087667	0.087667
0.554667	0.104333	0.089333	0.087	0.087333
0.568667	0.104333	0.089667	0.088	0.088
0.577333	0.104333	0.089333	0.087333	0.087667
0.576667	0.104	0.089333	0.087	0.087667
0.587	0.104	0.089333	0.087667	0.089333
0.59	0.104	0.089333	0.087	0.087667
0.597333	0.103667	0.089333	0.087333	0.087667
0.606	0.103667	0.089333	0.087	0.087667
0.614	0.103667	0.089333	0.087	0.087667
0.618667	0.104	0.089333	0.087	0.087667
0.633	0.104	0.089333	0.087333	0.087667
0.640667	0.104	0.089333	0.087333	0.087667
0.645	0.103667	0.089333	0.087	0.087667
0.650333	0.103667	0.089333	0.087333	0.087667
0.655333	0.103667	0.089333	0.087333	0.087667
0.660333	0.103667	0.089	0.087	0.087667
0.662333	0.103333	0.089	0.087333	0.088
0.667333	0.103667	0.089333	0.088	0.087667
0.671	0.103	0.089	0.087333	0.087667
0.671667	0.103333	0.089333	0.087	0.087667
0.676667	0.103333	0.088667	0.087333	0.087667
0.682	0.104	0.089	0.087333	0.087667
0.684333	0.103333	0.089	0.087	0.089333
0.686667	0.103	0.089	0.087	0.087667
0.693667	0.103	0.089	0.087333	0.087667
0.695333	0.103333	0.088667	0.087	0.087667
0.698333	0.103	0.089	0.087	0.087333
0.701333	0.103	0.088667	0.087	0.087667

Table B41. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. hansenii* in acetic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001	0.000577	0.001155	0.000577	0.002082
0.001732	0.001732	0.000577	0.000577	0.002082
0.001732	0.001528	0.000577	0.001	0.000577
0.002309	0.001732	0.001	0.001	0.000577
0.002887	0.001155	0.001	0.000577	0.000577
0.002309	0.002082	0.001	0.001	1.7E-17
0.002887	0.001732	0.001	0.001	0.000577
0.002887	0.001528	0.001	0.001528	0.000577
0.003786	0.002646	0.001	0.001	0.000577
0.004726	0.002309	0.001	0.001	0.000577
0.005033	0.001528	0.000577	0.001	0.001
0.006028	0.001732	0.000577	0.001155	0.001
0.007095	0.002082	0.000577	0.000577	0.001155
0.009165	0.001732	0.001	0.000577	0.001155
0.010408	0.002082	0.000577	0.001	0.000577
0.01193	0.001732	0.000577	0.001	0.001
0.013229	0.002082	0.000577	0.001	0.001155
0.014933	0.001732	0.000577	0.001	0.000577
0.016862	0.001732	0.000577	0.001	0.001
0.017578	0.002082	0.001	0.001	0.000577
0.020984	0.001528	0.000577	0.000577	0.001
0.020306	0.001732	0.000577	0.001	0.000577
0.025239	0.001732	0.000577	0.001	0.000577
0.028042	0.002082	0.000577	0.001	0.000577
0.03213	0.001528	0.000577	0.001	0.001155
0.033808	0.002082	0.000577	0.001	0.001155
0.047014	0.002082	0.000577	0.001	0.000577
0.05154	0.002082	0.000577	0.001	0.001528
0.061647	0.001732	0.000577	0.001	0.001155
0.085773	0.001732	0.000577	0.001	0.001155
0.116663	0.002082	0.000577	0.001	0.001
0.144119	0.001732	0.000577	0.000577	0.000577
0.175745	0.001732	0.000577	0.000577	0.000577
0.202466	0.001732	0.000577	0.000577	0.001155
0.226886	0.001732	0.000577	0.000577	0.001155
0.243361	0.001732	0.000577	0.001	0.000577
0.252637	0.001528	0.000577	0.001	0.001
0.253741	0.002082	0.000577	0.000577	0.001

Table B41. Continued

0.259197	0.002082	0.000577	0.000577	0.001
0.259731	0.001528	0.000577	0.001	0.000577
0.266212	0.002309	0.000577	0.000577	1.7E-17
0.262029	0.001528	0.000577	0.000577	0.001
0.267418	0.001528	0.000577	0.000577	0.000577
0.262863	0.001732	0.000577	0.000577	0.000577
0.255629	0.002082	0.000577	0.001	0.000577
0.241631	0.002082	0.000577	0.001	0.001
0.239638	0.002082	0.000577	0.001155	0.000577
0.242904	0.001732	0.000577	0.001	0.000577
0.229	0.001732	0.000577	0.000577	0.003215
0.228291	0.001732	0.000577	0.001	0.000577
0.224965	0.001528	0.000577	0.000577	0.000577
0.223108	0.001528	0.000577	0.001	0.000577
0.208192	0.001528	0.000577	0.001	0.000577
0.20731	0.001732	0.000577	0.001	0.000577
0.190292	0.001732	0.000577	0.000577	0.000577
0.182979	0.001732	0.000577	0.000577	0.000577
0.174851	0.001528	0.000577	0.001	0.000577
0.168838	0.001528	0.000577	0.000577	0.000577
0.161203	0.001528	0.000577	0.000577	0.000577
0.156756	0.001528	0.001	0.001	0.000577
0.150673	0.002082	0.001	0.000577	0.001
0.147412	0.001528	0.000577	1.7E-17	0.000577
0.142011	0.001732	0.001	0.000577	0.000577
0.139378	0.002082	0.000577	0.001	0.000577
0.133178	0.002082	0.000577	0.000577	0.000577
0.130885	0.002646	0.001	0.000577	0.000577
0.12344	0.002082	0.001	0.001	0.003215
0.116294	0.001732	0.001	0.001	0.000577
0.110074	0.001732	0.001	0.000577	0.000577
0.10551	0.002082	0.000577	0.001	0.000577
0.102432	0.001732	0.001	0.001	0.000577
0.098673	0.001732	0.000577	0.001	0.000577

Table B42. Averages of raw data from microtiter plate reader experiments for *S. cerevisiae* in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.111	0.142333	0.135667	0.121	0.115667
0.168667	0.175667	0.141667	0.123333	0.129667
0.259333	0.191333	0.145333	0.124333	0.135667
0.387	0.201333	0.148	0.124667	0.139
0.543333	0.203667	0.151	0.125667	0.141
0.720667	0.208333	0.153333	0.126333	0.142
0.862667	0.213	0.154333	0.126333	0.143333
0.961667	0.218	0.155667	0.126667	0.144333
1.035	0.229	0.157	0.127333	0.144667
1.071	0.222333	0.158	0.128	0.145667
1.098333	0.219333	0.158667	0.128333	0.146333
1.103333	0.210333	0.159667	0.129	0.147333
1.103667	0.202667	0.160667	0.129	0.148333
1.100667	0.200333	0.160667	0.129333	0.149
1.090667	0.193667	0.162	0.129667	0.15
1.082667	0.189667	0.162333	0.13	0.151333
1.073333	0.175	0.162333	0.13	0.151333
1.066	0.167333	0.163	0.130667	0.151667
1.059333	0.158667	0.163	0.130667	0.152667
1.056	0.153	0.162667	0.130333	0.153667
1.048333	0.149333	0.163	0.131	0.154
1.043333	0.146	0.162667	0.131	0.154667
1.035667	0.142333	0.162667	0.131	0.155
1.029	0.141	0.162	0.130667	0.155
1.022333	0.139667	0.162	0.131	0.155667
1.009333	0.139667	0.162	0.130667	0.156
0.999333	0.138667	0.161667	0.131667	0.156
0.984667	0.139333	0.161	0.130667	0.156
0.983333	0.135667	0.160667	0.130667	0.157
0.973667	0.134667	0.160333	0.130333	0.156
0.957667	0.133667	0.159333	0.13	0.156
0.937333	0.136333	0.159	0.13	0.156
0.916333	0.133333	0.159	0.129667	0.155333
0.888667	0.133667	0.158333	0.129	0.155
0.870667	0.134667	0.157333	0.129	0.155
0.846	0.135333	0.157	0.129	0.155
0.823	0.134667	0.156333	0.128667	0.154667
0.781667	0.134333	0.155333	0.128667	0.155
0.751333	0.132	0.155333	0.128333	0.154

Table B42. Continued

0.727	0.131	0.154333	0.128	0.154
0.676333	0.137333	0.154	0.128	0.153333
0.666333	0.130667	0.154	0.127333	0.153
0.631667	0.131	0.152333	0.127667	0.153
0.597667	0.128	0.152	0.126667	0.153333
0.57	0.125333	0.151333	0.127333	0.152
0.526	0.129667	0.150667	0.126667	0.152
0.520667	0.126333	0.15	0.126333	0.152
0.485	0.125333	0.149333	0.126	0.152
0.456667	0.124667	0.148667	0.125667	0.151
0.427667	0.122	0.148667	0.125333	0.151333
0.403667	0.123	0.147667	0.125333	0.150667
0.394333	0.122333	0.147667	0.125333	0.150333
0.368333	0.121333	0.146667	0.124667	0.150333
0.366667	0.121333	0.146	0.124333	0.150333
0.337333	0.122667	0.145667	0.124333	0.15
0.329667	0.119667	0.145	0.124	0.149667
0.321667	0.119667	0.144667	0.124	0.149333
0.306667	0.118	0.144333	0.123667	0.149
0.302333	0.117667	0.144	0.123333	0.149
0.292	0.117333	0.143667	0.123	0.149
0.294333	0.117	0.142667	0.123	0.148667
0.285667	0.116	0.142667	0.122333	0.148333
0.297333	0.116	0.142	0.122333	0.148
0.281667	0.115	0.141667	0.122333	0.148
0.289	0.116667	0.141333	0.122	0.148333
0.291667	0.116	0.140667	0.122333	0.147333
0.292	0.116333	0.140667	0.122	0.147333
0.301333	0.116333	0.14	0.122	0.147333
0.310333	0.117667	0.139333	0.121667	0.147333
0.317	0.117	0.138667	0.121333	0.146667
0.327667	0.116	0.139	0.121333	0.147
0.328667	0.115667	0.138333	0.121	0.146333
0.314667	0.116	0.138333	0.121333	0.146

Table B43. Standard deviations of averages of raw data from microtiter plate reader experiments for *S. cerevisiae* in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.003464	0.003512	0.001155	0.001	0.001155
0.049116	0.005033	0.001155	0.000577	0.008963
0.13903	0.008386	0.001528	0.000577	0.008145
0.258519	0.01115	0.001732	0.001155	0.006557
0.410761	0.013013	0.001732	0.000577	0.007
0.574477	0.015567	0.001528	0.001155	0.007
0.696532	0.015524	0.001528	0.001155	0.007024
0.769318	0.016	0.002082	0.001528	0.006506
0.818103	0.02265	0.001732	0.001155	0.006506
0.841971	0.024705	0.001732	0.001	0.006506
0.857245	0.02829	0.002082	0.001155	0.007024
0.859759	0.026951	0.002082	0.001732	0.006506
0.859095	0.026407	0.002082	0.001732	0.006506
0.857326	0.025384	0.002082	0.001155	0.007
0.852195	0.026083	0.002646	0.001528	0.007
0.848199	0.026083	0.002517	0.001732	0.006506
0.844	0.018682	0.002517	0.001732	0.007024
0.839662	0.013614	0.002646	0.001528	0.007506
0.83649	0.009452	0.003	0.001528	0.007506
0.834411	0.009539	0.003055	0.002082	0.007506
0.829364	0.008083	0.002646	0.001732	0.007
0.826181	0.007	0.003055	0.001732	0.007506
0.820742	0.005508	0.003055	0.001732	0.008
0.815522	0.006083	0.003	0.002309	0.00755
0.810314	0.005132	0.003	0.001732	0.007506
0.79837	0.004163	0.003	0.002309	0.008
0.788951	0.004933	0.003055	0.003512	0.008
0.770932	0.002887	0.003	0.002309	0.008
0.75847	0.004163	0.003055	0.002309	0.007
0.743022	0.004163	0.002517	0.002082	0.008
0.712219	0.002309	0.002517	0.002646	0.008
0.699314	0.004041	0.003	0.002646	0.008
0.694219	0.003055	0.003	0.002309	0.008021
0.679766	0.004163	0.002517	0.001732	0.008
0.660625	0.005033	0.002517	0.002646	0.008
0.635195	0.003512	0.002	0.002646	0.008
0.606698	0.004726	0.002517	0.002309	0.007024
0.574952	0.004041	0.002517	0.002309	0.008

Table B43. Continued

0.537015	0.005196	0.002517	0.002887	0.008
0.502537	0.006928	0.002517	0.002646	0.008
0.424911	0.007234	0.002646	0.002082	0.008
0.391625	0.00781	0.002517	0.002309	0.008
0.358402	0.007937	0.002646	0.002309	0.006506
0.336031	0.005859	0.002517	0.003055	0.008
0.300711	0.007234	0.002082	0.002309	0.008
0.278101	0.008505	0.002646	0.002082	0.008
0.255478	0.006807	0.002309	0.001732	0.008
0.231392	0.006658	0.002082	0.002309	0.008
0.207235	0.005568	0.002082	0.002082	0.007506
0.18253	0.007	0.002082	0.002082	0.007506
0.172631	0.007024	0.002082	0.002082	0.008021
0.146138	0.006429	0.002082	0.002309	0.007506
0.130082	0.008021	0.002646	0.002082	0.008021
0.117959	0.007506	0.002082	0.002082	0.008
0.103568	0.005774	0.002646	0.001732	0.007506
0.0977	0.006807	0.002082	0.001732	0.008021
0.091904	0.006083	0.002309	0.002309	0.008
0.080164	0.005859	0.002646	0.002082	0.008
0.090355	0.006351	0.002082	0.001732	0.007
0.087558	0.005292	0.002082	0.001732	0.007506
0.080829	0.006245	0.002082	0.002082	0.008021
0.077164	0.007211	0.002646	0.002082	0.008
0.093661	0.006245	0.002082	0.002082	0.008
0.084445	0.006658	0.002309	0.001732	0.008021
0.092219	0.005568	0.002082	0.002082	0.008021
0.099544	0.005686	0.002082	0.001732	0.008021
0.098612	0.006028	0.001732	0.001732	0.008021
0.104078	0.006506	0.002309	0.001528	0.008021
0.101946	0.005	0.002082	0.002082	0.007506
0.1005	0.005	0.001732	0.002082	0.007
0.103645	0.004726	0.002309	0.001732	0.008021
0.114771	0.004583	0.002309	0.002082	0.008

Table B44. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 73 in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.117	0.134	0.129	0.122333	0.130333
0.149667	0.145	0.130333	0.122333	0.157333
0.163667	0.141667	0.128	0.121	0.154667
0.171333	0.141333	0.127333	0.119667	0.15
0.180667	0.143	0.128	0.120333	0.150333
0.192333	0.145333	0.128667	0.120667	0.148333
0.206	0.148333	0.129667	0.120667	0.149333
0.215667	0.151333	0.133667	0.121667	0.15
0.228	0.155333	0.139667	0.122333	0.151
0.243333	0.158333	0.140667	0.124	0.152333
0.270333	0.160667	0.143	0.125667	0.153
0.310333	0.162333	0.146333	0.128	0.154
0.369	0.165333	0.149333	0.130333	0.156
0.437333	0.166667	0.152667	0.132	0.157667
0.504333	0.168667	0.157667	0.134667	0.159
0.57	0.169667	0.162667	0.137667	0.159667
0.627	0.172333	0.165667	0.141	0.161667
0.675667	0.175667	0.172	0.144667	0.162333
0.678667	0.180667	0.177	0.148333	0.163
0.69	0.186333	0.181	0.153333	0.164
0.69	0.197667	0.189333	0.159	0.166
0.684	0.208667	0.193667	0.164	0.167
0.627	0.217333	0.195333	0.168333	0.168667
0.554333	0.230333	0.195667	0.171667	0.169667
0.531	0.245667	0.194667	0.171	0.172
0.499	0.260667	0.192667	0.172333	0.173667
0.478333	0.271	0.194667	0.173	0.174333
0.450667	0.292667	0.197333	0.174667	0.175333
0.429667	0.302667	0.197667	0.171	0.177333
0.423333	0.316	0.201333	0.169667	0.178
0.408333	0.326	0.204667	0.167	0.179
0.393667	0.348	0.210333	0.166333	0.179667
0.389	0.359	0.208	0.165333	0.180667
0.374	0.378333	0.216	0.165667	0.181667
0.364667	0.393	0.219667	0.165667	0.182667
0.355333	0.412	0.225	0.166	0.183333
0.343333	0.427333	0.225667	0.166	0.183333
0.328	0.450333	0.233333	0.166333	0.184333
0.311	0.469667	0.234667	0.165667	0.184667

Table B44. Continued

0.296667	0.490667	0.238333	0.164333	0.185333
0.288333	0.522	0.244333	0.164333	0.185667
0.281	0.536333	0.248	0.164667	0.186667
0.274333	0.562333	0.260333	0.166	0.186
0.270667	0.567	0.269	0.165	0.187333
0.271	0.590333	0.275	0.166667	0.187
0.271333	0.611333	0.282	0.167	0.188333
0.267	0.631667	0.289	0.167667	0.188333
0.264	0.646333	0.300333	0.169667	0.188333
0.264667	0.660667	0.31	0.169667	0.189333
0.263	0.669	0.319	0.17	0.189333
0.264667	0.686667	0.341	0.173	0.191333
0.265	0.700333	0.353333	0.176	0.191
0.266	0.700333	0.367333	0.179	0.19
0.272667	0.708667	0.379667	0.183667	0.19
0.269667	0.718667	0.399333	0.192	0.189
0.271	0.722333	0.412667	0.200333	0.189333
0.272667	0.727667	0.424	0.208667	0.189
0.276	0.733667	0.444	0.218	0.189
0.277333	0.733333	0.458	0.227667	0.188667
0.280333	0.739333	0.474	0.236667	0.187667
0.281667	0.738667	0.478667	0.248333	0.187
0.283	0.740667	0.491333	0.259	0.187
0.288	0.742667	0.499667	0.264333	0.185333
0.293333	0.741667	0.518	0.279	0.183333
0.300667	0.741	0.523333	0.295333	0.181667
0.304333	0.743667	0.534333	0.312333	0.181333
0.314667	0.744667	0.544667	0.325	0.180333
0.320667	0.748333	0.552	0.346667	0.180333
0.325333	0.747333	0.563667	0.367667	0.180667
0.327	0.749333	0.570667	0.387	0.178333
0.330667	0.747	0.567	0.400333	0.178
0.328667	0.749667	0.576	0.414333	0.178333
0.342667	0.757333	0.581	0.434667	0.177

Table B45. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 73 in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.008718	0.004583	0.002646	0.001155	0.001528
0.020526	0.01044	0.000577	0.001155	0.005859
0.023352	0.009074	0.001732	0.001732	0.002309
0.022679	0.008505	0.002082	0.001528	0.002646
0.021939	0.007937	0.002	0.002082	0.002082
0.021939	0.008505	0.001528	0.001528	0.002517
0.022517	0.009452	0.001528	0.001528	0.002517
0.027227	0.009452	0.002082	0.001528	0.002
0.033045	0.010214	0.009074	0.002082	0.002
0.041004	0.010214	0.005686	0.001732	0.002517
0.052444	0.010263	0.004583	0.001528	0.002646
0.064299	0.010408	0.004509	0.001	0.002646
0.085434	0.010214	0.004041	0.002082	0.003464
0.109965	0.009866	0.003512	0.002	0.003786
0.13502	0.01097	0.003215	0.002517	0.003464
0.161084	0.011719	0.001155	0.002517	0.002887
0.185809	0.008386	0.001528	0.002646	0.003786
0.215064	0.008083	0.004359	0.002517	0.003215
0.256535	0.008963	0.005568	0.001528	0.003464
0.296885	0.01097	0.006245	0.002517	0.003464
0.349398	0.013279	0.007371	0.003606	0.003464
0.390174	0.008963	0.009292	0.004	0.003464
0.332098	0.014572	0.013429	0.003055	0.003786
0.250428	0.014434	0.011372	0.004163	0.002887
0.223341	0.012503	0.013051	0.004583	0.003464
0.191322	0.017954	0.011372	0.004041	0.002082
0.170907	0.015	0.011846	0.006	0.002309
0.150779	0.009074	0.013429	0.006028	0.002309
0.129527	0.016197	0.01365	0.008185	0.002309
0.116762	0.015	0.013317	0.006807	0.002646
0.102481	0.014107	0.015308	0.008	0.002646
0.085757	0.020421	0.018583	0.006506	0.002887
0.082018	0.018248	0.019698	0.008505	0.003786
0.069159	0.011846	0.022869	0.006658	0.003786
0.060136	0.028618	0.021455	0.007371	0.002887
0.053267	0.033287	0.024434	0.007937	0.002517
0.044072	0.042147	0.025007	0.006245	0.002517
0.036373	0.039703	0.028937	0.007767	0.003215

Table B45. Continued

0.027	0.039273	0.030925	0.007234	0.004041
0.020108	0.044859	0.033501	0.006807	0.004041
0.00755	0.042194	0.036428	0.008083	0.003512
0.009292	0.043016	0.041885	0.005568	0.003606
0.008505	0.039509	0.043715	0.006928	0.003786
0.010536	0.041956	0.050715	0.007234	0.003464
0.009452	0.048418	0.056471	0.00781	0.003786
0.007937	0.031786	0.059733	0.008963	0.002887
0.015875	0.043924	0.064825	0.010017	0.003055
0.014364	0.040204	0.071631	0.012423	0.003512
0.016371	0.044508	0.073328	0.013856	0.003512
0.019858	0.042911	0.086712	0.015588	0.003512
0.018735	0.039501	0.094585	0.019925	0.004583
0.020421	0.046479	0.10551	0.024331	0.005568
0.019425	0.032347	0.111921	0.031565	0.005568
0.023861	0.036665	0.119257	0.043405	0.006557
0.022113	0.036116	0.130082	0.056977	0.007572
0.024947	0.038397	0.140075	0.060913	0.007211
0.025515	0.035019	0.148	0.072774	0.006083
0.024786	0.037978	0.153568	0.084347	0.007234
0.027227	0.037899	0.161954	0.090523	0.008145
0.025658	0.033828	0.163623	0.099806	0.00781
0.025534	0.03581	0.171803	0.104072	0.007937
0.026058	0.034078	0.17065	0.111644	0.005859
0.030353	0.033382	0.173701	0.125216	0.00611
0.028919	0.037242	0.177557	0.138583	0.005033
0.026764	0.029838	0.179489	0.15179	0.005033
0.030089	0.034933	0.176664	0.160365	0.004041
0.030551	0.036088	0.168288	0.170218	0.004726
0.03296	0.02916	0.163369	0.17072	0.006658
0.034044	0.02829	0.174047	0.181364	0.005686
0.029484	0.02816	0.168653	0.182582	0.006245
0.027683	0.030616	0.174037	0.190875	0.006658
0.031896	0.024846	0.165276	0.185031	0.007

Table B46. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 96 in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.113	0.136	0.130667	0.123333	0.123333
0.146667	0.137333	0.129333	0.122	0.130667
0.162	0.135333	0.128	0.121333	0.130333
0.169	0.135	0.128	0.12	0.13
0.177333	0.137	0.128667	0.121	0.131333
0.189	0.139667	0.13	0.121667	0.133667
0.205	0.142333	0.131	0.122	0.135667
0.223667	0.146667	0.133	0.124	0.138
0.244	0.151	0.136	0.125667	0.140667
0.268333	0.157	0.139333	0.127667	0.143667
0.301667	0.162333	0.142667	0.129667	0.147
0.346333	0.169333	0.147667	0.133333	0.150333
0.401	0.174667	0.151667	0.136333	0.155333
0.466667	0.18	0.157	0.139667	0.161
0.538667	0.183333	0.163333	0.143333	0.167
0.613	0.185667	0.169667	0.147333	0.170667
0.688	0.188333	0.176333	0.151	0.176
0.758667	0.189	0.181667	0.155667	0.179667
0.826333	0.189333	0.186667	0.160667	0.184667
0.888	0.19	0.191	0.165667	0.188333
0.945333	0.191	0.197	0.170667	0.193667
0.894667	0.19	0.199333	0.174667	0.198333
0.835333	0.185333	0.202333	0.179333	0.202333
0.839667	0.185333	0.205	0.183333	0.207
0.873333	0.187	0.206667	0.186	0.21
0.833	0.190333	0.208	0.190333	0.213667
0.824	0.193667	0.205	0.194667	0.216667
0.860667	0.195	0.207	0.196333	0.22
0.882	0.192333	0.211	0.199	0.220333
0.917	0.193667	0.214667	0.200333	0.224333
0.840333	0.197333	0.215667	0.200667	0.223667
0.831	0.201667	0.219667	0.202	0.226
0.825667	0.214333	0.221667	0.202	0.227
0.829667	0.229333	0.224667	0.204333	0.226333
0.841667	0.259	0.227667	0.204667	0.227333
0.842	0.294333	0.227333	0.206333	0.227667
0.836	0.316667	0.232667	0.206	0.227667
0.682	0.335333	0.231	0.205333	0.227333
0.595333	0.355667	0.235333	0.207333	0.227

Table B46. Continued

0.566333	0.373667	0.238	0.208	0.227333
0.556333	0.388333	0.237333	0.206	0.226667
0.543333	0.396333	0.238667	0.210333	0.226
0.538667	0.398	0.237667	0.209	0.225667
0.516667	0.408667	0.24	0.211333	0.226
0.512333	0.404333	0.241333	0.209333	0.224
0.546	0.422667	0.245333	0.214333	0.224333
0.518	0.415	0.247333	0.214667	0.223667
0.518333	0.429	0.251333	0.216	0.224333
0.502667	0.419	0.251333	0.216	0.223333
0.483667	0.405667	0.256	0.216333	0.223
0.496333	0.393	0.264667	0.215333	0.222333
0.483667	0.390333	0.265667	0.224333	0.222667
0.461	0.394667	0.273667	0.221667	0.223
0.440333	0.373	0.276	0.223	0.223
0.449	0.392333	0.299667	0.222333	0.221
0.431	0.396667	0.298333	0.221	0.221667
0.426333	0.398	0.295333	0.222333	0.222333
0.418667	0.406	0.324667	0.227333	0.221667
0.410667	0.394	0.350667	0.219667	0.221667
0.409333	0.411333	0.367667	0.225333	0.222667
0.402667	0.419333	0.387	0.225667	0.222667
0.402667	0.433667	0.438	0.226667	0.223333
0.398	0.435	0.448333	0.224667	0.223667
0.404333	0.444667	0.455	0.229	0.224
0.412667	0.491333	0.471667	0.230333	0.326333
0.415	0.514667	0.48	0.229	0.245
0.419667	0.545667	0.476333	0.227333	0.246333
0.424	0.564667	0.498	0.230333	0.249333
0.423667	0.566667	0.52	0.233667	0.280667
0.423667	0.602667	0.579333	0.225333	0.263667
0.424667	0.604667	0.607333	0.226333	0.282
0.425667	0.618333	0.637	0.229667	0.311667
0.433	0.628333	0.651667	0.229667	0.284667

Table B47. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 96 in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.002646	0.004	0.002517	0.001155	0.008083
0.031644	0.005033	0.002082	0.001	0.013051
0.04279	0.005033	0.002646	0.001155	0.01124
0.046776	0.004583	0.002646	0.001	0.010149
0.05054	0.004583	0.002309	0.001	0.009609
0.055462	0.005132	0.002646	0.001528	0.009074
0.061652	0.005033	0.002646	0.001	0.009074
0.069212	0.005508	0.002646	0.001	0.009539
0.084256	0.006	0.002646	0.001528	0.010066
0.101106	0.006	0.003055	0.001528	0.01106
0.123225	0.005508	0.003215	0.001528	0.011136
0.149948	0.006506	0.004163	0.001528	0.010599
0.186019	0.006658	0.004041	0.001528	0.010017
0.223007	0.007	0.004359	0.002082	0.008
0.260178	0.008083	0.004619	0.002309	0.006245
0.292436	0.006429	0.004041	0.001528	0.006429
0.318313	0.008505	0.007234	0.002	0.006083
0.335245	0.009165	0.005774	0.002887	0.006429
0.34798	0.009504	0.00611	0.003055	0.006429
0.357161	0.008185	0.006557	0.002887	0.006807
0.360888	0.007211	0.007211	0.004619	0.006351
0.318134	0.009539	0.008327	0.002082	0.006658
0.37143	0.003786	0.007234	0.002517	0.006658
0.407083	0.003055	0.007211	0.004041	0.006928
0.406002	0.003606	0.009713	0.004	0.007
0.278555	0.003786	0.009539	0.004163	0.006351
0.21764	0.006658	0.008544	0.005033	0.007371
0.221599	0.005292	0.008888	0.004509	0.007
0.257053	0.003786	0.010149	0.004359	0.007572
0.274022	0.006658	0.007506	0.005859	0.007506
0.157001	0.004726	0.006807	0.007371	0.006429
0.149523	0.010214	0.007767	0.006245	0.006928
0.160282	0.006028	0.00611	0.006083	0.006928
0.170899	0.01124	0.009504	0.007506	0.008386
0.184858	0.005196	0.007506	0.007371	0.008386
0.200397	0.02409	0.008327	0.009238	0.007371
0.20266	0.031501	0.010214	0.010817	0.007234
0.14279	0.034847	0.00781	0.010116	0.007572

Table B47. Continued

0.247421	0.028572	0.011504	0.010116	0.007211
0.241334	0.050402	0.013077	0.009644	0.007572
0.239471	0.051052	0.012503	0.012342	0.007211
0.222363	0.050567	0.011676	0.011269	0.006351
0.197021	0.054848	0.01249	0.011846	0.007
0.161636	0.052003	0.014572	0.013051	0.007
0.164584	0.048014	0.018583	0.011015	0.008505
0.15007	0.048539	0.014224	0.012662	0.008145
0.114072	0.053226	0.019348	0.012166	0.007572
0.091719	0.058043	0.020207	0.014177	0.007572
0.07788	0.051782	0.019925	0.013796	0.007
0.074144	0.04531	0.024786	0.014742	0.008386
0.090694	0.046231	0.02797	0.016258	0.007371
0.073777	0.049166	0.03635	0.013204	0.007
0.062852	0.04859	0.044193	0.020224	0.00781
0.075386	0.048087	0.084246	0.01963	0.00781
0.065506	0.070188	0.079764	0.019672	0.007371
0.070777	0.068695	0.08631	0.021502	0.008505
0.051936	0.082146	0.07239	0.022189	0.008145
0.043662	0.075717	0.075745	0.017786	0.009074
0.029366	0.067002	0.092354	0.025929	0.008145
0.038371	0.064632	0.085106	0.025716	0.009815
0.031896	0.065957	0.136722	0.019757	0.009713
0.033779	0.065795	0.146483	0.023245	0.010017
0.026502	0.078015	0.143816	0.026458	0.009539
0.034356	0.120338	0.1321	0.020033	0.115596
0.04987	0.131325	0.129464	0.026058	0.027622
0.057882	0.102002	0.137885	0.023438	0.024542
0.058813	0.099521	0.10333	0.031786	0.026102
0.063674	0.076265	0.087069	0.028885	0.079387
0.064501	0.040377	0.081672	0.024379	0.044959
0.07257	0.057457	0.068237	0.03107	0.031241
0.070685	0.085114	0.065	0.027429	0.047226
0.077621	0.082379	0.070713	0.031628	0.032532

Table B48. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 216 in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.158	0.164667	0.153667	0.144667	0.132667
0.189	0.177333	0.16	0.15	0.144333
0.198667	0.178667	0.161	0.151	0.148667
0.214	0.183667	0.162333	0.151667	0.151333
0.234667	0.192333	0.167667	0.156	0.155333
0.262	0.202667	0.174333	0.161333	0.160333
0.293667	0.217	0.180333	0.165333	0.164
0.332333	0.237333	0.189	0.170667	0.168
0.380333	0.264333	0.2	0.175667	0.172333
0.427667	0.301	0.213333	0.182	0.176667
0.485667	0.356	0.230333	0.189	0.181667
0.552333	0.435	0.252667	0.198	0.188333
0.629	0.530667	0.280333	0.208	0.195667
0.706	0.617333	0.316667	0.220667	0.204
0.78	0.685333	0.357	0.235333	0.214333
0.848	0.739333	0.402	0.251	0.225667
0.91	0.787	0.453667	0.269667	0.239667
0.965667	0.83	0.505667	0.29	0.254667
1.014	0.867667	0.554	0.311333	0.271333
1.055333	0.901	0.594667	0.334333	0.289
1.091667	0.932667	0.629667	0.358667	0.308
1.126333	0.959333	0.659667	0.383	0.327667
1.156667	0.984333	0.686667	0.408	0.347667
1.188333	1.006667	0.711667	0.433	0.368667
1.216	1.028333	0.734	0.457333	0.390333
1.233333	1.047	0.755333	0.481667	0.412
1.234	1.064667	0.774667	0.506333	0.434333
1.229	1.082667	0.792	0.53	0.457333
1.221333	1.097667	0.808	0.551	0.48
1.215	1.112667	0.822333	0.572333	0.503
1.21	1.126	0.835	0.591	0.526333
1.207	1.139	0.847333	0.608	0.55
1.202	1.152	0.859333	0.624333	0.573333
1.201333	1.163	0.870667	0.639333	0.596333
1.201667	1.174667	0.880333	0.654333	0.619
1.193	1.185333	0.89	0.668333	0.642
1.139	1.195667	0.900667	0.681667	0.663667
1.121667	1.204667	0.911	0.695	0.685333
1.096667	1.214333	0.921667	0.706667	0.705333

Table B48. Continued

1.040333	1.221333	0.931	0.719	0.725667
0.951	1.225667	0.940667	0.730667	0.745
0.926333	1.228	0.950333	0.740667	0.764
0.905	1.229667	0.960333	0.751667	0.782667
0.885667	1.231	0.969667	0.761667	0.800667
0.843	1.231	0.979	0.772	0.817667
0.834667	1.233	0.988	0.782	0.834
0.827333	1.233667	0.997	0.791333	0.849667
0.835667	1.234	1.005333	0.800333	0.865
0.846	1.234667	1.013	0.809667	0.877667
0.851333	1.234667	1.021667	0.819333	0.890333
0.863333	1.235	1.028667	0.827667	0.902
0.865667	1.236333	1.035	0.837	0.913333
0.869333	1.237	1.039	0.845	0.923333
0.868333	1.237667	1.042333	0.853333	0.933
0.875667	1.238	1.043667	0.861	0.943333
0.877333	1.239	1.046	0.868333	0.951
0.879	1.239667	1.047333	0.876	0.959333
0.883333	1.240667	1.048333	0.882333	0.967
0.880333	1.240667	1.049	0.89	0.973333
0.887	1.241333	1.049333	0.896667	0.979333
0.891333	1.242	1.050333	0.903667	0.986333
0.899	1.242	1.051667	0.908	0.991333
0.891667	1.243333	1.053	0.914	0.996667
0.904667	1.244333	1.054	0.919	1.001
0.901667	1.245667	1.055333	0.924667	1.005333
0.909667	1.246	1.056	0.930333	1.011
0.909667	1.246667	1.057	0.934667	1.014667
0.907333	1.247	1.057667	0.938333	1.019
0.904	1.247667	1.058667	0.942667	1.021667
0.901	1.247667	1.059667	0.946	1.024
0.901667	1.249333	1.060667	0.950333	1.025333
0.898333	1.249333	1.062	0.954	1.027
0.901	1.251	1.063	0.957	1.027667

Table B49. Standard deviations of Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 216 in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.006557	0.002887	0.003215	0.002517	0.003215
0.024021	0.004933	0.002646	0.006	0.002887
0.028431	0.005508	0.002646	0.007	0.004933
0.032741	0.005508	0.002887	0.006506	0.003512
0.03691	0.006658	0.003215	0.007	0.003512
0.043555	0.007234	0.002887	0.007506	0.003215
0.052291	0.00781	0.002887	0.007506	0.003606
0.067545	0.008386	0.003464	0.008505	0.003606
0.087843	0.008386	0.003464	0.008505	0.004163
0.103722	0.010392	0.004619	0.009	0.004726
0.118056	0.013077	0.004619	0.009	0.004726
0.132742	0.015716	0.004933	0.01	0.005132
0.147713	0.018717	0.006351	0.011	0.005686
0.160586	0.019732	0.007506	0.011015	0.007211
0.168217	0.020551	0.00781	0.012503	0.007767
0.174897	0.020502	0.00866	0.013528	0.008327
0.179209	0.020809	0.010116	0.015011	0.009074
0.180705	0.020809	0.011015	0.016523	0.008963
0.180867	0.021079	0.011358	0.018037	0.010116
0.180306	0.020785	0.01193	0.019502	0.01044
0.178304	0.021079	0.012858	0.022008	0.011358
0.177664	0.020502	0.01365	0.023516	0.011719
0.176143	0.01963	0.01365	0.026	0.012662
0.175745	0.020207	0.01365	0.028	0.012897
0.172939	0.01963	0.014933	0.030501	0.014012
0.170227	0.019925	0.014364	0.032501	0.014422
0.169337	0.019348	0.015503	0.034005	0.015275
0.169832	0.019348	0.015875	0.035	0.015631
0.168776	0.018475	0.015875	0.035511	0.016703
0.167654	0.017616	0.016503	0.036529	0.017692
0.163117	0.017321	0.015133	0.03759	0.018877
0.157086	0.017321	0.015535	0.038039	0.019313
0.150662	0.017321	0.015535	0.039068	0.020207
0.140472	0.017321	0.015275	0.039068	0.021197
0.136445	0.016743	0.015822	0.040067	0.022913
0.124964	0.016166	0.016371	0.040067	0.02358
0.108862	0.016743	0.015275	0.04055	0.02442
0.131154	0.015885	0.015716	0.040583	0.025541

Table B49. Continued

0.154079	0.016197	0.015631	0.040673	0.026274
0.140536	0.016289	0.017088	0.04015	0.028537
0.174897	0.016258	0.016042	0.041102	0.029866
0.244246	0.016371	0.01601	0.040104	0.030643
0.278878	0.016803	0.01701	0.040104	0.03166
0.286701	0.017349	0.016503	0.040673	0.03247
0.298456	0.016703	0.017	0.040583	0.034122
0.31012	0.016703	0.017	0.040583	0.034655
0.322655	0.016166	0.017	0.040624	0.035796
0.315921	0.016703	0.017502	0.039627	0.036387
0.307264	0.017156	0.017521	0.040104	0.037581
0.304009	0.016563	0.017502	0.039068	0.039703
0.299537	0.016093	0.017502	0.039107	0.041677
0.30275	0.016623	0.017692	0.039154	0.042336
0.303335	0.0151	0.016371	0.04015	0.043247
0.319038	0.015177	0.015695	0.039627	0.044508
0.295619	0.015716	0.015308	0.038588	0.046307
0.293778	0.016093	0.015716	0.03807	0.046508
0.295772	0.01701	0.015503	0.038588	0.047438
0.290658	0.016563	0.016442	0.038631	0.048775
0.290197	0.016166	0.015875	0.038158	0.049339
0.271796	0.016042	0.015503	0.037687	0.050521
0.254547	0.015524	0.014572	0.037687	0.0527
0.241919	0.016523	0.014224	0.03759	0.054372
0.247227	0.015631	0.014799	0.03759	0.05493
0.21259	0.016623	0.015716	0.03759	0.055749
0.186441	0.015567	0.015503	0.037112	0.057274
0.170089	0.016093	0.015716	0.037634	0.057689
0.153692	0.014572	0.015716	0.037112	0.058106
0.133979	0.016093	0.016073	0.037634	0.059925
0.112942	0.01701	0.016073	0.037554	0.058046
0.096234	0.016563	0.015948	0.038158	0.058924
0.085582	0.017039	0.016073	0.037072	0.058192
0.079425	0.016042	0.016643	0.03759	0.058284
0.076217	0.017088	0.016643	0.036042	0.057744

Table B50. Averages of raw data from microtiter plate reader experiments for *Z. rouxii* in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.128667	0.135667	0.134667	0.127333	0.135667
0.137333	0.140333	0.139	0.145	0.143333
0.148	0.145	0.143333	0.150667	0.148333
0.166667	0.151333	0.145	0.153667	0.151
0.195667	0.152667	0.147	0.156333	0.152333
0.232667	0.154667	0.148667	0.158333	0.153667
0.28	0.155333	0.149667	0.16	0.155
0.338	0.156333	0.150667	0.161333	0.155333
0.406333	0.156333	0.151333	0.162333	0.155667
0.483	0.156667	0.151667	0.163333	0.156333
0.561	0.157	0.152333	0.164333	0.157
0.634667	0.157333	0.152333	0.165333	0.157667
0.702	0.157667	0.152667	0.166	0.158333
0.760333	0.157667	0.153333	0.166333	0.158333
0.812333	0.157667	0.153	0.167333	0.159333
0.859667	0.157667	0.153	0.167667	0.159333
0.898333	0.158	0.153	0.168333	0.159333
0.934667	0.157667	0.153333	0.168667	0.159333
0.968	0.158	0.153333	0.168667	0.159667
0.994333	0.158	0.153333	0.169	0.16
1.019667	0.158667	0.153333	0.169333	0.160333
1.041667	0.158333	0.153667	0.169333	0.16
1.062	0.158333	0.153333	0.169333	0.160333
1.076333	0.158333	0.153667	0.169667	0.160333
1.089333	0.158333	0.153333	0.169333	0.159667
1.096667	0.158667	0.154	0.169333	0.160333
1.099	0.158667	0.154	0.169667	0.160333
1.100667	0.158667	0.153333	0.169333	0.160333
1.099667	0.158333	0.153667	0.17	0.160333
1.097	0.158333	0.153333	0.170333	0.16
1.095333	0.158667	0.153667	0.169333	0.160667
1.092667	0.158333	0.153667	0.17	0.16
1.092	0.159667	0.153333	0.169667	0.16
1.089	0.158333	0.153333	0.170333	0.160333
1.088	0.158667	0.153	0.17	0.16
1.085667	0.159667	0.153	0.170333	0.160333
1.084667	0.158667	0.153	0.169667	0.159667
1.083333	0.158333	0.153333	0.170333	0.160333
1.082	0.158333	0.152667	0.17	0.16

Table B50. Continued

1.081333	0.159333	0.153333	0.170333	0.16
1.080667	0.158	0.152667	0.170333	0.16
1.079667	0.157667	0.152667	0.17	0.16
1.079333	0.158	0.153	0.17	0.159667
1.079333	0.158333	0.152	0.17	0.159667
1.078667	0.157667	0.152	0.17	0.159667
1.078	0.157667	0.151667	0.170333	0.159667
1.077333	0.157333	0.151667	0.17	0.159667
1.078333	0.157667	0.152333	0.170333	0.159667
1.077333	0.157667	0.152	0.170333	0.159667
1.077	0.157333	0.151667	0.170333	0.159667
1.077	0.157333	0.151333	0.170333	0.159667
1.077667	0.157667	0.151333	0.170333	0.16
1.077333	0.157333	0.151333	0.170333	0.159667
1.077333	0.157667	0.151667	0.170333	0.159667
1.077	0.157333	0.151	0.170333	0.159667
1.077333	0.157333	0.151333	0.170333	0.159667
1.076667	0.157333	0.151333	0.170667	0.159667
1.077667	0.158333	0.150667	0.170333	0.159667
1.077333	0.157333	0.150667	0.170333	0.159667
1.077667	0.157333	0.150667	0.170667	0.16
1.079	0.157	0.150667	0.170667	0.159667
1.080667	0.156667	0.150333	0.170667	0.159667
1.082333	0.156667	0.15	0.170333	0.159667
1.085	0.157	0.150333	0.170667	0.159667
1.086	0.157	0.15	0.170667	0.159667
1.087333	0.156667	0.15	0.170333	0.159667
1.088	0.156667	0.150333	0.170667	0.159667
1.089333	0.157333	0.150667	0.170333	0.159
1.091	0.156667	0.150667	0.170667	0.159667
1.092333	0.156333	0.15	0.170667	0.159667
1.093333	0.156333	0.149	0.170667	0.159333
1.094667	0.156333	0.149	0.170667	0.16
1.095667	0.156	0.149333	0.170667	0.159333

Table B51. Standard deviations of Averages of raw data from microtiter plate reader experiments for *Z. rouxii* in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.004041	0.001528	0.001528	0.001155	0.004163
0.004163	0.000577	0.002646	0.001732	0.006429
0.006245	0.001	0.002887	0.002082	0.005508
0.008083	0.001528	0.002646	0.002082	0.004359
0.009815	0.001528	0.002646	0.002517	0.003786
0.013317	0.001155	0.003215	0.002517	0.004163
0.020075	0.001528	0.003215	0.002	0.003606
0.030806	0.001528	0.003215	0.002517	0.004726
0.043558	0.001528	0.003786	0.002517	0.004163
0.050922	0.001528	0.003215	0.002517	0.004726
0.054525	0.002	0.003786	0.002517	0.004359
0.059248	0.001528	0.003786	0.002517	0.004933
0.06245	0.001528	0.003215	0.002	0.004726
0.063256	0.001528	0.003786	0.002517	0.004726
0.063256	0.001528	0.003606	0.002517	0.004726
0.063815	0.001528	0.003606	0.002082	0.004726
0.062051	0.001	0.003606	0.002517	0.004726
0.066335	0.001528	0.003055	0.002082	0.004726
0.061294	0.001	0.003055	0.002517	0.004933
0.06426	0.001	0.003055	0.002	0.004359
0.063571	0.001528	0.003055	0.002517	0.004726
0.065493	0.001528	0.003215	0.002517	0.004359
0.065391	0.001528	0.003055	0.002517	0.004726
0.06426	0.001528	0.003215	0.002082	0.004726
0.063122	0.001528	0.003055	0.002517	0.004933
0.064291	0.001528	0.002646	0.002517	0.004726
0.0652	0.001528	0.003606	0.002517	0.004726
0.066161	0.001528	0.003055	0.002517	0.004726
0.067099	0.001528	0.003512	0.003	0.004726
0.067668	0.001528	0.003055	0.002517	0.005292
0.068237	0.001528	0.003215	0.002517	0.003215
0.06787	0.001528	0.003215	0.002	0.005292
0.067506	0.001528	0.003055	0.003055	0.005292
0.066573	0.001528	0.003055	0.002517	0.004726
0.067357	0.001528	0.003606	0.002646	0.004359
0.068646	0.001528	0.003606	0.002517	0.004726
0.06787	0.001528	0.003606	0.002517	0.004933
0.068237	0.001528	0.004041	0.002517	0.004726

Table B51. Continued

0.067506	0.001528	0.003512	0.002	0.004359
0.0673	0.001155	0.002517	0.002517	0.004359
0.068646	0.001	0.003215	0.002517	0.004359
0.068646	0.001528	0.002517	0.002	0.004359
0.068076	0.001	0.003	0.002	0.004933
0.068857	0.000577	0.003606	0.002	0.004933
0.068646	0.001528	0.003	0.002	0.004933
0.06844	0.001528	0.003512	0.002517	0.004933
0.068237	0.001528	0.003512	0.002	0.004933
0.068237	0.001528	0.003055	0.002517	0.004933
0.068237	0.001528	0.003606	0.002517	0.004933
0.068608	0.001528	0.003512	0.002517	0.004933
0.068608	0.001528	0.003055	0.002517	0.004933
0.068981	0.001528	0.003055	0.002517	0.005292
0.069357	0.001528	0.003055	0.002517	0.004933
0.069357	0.001528	0.002517	0.002517	0.004933
0.069735	0.001528	0.003	0.002517	0.004933
0.069357	0.001528	0.003055	0.002517	0.004933
0.070117	0.001528	0.003055	0.002517	0.004933
0.06842	0.001155	0.003512	0.002517	0.004933
0.069551	0.001528	0.003512	0.002517	0.004933
0.069169	0.001528	0.003512	0.002517	0.004359
0.06879	0.001	0.003512	0.002517	0.004933
0.068981	0.001528	0.003055	0.002517	0.004933
0.069357	0.001528	0.003	0.002517	0.004933
0.069735	0.001	0.003055	0.002082	0.004933
0.069549	0.001	0.003	0.002082	0.004933
0.069551	0.001528	0.003	0.002517	0.004163
0.069936	0.001528	0.003055	0.002082	0.004933
0.070501	0.001528	0.002517	0.002517	0.005292
0.069735	0.001528	0.003512	0.002082	0.004933
0.070302	0.001528	0.003	0.002082	0.004933
0.070501	0.001528	0.003	0.002082	0.004726
0.070323	0.001528	0.003	0.002082	0.004359
0.070543	0.002	0.003512	0.002082	0.004726

Table B52. Averages of raw data from microtiter plate reader experiments for *Z. bailii* 159 in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.136667	0.144667	0.145	0.132333	0.132
0.135333	0.143333	0.150333	0.142667	0.139333
0.147333	0.149667	0.154	0.147	0.142
0.178667	0.160333	0.157333	0.150333	0.143667
0.23	0.178667	0.161333	0.152667	0.144333
0.288333	0.206	0.164667	0.156333	0.145333
0.327	0.237667	0.168333	0.157333	0.145667
0.452	0.267333	0.172	0.159333	0.146667
0.513667	0.314667	0.175667	0.161	0.146667
0.548	0.392	0.178667	0.162667	0.147333
0.554	0.464667	0.181667	0.164667	0.147333
0.540667	0.530667	0.183667	0.166	0.147667
0.544333	0.581	0.185667	0.166333	0.147667
0.552667	0.622333	0.187333	0.168333	0.148
0.536667	0.671667	0.188333	0.169333	0.148667
0.524333	0.713667	0.189	0.17	0.148667
0.528667	0.757	0.189667	0.170333	0.148667
0.526	0.799333	0.19	0.170333	0.148667
0.513667	0.823333	0.190333	0.171333	0.149
0.505	0.842333	0.190667	0.171333	0.149333
0.501	0.834333	0.191	0.171333	0.149667
0.497	0.829667	0.191333	0.172333	0.149
0.489	0.821333	0.191	0.171667	0.149667
0.487	0.825667	0.191333	0.172333	0.149667
0.484667	0.811333	0.191333	0.172	0.149333
0.478667	0.801333	0.192	0.172667	0.149667
0.479	0.801333	0.192	0.173	0.149667
0.469667	0.806333	0.191667	0.172667	0.149667
0.471	0.797667	0.191667	0.173	0.149667
0.471667	0.791333	0.191333	0.172667	0.149667
0.462	0.796667	0.191667	0.172667	0.149667
0.453667	0.793333	0.191333	0.172667	0.15
0.449333	0.796333	0.191333	0.172667	0.149667
0.445667	0.788	0.191	0.172667	0.149667
0.452333	0.783333	0.191	0.173	0.149667
0.448667	0.78	0.191	0.172667	0.149667
0.441	0.788333	0.191	0.172667	0.149667
0.439333	0.776333	0.191	0.173	0.15
0.437	0.784	0.191	0.172667	0.149667

Table B52. Continued

0.426333	0.778667	0.191	0.172667	0.149667
0.422	0.778333	0.190333	0.173	0.149667
0.418	0.781333	0.191	0.171667	0.149667
0.413667	0.777333	0.190667	0.172	0.15
0.411333	0.777333	0.190333	0.171667	0.15
0.405	0.775333	0.19	0.172333	0.15
0.409	0.771667	0.19	0.171667	0.149667
0.397667	0.775333	0.19	0.172	0.149667
0.401333	0.773	0.19	0.172	0.15
0.397333	0.775	0.189667	0.172333	0.150333
0.396333	0.773	0.189667	0.172	0.15
0.394333	0.774333	0.189667	0.172	0.149667
0.387	0.765333	0.189667	0.172	0.15
0.384	0.769	0.189667	0.172333	0.149667
0.378	0.768333	0.19	0.172	0.15
0.384	0.766333	0.189333	0.173	0.150667
0.375667	0.767333	0.189333	0.173333	0.150333
0.364	0.762	0.189	0.173333	0.151
0.343333	0.767667	0.188667	0.173	0.150333
0.346	0.769333	0.189	0.173	0.150667
0.345	0.762333	0.189	0.173	0.150333
0.344	0.763667	0.189	0.173	0.150667
0.346667	0.769333	0.188667	0.173	0.150333
0.341	0.759	0.188333	0.172333	0.15
0.345	0.764	0.188333	0.172	0.15
0.34	0.763333	0.188333	0.172667	0.149667
0.332667	0.758	0.188333	0.172	0.149667
0.321	0.765667	0.188333	0.172333	0.15
0.319	0.763667	0.188333	0.172333	0.149667
0.313667	0.765333	0.188	0.172333	0.15
0.309333	0.755	0.188	0.172667	0.149667
0.300333	0.757333	0.188	0.172333	0.149667
0.299	0.758333	0.187667	0.172667	0.15
0.304667	0.761667	0.187333	0.172667	0.149667

Table B53. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. bailii* 159 in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.005132	0.003512	0.001732	0.000577	0.001
0.009074	0.003512	0.011372	0.004619	0.001528
0.01097	0.004041	0.012767	0.005196	0.002
0.014978	0.005132	0.014012	0.005774	0.002082
0.017692	0.006429	0.015695	0.007234	0.001528
0.010599	0.009539	0.017214	0.009238	0.001528
0.074719	0.013279	0.018339	0.010116	0.002082
0.035086	0.013317	0.020421	0.011015	0.002082
0.055194	0.017673	0.022502	0.011269	0.002082
0.081835	0.011269	0.024194	0.01159	0.001528
0.110802	0.021733	0.025891	0.01159	0.001528
0.148598	0.021572	0.027592	0.012166	0.002082
0.162457	0.019975	0.029297	0.012741	0.002082
0.186822	0.028219	0.030436	0.012741	0.002
0.211666	0.026558	0.031374	0.012741	0.002082
0.217295	0.032316	0.031575	0.013	0.002082
0.218436	0.027875	0.031943	0.012741	0.002082
0.221502	0.031896	0.032512	0.01365	0.002082
0.231485	0.025482	0.032146	0.01365	0.002646
0.234955	0.023714	0.032716	0.01365	0.002517
0.238218	0.031628	0.032512	0.01365	0.002082
0.23759	0.027465	0.033081	0.01365	0.002
0.239858	0.031214	0.032512	0.014364	0.002082
0.238434	0.018771	0.033081	0.01365	0.002082
0.24071	0.032655	0.033081	0.014	0.002517
0.24661	0.028919	0.032512	0.014224	0.002082
0.248137	0.021548	0.032512	0.013892	0.002082
0.238856	0.02558	0.032884	0.014224	0.002082
0.233352	0.017616	0.032716	0.013892	0.002082
0.233868	0.020306	0.033081	0.014224	0.002082
0.230788	0.025325	0.032716	0.014224	0.002082
0.227478	0.016258	0.033081	0.014224	0.002646
0.221825	0.026312	0.032316	0.014224	0.002082
0.219778	0.021656	0.032512	0.014224	0.002082
0.217601	0.018009	0.032512	0.014	0.002082
0.220876	0.024021	0.032512	0.014224	0.002082
0.216839	0.031786	0.032512	0.014224	0.002082
0.209605	0.026312	0.032512	0.014	0.002646

Table B53. Continued

0.208	0.020881	0.032512	0.014224	0.002082
0.198155	0.01823	0.032512	0.014224	0.002082
0.197659	0.023861	0.032146	0.014	0.002082
0.192385	0.023692	0.032512	0.015308	0.002082
0.175671	0.020599	0.031943	0.015133	0.002646
0.171308	0.024338	0.032316	0.015308	0.002646
0.16825	0.021362	0.032512	0.015695	0.002646
0.172044	0.024007	0.032512	0.015308	0.002082
0.158481	0.010786	0.032512	0.015133	0.002082
0.159001	0.027731	0.032512	0.015133	0.002646
0.165802	0.019975	0.031943	0.015695	0.002517
0.16002	0.01562	0.031943	0.015133	0.002646
0.155362	0.021962	0.031943	0.015133	0.002082
0.159549	0.023756	0.031943	0.015133	0.002646
0.146891	0.017321	0.031943	0.015695	0.002082
0.141481	0.020744	0.031749	0.015133	0.002646
0.146734	0.017954	0.031374	0.015133	0.002082
0.139055	0.010017	0.031374	0.014742	0.002517
0.119512	0.008718	0.031749	0.015695	0.002646
0.091741	0.010116	0.031943	0.015133	0.002517
0.08454	0.02318	0.031749	0.015133	0.002082
0.090266	0.021733	0.031575	0.015133	0.002517
0.085773	0.017926	0.031749	0.015133	0.002082
0.086048	0.016803	0.031943	0.015133	0.002517
0.075425	0.016523	0.031374	0.015695	0.002646
0.077078	0.01253	0.031374	0.015133	0.002646
0.078352	0.011372	0.031374	0.015308	0.002082
0.069573	0.012288	0.031374	0.015133	0.002082
0.058043	0.021455	0.031374	0.015695	0.002646
0.05557	0.023029	0.031374	0.015695	0.002082
0.034064	0.016862	0.030806	0.015695	0.002646
0.03876	0.008888	0.030806	0.015308	0.002082
0.026102	0.019425	0.031749	0.015695	0.002082
0.025515	0.014189	0.031182	0.015308	0.002646
0.023007	0.017039	0.031374	0.015308	0.002082

Table B54. Averages of raw data from microtiter plate reader experiments for *Z. bailii* 158 in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.231667	0.197333	0.181667	0.162667	0.177667
0.221667	0.203333	0.208667	0.192667	0.193667
0.245667	0.206	0.202	0.213	0.192667
0.304667	0.212667	0.199	0.209667	0.191333
0.398667	0.217	0.196667	0.201333	0.19
0.526667	0.220333	0.196	0.207	0.189667
0.667	0.223	0.196333	0.213	0.189
0.779	0.226	0.195667	0.214667	0.188333
0.850667	0.227667	0.194333	0.218333	0.188
0.912	0.229667	0.194	0.219	0.187333
0.948667	0.231	0.193667	0.214	0.188
0.979333	0.232333	0.192667	0.211	0.186333
1.005333	0.234	0.192	0.208667	0.186
1.021667	0.235333	0.191667	0.208	0.185667
1.035333	0.237333	0.191	0.206333	0.185333
1.028333	0.238667	0.190333	0.206	0.184333
1.022667	0.239667	0.190333	0.205333	0.183667
1.020333	0.240333	0.189	0.204333	0.183333
1.008333	0.242333	0.188667	0.203667	0.181667
1.003667	0.243333	0.188	0.203333	0.181333
0.994	0.244667	0.187333	0.203333	0.181667
0.984333	0.246	0.187	0.203	0.180333
0.979333	0.247333	0.186333	0.202	0.179
0.975333	0.248333	0.186	0.201333	0.178667
0.969333	0.249667	0.186	0.200667	0.177333
0.960667	0.251333	0.185667	0.201333	0.177667
0.959667	0.252667	0.185667	0.200667	0.177333
0.949	0.253667	0.185667	0.200667	0.177
0.95	0.255	0.185667	0.200333	0.176333
0.942	0.256	0.185	0.199667	0.176333
0.936667	0.257333	0.185	0.199667	0.175333
0.932333	0.258333	0.184	0.199333	0.175
0.930333	0.259667	0.185	0.199	0.175333
0.929	0.260667	0.184333	0.198667	0.174667
0.920667	0.262	0.184333	0.199	0.175333
0.919667	0.262333	0.183667	0.199	0.174
0.911	0.263333	0.184	0.198333	0.173
0.912	0.264667	0.184	0.198333	0.173667
0.907333	0.265333	0.183333	0.198	0.173

Table B54. Continued

0.907333	0.268333	0.183667	0.197667	0.173333
0.900333	0.269	0.183667	0.197667	0.172667
0.897667	0.271	0.184	0.197667	0.173
0.894	0.274	0.183333	0.197667	0.173
0.893	0.278333	0.184	0.197667	0.171333
0.890333	0.281	0.183	0.197667	0.171667
0.891333	0.286333	0.183333	0.197333	0.171333
0.882	0.294	0.183	0.197	0.172333
0.883667	0.303333	0.182333	0.196333	0.171333
0.878333	0.312667	0.182333	0.196333	0.171
0.875667	0.329667	0.182667	0.196667	0.170333
0.881667	0.349	0.182667	0.195667	0.17
0.875	0.366	0.182667	0.196	0.17
0.875333	0.395667	0.182333	0.195667	0.17
0.873333	0.422667	0.182333	0.195667	0.17
0.875333	0.446667	0.182	0.196667	0.171
0.871667	0.479333	0.181667	0.195667	0.171
0.873333	0.507333	0.181667	0.196	0.170667
0.873333	0.535667	0.181667	0.195	0.170667
0.871	0.572	0.181333	0.195333	0.17
0.870667	0.598667	0.180667	0.195	0.17
0.868333	0.628333	0.180333	0.195667	0.170333
0.871333	0.658333	0.180333	0.195	0.17
0.872	0.684	0.18	0.193333	0.168
0.871	0.709	0.179667	0.193333	0.168
0.868667	0.733667	0.179	0.193	0.168
0.871667	0.750333	0.179	0.194333	0.167333
0.872667	0.76	0.179	0.192667	0.167333
0.872667	0.762	0.178333	0.192667	0.166667
0.873333	0.771	0.178333	0.192333	0.167333
0.872667	0.778	0.177333	0.191333	0.166667
0.872667	0.770333	0.178	0.191667	0.166667
0.877	0.778333	0.176667	0.191	0.167
0.876333	0.782667	0.177667	0.190333	0.167333

Table B55. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. bailii* 158 in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.046694	0.018771	0.002517	0.004041	0.004509
0.045764	0.022745	0.005033	0.012897	0.002309
0.052291	0.022605	0.004583	0.027785	0.003215
0.065056	0.023159	0.003606	0.016197	0.002082
0.08107	0.023302	0.004619	0.01106	0.003
0.089366	0.023714	0.004359	0.013454	0.001528
0.081	0.023302	0.003215	0.01833	0.001732
0.060225	0.024021	0.004726	0.014154	0.001155
0.04055	0.024583	0.004509	0.010263	0.001732
0.023302	0.024826	0.004	0.011533	0.001155
0.009074	0.02498	0.004041	0.007937	3.4E-17
0.01159	0.025384	0.004509	0.006083	0.000577
0.009713	0.025239	0.004	0.004509	0.001
0.017388	0.025658	0.003512	0.004	0.001155
0.016503	0.024685	0.003606	0.003512	0.000577
0.012583	0.025106	0.003055	0.003606	0.001155
0.015948	0.025106	0.003512	0.003512	0.001528
0.015535	0.025658	0.003606	0.004509	0.002082
0.010599	0.025658	0.004163	0.004509	0.001528
0.015044	0.026633	0.004359	0.004041	0.001155
0.013748	0.027062	0.004726	0.004041	0.001528
0.013013	0.027185	0.004583	0.004583	0.001155
0.011846	0.02761	0.004726	0.004583	0.001
0.011676	0.02761	0.005292	0.004509	0.000577
0.011372	0.028042	0.005292	0.004509	0.001528
0.005508	0.028589	0.004163	0.004726	0.001155
0.002887	0.029023	0.004933	0.003512	0.001528
0.005292	0.029023	0.004163	0.004163	0.001
0.004359	0.029462	0.005132	0.004509	0.001528
0.005568	0.029462	0.005292	0.003512	0.001528
0.006807	0.030551	0.005292	0.004163	0.001528
0.007234	0.030551	0.005292	0.004041	0.002
0.007024	0.030989	0.004583	0.004583	0.001528
0.007211	0.030989	0.004726	0.004509	0.002082
0.010693	0.030447	0.004726	0.004	0.001528
0.009452	0.031533	0.004041	0.004	0.002
0.007937	0.030892	0.003464	0.004509	0.002
0.010817	0.030353	0.003464	0.004509	0.002082

Table B55. Continued

0.012423	0.030892	0.002887	0.005	0.002
0.010693	0.02928	0.003215	0.005033	0.002517
0.008145	0.028213	0.004041	0.005033	0.002517
0.010408	0.028213	0.002646	0.004509	0.002
0.008718	0.024062	0.002887	0.004509	0.003606
0.00755	0.020502	0.002646	0.004509	0.002082
0.009815	0.017521	0.001732	0.004509	0.002517
0.013317	0.014012	0.002082	0.005033	0.002082
0.013	0.008544	0.001732	0.004583	0.003512
0.014468	0.008021	0.002082	0.004726	0.002082
0.010786	0.013614	0.002082	0.004726	0.002
0.013577	0.029023	0.001528	0.005132	0.002082
0.012741	0.045924	0.001528	0.005132	0.002646
0.014422	0.058387	0.001528	0.004583	0.002646
0.013614	0.080959	0.001528	0.004933	0.002646
0.015011	0.092738	0.001528	0.004933	0.002646
0.01124	0.104314	0.001732	0.004933	0.002646
0.011846	0.125285	0.001528	0.004509	0.002646
0.008145	0.135975	0.000577	0.004583	0.002309
0.009074	0.147842	0.001155	0.004583	0.002517
0.008888	0.162936	0.000577	0.005033	0.002646
0.009238	0.166884	0.001528	0.004583	0.002646
0.009609	0.172062	0.001528	0.005132	0.002082
0.008145	0.170016	0.001155	0.004583	0.002646
0.008888	0.169767	0.002	0.004726	0.002646
0.011358	0.170696	0.002517	0.004726	0.002646
0.010116	0.155565	0.002	0.004359	0.002646
0.010408	0.145332	0.002	0.006429	0.002887
0.009238	0.136865	0.002	0.004933	0.003055
0.010116	0.128421	0.002517	0.004933	0.003215
0.01193	0.116889	0.003055	0.005508	0.003786
0.009074	0.109503	0.003055	0.005508	0.003215
0.008505	0.09711	0.003606	0.005774	0.003215
0.007937	0.08837	0.003512	0.005196	0.003606
0.007234	0.082343	0.003215	0.004726	0.004041

Table B56. Averages of raw data from microtiter plate reader experiments for *K. lactis* in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.097667	0.106333	0.107	0.102	0.101667
0.099333	0.108	0.112667	0.103667	0.101667
0.101333	0.108667	0.115	0.105	0.102
0.108	0.109667	0.116	0.105333	0.102333
0.126	0.110333	0.116333	0.106	0.102
0.16	0.111	0.116333	0.106	0.102
0.213	0.112333	0.116667	0.105667	0.102
0.286	0.113667	0.117	0.105667	0.102
0.380667	0.114667	0.117	0.105667	0.102
0.487	0.116	0.117	0.105667	0.102
0.586667	0.116667	0.117	0.105667	0.102
0.672667	0.117667	0.117	0.105333	0.102
0.736667	0.118667	0.116667	0.105333	0.101667
0.786	0.119667	0.116667	0.105	0.101667
0.806	0.120667	0.116333	0.105	0.101
0.852	0.121333	0.116333	0.105	0.101667
0.856	0.121333	0.116333	0.105	0.101333
0.646667	0.122333	0.116667	0.105	0.101
0.686333	0.122333	0.116	0.105	0.101
0.719	0.123333	0.116	0.105	0.101
0.759333	0.123667	0.116	0.104667	0.101
0.806333	0.123667	0.116	0.104667	0.101
0.697	0.124	0.115667	0.105	0.101
0.692	0.124667	0.115333	0.105	0.100667
0.689667	0.124667	0.115667	0.105	0.100667
0.722	0.125	0.115333	0.105	0.100667
0.737	0.125667	0.115333	0.105	0.100667
0.764	0.126667	0.115333	0.104667	0.100667
0.778667	0.127667	0.115	0.104	0.100333
0.773667	0.128667	0.115	0.104667	0.101333
0.801	0.129667	0.115333	0.104333	0.101333
0.882	0.131333	0.115	0.105	0.101333
0.902667	0.135333	0.115	0.104333	0.101333
0.935667	0.139667	0.115	0.104	0.101
0.951	0.144667	0.115	0.104333	0.101
0.971667	0.149	0.114667	0.104	0.101
0.985333	0.159	0.115	0.104667	0.101
1.002	0.170667	0.114667	0.104	0.101
1.007	0.181	0.114667	0.104	0.101

Table B56. Continued

1.017333	0.198333	0.114333	0.104333	0.100667
1.024	0.22	0.114333	0.104	0.100667
1.046	0.244333	0.114333	0.104	0.100667
1.051333	0.279	0.114333	0.104	0.100667
1.062667	0.305667	0.114333	0.104	0.100667
1.065667	0.351	0.114333	0.104	0.101
1.07	0.395333	0.113667	0.104	0.100667
1.077333	0.442	0.114333	0.104	0.100667
1.103333	0.486333	0.114	0.104	0.100333
1.104	0.522333	0.113667	0.104	0.100667
1.123667	0.546333	0.113667	0.104	0.100667
1.119667	0.571	0.113667	0.104	0.100667
1.144667	0.593667	0.113667	0.104	0.100667
1.14	0.614333	0.113667	0.104	0.100333
1.131667	0.630667	0.113667	0.104	0.100333
1.128333	0.626	0.113333	0.104	0.1
1.131333	0.641333	0.113	0.104	0.1
1.117333	0.63	0.113333	0.104	0.1
1.123667	0.637	0.113	0.104	0.1
1.131333	0.643	0.113	0.104	0.100333
1.139	0.649	0.113	0.104	0.1
1.145	0.645	0.113	0.104	0.1
1.143667	0.658	0.112667	0.103667	0.099667
1.151667	0.663667	0.113	0.104	0.1
1.159	0.666	0.113	0.104	0.1
1.160333	0.675	0.113	0.104	0.100333
1.171	0.662333	0.112667	0.104	0.1
1.161333	0.669667	0.113	0.104	0.100333
1.154333	0.672333	0.112333	0.103667	0.099667
1.160333	0.676	0.112	0.103333	0.1
1.165	0.665333	0.112	0.103333	0.099667
1.155	0.670333	0.112	0.103667	0.099333
1.153	0.668	0.112	0.103	0.099333
1.164333	0.671333	0.112333	0.103333	0.099333

Table B57. Standard deviations of averages of raw data from microtiter plate reader experiments for *K. lactis* in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.000577	0.000577	0.001	0.002646	0.001155
0.000577	0.001	0.002517	0.004163	0.000577
0.000577	0.000577	0.003	0.004359	0
0.001732	0.000577	0.003	0.003786	0.000577
0.002646	0.000577	0.002517	0.003464	0
0.005292	0	0.002517	0.003464	0
0.009849	0.000577	0.003055	0.004041	0
0.014933	0.000577	0.003	0.004041	0
0.019399	0.000577	0.003	0.004041	0
0.022517	0.001	0.003	0.004041	0
0.022855	0.001155	0.003	0.004041	0
0.024664	0.001155	0.003	0.003786	0
0.028885	0.001155	0.002517	0.003786	0.000577
0.028583	0.001155	0.003055	0.003464	0.000577
0.060655	0.001155	0.002517	0.003464	1.7E-17
0.046701	0.001528	0.002517	0.003464	0.000577
0.103783	0.001528	0.002517	0.003464	0.000577
0.241581	0.001528	0.003055	0.003464	1.7E-17
0.212227	0.001528	0.003	0.003464	1.7E-17
0.205516	0.001528	0.003	0.003464	1.7E-17
0.198016	0.002082	0.003	0.004041	1.7E-17
0.189511	0.002082	0.003	0.004041	1.7E-17
0.080802	0.002	0.003055	0.003464	1.7E-17
0.091848	0.001528	0.002517	0.003464	0.000577
0.125385	0.002517	0.002517	0.003464	0.000577
0.125407	0.002	0.002517	0.003464	0.000577
0.126996	0.003055	0.002517	0.003464	0.000577
0.127079	0.002517	0.002517	0.003215	0.000577
0.126674	0.002082	0.003	0.003464	0.000577
0.159061	0.001528	0.003	0.004041	0.000577
0.153522	0.002309	0.002517	0.002887	0.000577
0.095394	0.001528	0.003	0.003464	0.000577
0.076002	0.003055	0.003	0.003786	0.000577
0.08199	0.003786	0.003	0.003464	1.7E-17
0.063553	0.003215	0.003	0.003786	1.7E-17
0.046264	0.001	0.003055	0.003464	1.7E-17
0.038682	0.001	0.003	0.003215	1.7E-17
0.033779	0.008083	0.003055	0.003464	1.7E-17

Table B57. Continued

0.031225	0.006928	0.003055	0.003464	1.7E-17
0.022898	0.008083	0.002517	0.003786	0.000577
0.037242	0.009539	0.002517	0.003464	0.000577
0.024269	0.011846	0.002517	0.003464	0.000577
0.027227	0.019	0.002517	0.003464	0.000577
0.038889	0.016773	0.002517	0.003464	0.000577
0.0394	0.027185	0.002517	0.003464	1.7E-17
0.033151	0.025541	0.003055	0.003464	0.000577
0.031214	0.024062	0.002517	0.003464	0.000577
0.029569	0.027755	0.003	0.003464	0.000577
0.017	0.027737	0.003055	0.003464	0.000577
0.015822	0.022234	0.003055	0.003464	0.000577
0.005859	0.020809	0.003055	0.003464	0.000577
0.03885	0.03453	0.003055	0.003464	0.000577
0.03851	0.023116	0.003055	0.003464	0.000577
0.033501	0.021825	0.003055	0.003464	0.000577
0.03453	0.018028	0.002517	0.003464	1.7E-17
0.02669	0.017474	0.002646	0.003464	1.7E-17
0.043108	0.025239	0.002517	0.003464	1.7E-17
0.02442	0.020224	0.002646	0.003464	1.7E-17
0.040216	0.021932	0.002646	0.003464	0.000577
0.046872	0.026889	0.002646	0.003464	1.7E-17
0.046808	0.016462	0.002646	0.003464	1.7E-17
0.03371	0.019672	0.003055	0.003215	0.000577
0.044636	0.019757	0.002646	0.003464	1.7E-17
0.058198	0.02506	0.002646	0.003464	1.7E-17
0.053519	0.020518	0.002646	0.003464	0.000577
0.058026	0.01601	0.003055	0.003464	1.7E-17
0.064081	0.012662	0.002646	0.003464	0.000577
0.05523	0.023502	0.003215	0.003215	0.000577
0.047035	0.018	0.002646	0.003786	1.7E-17
0.053357	0.014364	0.002646	0.002887	0.000577
0.052374	0.010017	0.002646	0.003215	0.000577
0.04613	0.018	0.002646	0.003464	0.000577
0.048387	0.010263	0.003215	0.003786	0.000577

Table B58. Averages of raw data from microtiter plate reader experiments for *S. passalidarum* in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.092667	0.103	0.108667	0.102	0.100333
0.093	0.103667	0.126333	0.106333	0.101
0.093333	0.104	0.137333	0.107667	0.102
0.099333	0.104	0.143	0.108	0.102333
0.119	0.104	0.147333	0.108	0.102667
0.161	0.104333	0.15	0.107667	0.102667
0.231667	0.104333	0.152667	0.109333	0.102333
0.314	0.104667	0.154333	0.107667	0.102333
0.407	0.104333	0.155333	0.107667	0.102333
0.494667	0.104667	0.156	0.107667	0.103
0.530667	0.104333	0.156667	0.108	0.102667
0.322	0.104333	0.157	0.107667	0.102667
0.38	0.104667	0.156333	0.108	0.102667
0.460333	0.105	0.156667	0.108333	0.102667
0.554333	0.105333	0.155667	0.108333	0.102667
0.645	0.105	0.154667	0.109	0.102667
0.689	0.105	0.153	0.109667	0.102667
0.714667	0.105333	0.151	0.114	0.103333
0.757333	0.105333	0.148667	0.111	0.103333
0.794333	0.105333	0.145333	0.111667	0.104333
0.821333	0.105667	0.143	0.113	0.104333
0.870333	0.106333	0.144667	0.114667	0.105
0.882	0.107	0.151667	0.116667	0.105667
0.894	0.107667	0.16	0.118	0.107
0.927333	0.108667	0.171333	0.120667	0.107667
0.948667	0.11	0.184667	0.124	0.109667
0.968667	0.110667	0.201333	0.127333	0.110333
0.999	0.112667	0.221	0.131667	0.112
1.015667	0.114667	0.246	0.138333	0.113667
1.055333	0.117667	0.276	0.144667	0.116
1.061	0.119333	0.309	0.151333	0.118
1.114667	0.124667	0.347333	0.159667	0.121333
1.103	0.127667	0.387667	0.169333	0.124667
1.115667	0.133	0.429	0.18	0.128
1.13	0.14	0.476	0.194333	0.132
1.141333	0.146667	0.522	0.21	0.137667
1.164667	0.156667	0.563667	0.228667	0.143667
1.192333	0.174667	0.601	0.248667	0.151333
1.184	0.189333	0.635	0.27	0.159333

Table B58. Continued

1.194333	0.218	0.667667	0.295333	0.170333
1.186667	0.248333	0.698333	0.320667	0.181667
1.197667	0.283	0.727333	0.347333	0.194667
1.193333	0.329333	0.754333	0.375	0.208667
1.192667	0.391333	0.780333	0.402667	0.224
1.196333	0.463	0.804667	0.427333	0.241
1.204	0.539333	0.828	0.451667	0.257
1.201333	0.620333	0.849333	0.473333	0.277
1.202667	0.689667	0.869	0.494667	0.296667
1.198333	0.757667	0.887333	0.514333	0.316333
1.199	0.815333	0.906333	0.535	0.336333
1.208	0.864333	0.922333	0.554333	0.354333
1.207667	0.907	0.937667	0.572333	0.372667
1.209667	0.944333	0.953667	0.591333	0.390333
1.214	0.984	0.967667	0.606667	0.407
1.205667	1.021	0.981667	0.623333	0.424667
1.211667	1.051333	0.993333	0.64	0.441
1.21	1.071	1.006	0.653667	0.457333
1.228667	1.090333	1.018	0.668333	0.474
1.227333	1.098667	1.031667	0.681333	0.489333
1.234	1.107667	1.042	0.695	0.503667
1.231	1.115	1.053333	0.706667	0.517333
1.247333	1.121	1.063667	0.718333	0.530667
1.25	1.122333	1.074333	0.731	0.545667
1.254667	1.128333	1.084	0.742333	0.559
1.260667	1.135333	1.094	0.754667	0.571
1.256	1.135667	1.102667	0.766	0.583667
1.259667	1.142333	1.109333	0.778667	0.593
1.262667	1.143333	1.117	0.788667	0.603333
1.266333	1.143667	1.122	0.799	0.612667
1.26	1.147667	1.126	0.811333	0.623
1.280333	1.144667	1.127667	0.822333	0.630667
1.273333	1.144667	1.129333	0.831667	0.640667
1.286667	1.149667	1.131	0.844	0.649667

Table B59. Standard deviations of averages of raw data from microtiter plate reader experiments for *S. passalidarum* in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001155	0	0.000577	0.001	0.001155
0.001	0.000577	0.02318	0.000577	1.7E-17
0.000577	0	0.036171	0.001528	0
0.001528	0	0.043405	0.001732	0.001155
0.003606	0	0.050003	0.001732	0.000577
0.008888	0.000577	0.054617	0.001528	0.000577
0.017214	0.000577	0.058389	0.003512	0.001155
0.021	0.000577	0.060385	0.001528	0.001155
0.023812	0.000577	0.062115	0.001528	0.001155
0.025384	0.000577	0.063269	0.001528	0.002
0.068574	0.000577	0.06354	0.001732	0.001528
0.062482	0.000577	0.063269	0.001528	0.001528
0.019	0.000577	0.062115	0.001732	0.001528
0.036019	0.001	0.060962	0.001155	0.001528
0.004041	0.000577	0.057501	0.001155	0.001528
0.02488	0	0.053201	0.001732	0.001528
0.018083	0	0.046861	0.001528	0.001528
0.038812	0.000577	0.03995	0.007937	0.002082
0.035233	0.000577	0.030746	0.001732	0.002082
0.035233	0.000577	0.019858	0.002309	0.002517
0.02409	0.000577	0.008544	0.001732	0.002082
0.019035	0.000577	0.004163	0.002309	0.002
0.026058	0.001	0.005132	0.002309	0.002517
0.047508	0.001155	0.005292	0.002646	0.003
0.028042	0.001528	0.006429	0.003215	0.003512
0.030665	0.001	0.006807	0.003606	0.004163
0.029838	0.002082	0.008145	0.004726	0.004509
0.022605	0.002082	0.009539	0.005132	0.005
0.020599	0.003055	0.010392	0.008327	0.005033
0.030665	0.002082	0.012124	0.008505	0.005568
0.014	0.003215	0.013856	0.009815	0.006
0.0727	0.002887	0.014154	0.011015	0.006506
0.019519	0.005686	0.015308	0.012662	0.008021
0.008505	0.005	0.014731	0.014107	0.009
0.022869	0.007	0.015588	0.016166	0.009
0.019757	0.008083	0.01562	0.01852	0.010504
0.018009	0.012097	0.014434	0.022008	0.010504
0.042477	0.017898	0.013	0.026102	0.012503

Table B59. Continued

0.029206	0.02635	0.012124	0.030116	0.015503
0.023692	0.035679	0.011846	0.033975	0.018502
0.031896	0.045786	0.010786	0.037873	0.021008
0.030089	0.056507	0.008145	0.041633	0.025007
0.032393	0.072231	0.005686	0.045398	0.028537
0.045654	0.090782	0.005508	0.048003	0.032787
0.037528	0.100265	0.005508	0.052729	0.037643
0.032047	0.112647	0.005292	0.056695	0.043486
0.038371	0.107858	0.005859	0.059534	0.047823
0.042899	0.114334	0.006	0.061809	0.052348
0.037233	0.10055	0.006028	0.064655	0.056323
0.032357	0.098896	0.006028	0.067668	0.060476
0.03985	0.090235	0.006658	0.069945	0.063721
0.044061	0.081957	0.007095	0.072432	0.067575
0.033501	0.081684	0.00611	0.073704	0.071361
0.043589	0.077582	0.005508	0.077216	0.075147
0.034588	0.080225	0.005508	0.079952	0.079727
0.039311	0.077983	0.007638	0.081099	0.083738
0.03148	0.074907	0.008185	0.083966	0.086153
0.036364	0.06481	0.009539	0.085921	0.090216
0.048993	0.058046	0.008021	0.088455	0.0925
0.048754	0.050521	0.009539	0.090421	0.0965
0.038743	0.039395	0.009074	0.093297	0.100027
0.04729	0.035341	0.009609	0.094537	0.10416
0.042532	0.039804	0.010408	0.095598	0.105761
0.042899	0.040698	0.010583	0.097823	0.108296
0.048128	0.043981	0.01044	0.099229	0.110811
0.04828	0.047878	0.010693	0.100777	0.112216
0.033724	0.042028	0.012858	0.102832	0.115169
0.044287	0.042922	0.0151	0.102832	0.117142
0.046231	0.044163	0.019079	0.105057	0.120451
0.040361	0.038799	0.021071	0.104806	0.123089
0.051733	0.042158	0.024111	0.104673	0.124917
0.046285	0.039954	0.025166	0.105197	0.126342
0.050501	0.042572	0.025632	0.105773	0.129882

Table B60. Averages of raw data from microtiter plate reader experiments for *P. stipitis* in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.094333	0.106333	0.105667	0.098	0.096
0.095667	0.109	0.107	0.103333	0.097
0.096333	0.11	0.106667	0.105667	0.096667
0.096667	0.108333	0.106333	0.106667	0.096667
0.096667	0.108333	0.106667	0.108	0.096667
0.097667	0.108667	0.106333	0.108333	0.096333
0.098667	0.108667	0.107	0.109333	0.096667
0.100333	0.109333	0.107333	0.109667	0.097
0.103	0.110333	0.108333	0.110333	0.097
0.106333	0.111667	0.109333	0.111	0.097333
0.111667	0.113	0.111333	0.112	0.098
0.12	0.115667	0.113667	0.112667	0.098333
0.128667	0.118667	0.116667	0.113667	0.098667
0.143667	0.123333	0.121	0.115	0.1
0.164667	0.129333	0.126333	0.116	0.100667
0.19	0.137	0.133	0.118	0.102333
0.224	0.146333	0.142	0.120333	0.103667
0.268667	0.159333	0.153333	0.123	0.105667
0.316667	0.174333	0.167333	0.126667	0.108667
0.366667	0.193667	0.185667	0.134333	0.111333
0.417667	0.217333	0.207333	0.143333	0.114333
0.467667	0.242667	0.235	0.154	0.118667
0.523	0.273667	0.266667	0.165333	0.123667
0.568667	0.306667	0.305333	0.180333	0.129
0.616667	0.344	0.348667	0.199667	0.136
0.662333	0.386667	0.393	0.221333	0.145
0.700667	0.431333	0.442	0.247333	0.154333
0.749333	0.475	0.494	0.276667	0.165333
0.788	0.518333	0.544333	0.311333	0.179333
0.845667	0.558	0.59	0.349	0.195667
0.891667	0.595333	0.630333	0.386	0.214333
0.93	0.634	0.669333	0.426	0.236333
0.975	0.674	0.704333	0.467333	0.261
1.016333	0.709667	0.738333	0.506333	0.289333
1.05	0.744667	0.769667	0.541667	0.318333
1.082333	0.777333	0.799	0.574	0.348333
1.097	0.806667	0.826667	0.606	0.381333
1.094667	0.835333	0.851333	0.635333	0.415333
1.087333	0.864667	0.874333	0.663	0.446667

Table B60. Continued

1.078	0.886333	0.896	0.689333	0.477333
1.087667	0.909	0.916333	0.715667	0.505333
1.080667	0.929333	0.934667	0.739	0.533
1.075	0.947333	0.952667	0.762	0.560333
1.073667	0.965333	0.969	0.783333	0.585333
1.06	0.981333	0.984	0.803	0.611333
1.064333	0.998333	0.998	0.821	0.635333
1.060667	1.004333	1.012	0.838667	0.657333
1.063333	1.007	1.025333	0.854333	0.679
1.062	1.004333	1.038667	0.871	0.699333
1.06	1.003667	1.050667	0.886333	0.719
1.062333	1.002667	1.062333	0.9	0.736
1.058667	1.005	1.074	0.914	0.753333
1.059333	1.005333	1.084333	0.927667	0.769667
1.060333	1.008667	1.094333	0.941	0.785333
1.079	1.014333	1.104	0.951333	0.799667
1.079	1.022333	1.113	0.964	0.813667
1.083333	1.028667	1.120333	0.976667	0.828333
1.103	1.032667	1.127	0.988	0.841333
1.092667	1.039	1.131667	1.000667	0.854667
1.092333	1.046333	1.133	1.012	0.864667
1.100333	1.05	1.134	1.023	0.877
1.095333	1.053667	1.134333	1.034	0.887
1.089	1.053333	1.135333	1.045	0.897333
1.089667	1.051	1.136	1.055	0.907667
1.097	1.050333	1.137333	1.065	0.917
1.097667	1.054	1.137	1.073667	0.923667
1.097	1.054	1.138	1.081667	0.93
1.096333	1.053667	1.138333	1.085667	0.933
1.098	1.052667	1.139	1.088667	0.936
1.105333	1.051667	1.139667	1.089667	0.936667
1.102	1.053	1.140333	1.090667	0.937667
1.100667	1.054667	1.141	1.091667	0.938333
1.108	1.056333	1.143	1.094333	0.939667

Table B61. Standard deviations of averages of raw data from microtiter plate reader experiments for *P. stipitis* in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.000577	0.000577	0.000577	0.001	0.001
0.001155	0.001	0.001	0.007767	0.001
0.000577	0.001	0.001528	0.010786	0.001155
0.001155	0.000577	0.001528	0.013429	0.001155
0.001155	0.000577	0.002082	0.015716	0.001155
0.000577	0.001155	0.002517	0.017214	0.001528
0.001155	0.001155	0.002	0.018009	0.001155
0.000577	0.000577	0.002517	0.018583	0.001732
0.001732	0.000577	0.002517	0.01893	0.001732
0.001528	0.001155	0.002517	0.018358	0.001528
0.001528	0.001	0.002517	0.018358	0.001732
0.002646	0.001155	0.003055	0.017786	0.001528
0.003055	0.001155	0.003786	0.01701	0.002082
0.004041	0.001528	0.004583	0.015133	0.001732
0.004933	0.001528	0.005132	0.013454	0.002082
0.006083	0.002	0.006245	0.01179	0.001528
0.007	0.002517	0.007937	0.009504	0.002082
0.008386	0.003215	0.009452	0.006245	0.002082
0.01097	0.004041	0.012097	0.005132	0.001155
0.01193	0.004619	0.014364	0.005686	0.002517
0.014468	0.004933	0.018148	0.006658	0.002517
0.017898	0.004619	0.021166	0.007937	0.003055
0.015716	0.007024	0.025716	0.009292	0.004041
0.017039	0.008327	0.030436	0.01097	0.004583
0.024826	0.014799	0.034588	0.012097	0.005292
0.023072	0.020306	0.039686	0.015144	0.006083
0.02248	0.021385	0.045574	0.018583	0.007767
0.017898	0.023516	0.05009	0.020551	0.008505
0.022338	0.027647	0.054243	0.024583	0.010214
0.022811	0.030414	0.056321	0.028618	0.01159
0.020429	0.033501	0.058774	0.032047	0.01365
0.022113	0.036387	0.060666	0.035511	0.015373
0.020075	0.035511	0.060666	0.039273	0.018193
0.023502	0.037541	0.061614	0.041932	0.020502
0.023643	0.040129	0.06218	0.044881	0.023094
0.026951	0.043016	0.062	0.047843	0.025697
0.027495	0.041861	0.062389	0.048754	0.027429
0.022279	0.041284	0.06278	0.050718	0.029195

Table B61. Continued

0.027429	0.043294	0.061093	0.054745	0.031501
0.029513	0.04497	0.060531	0.055896	0.033546
0.027465	0.04078	0.059408	0.057047	0.035275
0.035642	0.043155	0.059969	0.057376	0.037323
0.039887	0.042442	0.059011	0.058284	0.037978
0.040857	0.043247	0.058847	0.05862	0.039627
0.046508	0.044814	0.058847	0.060108	0.041356
0.044501	0.048789	0.058129	0.060108	0.042253
0.045654	0.048387	0.05742	0.060682	0.04477
0.044636	0.049244	0.05658	0.06137	0.044238
0.044193	0.049893	0.055474	0.062746	0.044814
0.050319	0.051082	0.054794	0.062292	0.045044
0.047374	0.050461	0.053575	0.06183	0.046808
0.047511	0.04996	0.053028	0.061944	0.047353
0.051423	0.049369	0.052596	0.062517	0.047057
0.059349	0.049238	0.052918	0.061944	0.049963
0.038743	0.052624	0.050744	0.062292	0.048809
0.037242	0.056074	0.049427	0.061944	0.05054
0.041861	0.056003	0.046705	0.062517	0.049166
0.050587	0.060011	0.043209	0.061944	0.050846
0.042336	0.059102	0.041041	0.060682	0.051423
0.04236	0.062453	0.039962	0.059304	0.050639
0.038475	0.062984	0.038354	0.059304	0.051215
0.04712	0.069695	0.037287	0.058387	0.050478
0.047843	0.068252	0.036295	0.058387	0.051052
0.050895	0.068198	0.036373	0.057585	0.052653
0.058617	0.067826	0.034933	0.056666	0.052735
0.060368	0.069635	0.034395	0.055645	0.055411
0.057088	0.069635	0.036014	0.054501	0.055973
0.058731	0.068296	0.034933	0.053687	0.05742
0.060225	0.069874	0.034771	0.054721	0.059632
0.067174	0.070868	0.033858	0.053687	0.059079
0.066731	0.07076	0.03296	0.051965	0.059375
0.064034	0.07115	0.033407	0.052776	0.058526
0.07184	0.073664	0.032787	0.052367	0.057422

Table B62. Averages of raw data from microtiter plate reader experiments for *D. hansenii* in citric acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.104333	0.115	0.117667	0.113667	0.114
0.106667	0.117333	0.121667	0.112667	0.109
0.108	0.117667	0.122	0.112	0.107333
0.109	0.117	0.122	0.110333	0.106333
0.11	0.116667	0.122	0.110667	0.106333
0.112	0.116333	0.121667	0.109667	0.105667
0.115333	0.116333	0.121667	0.109667	0.105
0.119	0.116	0.121667	0.109667	0.105333
0.123333	0.116	0.121333	0.109333	0.105333
0.129333	0.115667	0.121333	0.109667	0.105333
0.137333	0.115667	0.121333	0.11	0.105333
0.146	0.115333	0.121	0.109667	0.105
0.152	0.115333	0.120667	0.109333	0.105
0.16	0.115333	0.120333	0.109	0.105
0.167333	0.115	0.120667	0.108667	0.104667
0.174	0.115	0.120667	0.109	0.105333
0.179667	0.115	0.120333	0.109	0.105
0.186333	0.115	0.120333	0.109	0.104333
0.191	0.114	0.120333	0.108667	0.104667
0.198333	0.114667	0.120333	0.108333	0.105
0.206333	0.114667	0.12	0.109	0.105
0.213	0.114333	0.12	0.108667	0.104333
0.222333	0.114	0.12	0.108667	0.104667
0.232333	0.114	0.119667	0.108667	0.104667
0.239667	0.113	0.119667	0.108333	0.104667
0.254333	0.113667	0.119667	0.108333	0.104667
0.276333	0.114333	0.119667	0.108333	0.104667
0.297333	0.113333	0.12	0.108	0.104667
0.312667	0.113	0.119	0.108	0.104333
0.331333	0.113	0.121	0.108667	0.104667
0.357667	0.112333	0.119667	0.108333	0.104333
0.364333	0.112	0.119667	0.108	0.104333
0.375667	0.112333	0.12	0.108	0.104
0.383667	0.112667	0.119	0.108	0.104
0.395667	0.112	0.12	0.108667	0.104
0.401333	0.112	0.118667	0.108667	0.104
0.415	0.112	0.119333	0.108667	0.104333
0.418667	0.112	0.119	0.108333	0.104
0.423333	0.111667	0.119	0.108	0.104333

Table B62. Continued

0.431	0.111333	0.118667	0.110333	0.104333
0.433667	0.110667	0.118667	0.108667	0.103667
0.435667	0.111	0.118333	0.108333	0.103333
0.440667	0.110667	0.118667	0.108667	0.103667
0.448667	0.111333	0.118333	0.108	0.104
0.453	0.110667	0.118333	0.108667	0.103667
0.460667	0.110667	0.117333	0.107333	0.103333
0.467333	0.110333	0.117333	0.109	0.103333
0.474	0.11	0.117333	0.108333	0.103
0.48	0.111	0.118	0.107667	0.103333
0.484333	0.110333	0.117667	0.108	0.103333
0.494667	0.11	0.118	0.108333	0.102333
0.498333	0.110333	0.117333	0.107333	0.102667
0.506333	0.11	0.117	0.107333	0.102333
0.513	0.109333	0.117667	0.106667	0.102333
0.520667	0.109667	0.117	0.107	0.102333
0.531	0.109333	0.117333	0.106667	0.102
0.543333	0.109333	0.117667	0.106667	0.102333
0.557333	0.109667	0.116667	0.106333	0.102333
0.565	0.109333	0.118	0.106667	0.102333
0.572	0.109333	0.116667	0.106333	0.102667
0.583333	0.109333	0.118	0.109333	0.102667
0.584333	0.109	0.117	0.106333	0.102
0.589333	0.108667	0.117667	0.108667	0.102667
0.585333	0.108333	0.118	0.108333	0.102667
0.590333	0.108333	0.117333	0.108667	0.103667
0.591667	0.107667	0.115667	0.106667	0.102333
0.596	0.108333	0.117667	0.107333	0.103
0.606667	0.108667	0.116667	0.107333	0.102667
0.616333	0.107333	0.116333	0.106	0.104333
0.622333	0.107667	0.116667	0.107	0.103667
0.625	0.107333	0.116333	0.109333	0.104
0.631667	0.107333	0.116667	0.107	0.104333
0.643667	0.107	0.114667	0.106667	0.103333

Table B63. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. hansenii* in citric acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.000577	0.002646	0.001528	0.01097	0.009539
0.004163	0.001528	0.002309	0.001528	0.002
0.003	0.001528	0.001732	0.001732	0.001528
0.004	0.003606	0.002646	0.000577	0.001528
0.004583	0.003215	0.002646	0.000577	0.001528
0.005	0.003055	0.002309	0.000577	0.002082
0.004509	0.003055	0.002309	0.000577	0.001
0.005	0.002646	0.002309	0.000577	0.001528
0.005132	0.003606	0.002887	0.000577	0.002517
0.004509	0.003215	0.002887	0.000577	0.001528
0.004163	0.003215	0.002887	0	0.001528
0.004583	0.003055	0.002646	0.000577	0.002
0.004359	0.003055	0.002309	0.000577	0.002
0.006245	0.003055	0.002887	0	0.001732
0.005508	0.002646	0.002309	0.000577	0.002082
0.006083	0.002646	0.002309	0	0.001528
0.005508	0.002646	0.002887	0	0.001732
0.007572	0.002646	0.002887	0	0.001528
0.005196	0.002646	0.002887	0.000577	0.002082
0.004933	0.003215	0.002887	0.000577	0.001732
0.004509	0.002517	0.002646	0.001	0.001732
0.004359	0.002887	0.002646	0.001155	0.001528
0.010408	0.002646	0.002646	0.000577	0.002082
0.017243	0.002646	0.003215	0.000577	0.002082
0.017786	0.002646	0.003215	0.000577	0.002082
0.022279	0.002309	0.003215	0.000577	0.002082
0.021197	0.003055	0.003215	0.000577	0.002082
0.018148	0.002887	0.003464	0	0.002082
0.024583	0.002646	0.002646	0	0.002309
0.028006	0.002646	0.001	0.000577	0.002082
0.035529	0.002887	0.003215	0.000577	0.002309
0.032021	0.002646	0.003215	0	0.002309
0.025968	0.002887	0.003606	0	0.001732
0.023714	0.002517	0.003464	0	0.002646
0.020232	0.002646	0.003606	0.000577	0.001732
0.017926	0.002646	0.003215	0.001155	0.001732
0.018	0.002646	0.002887	0.000577	0.002309
0.01701	0.002646	0.003606	0.000577	0.001732

Table B63. Continued

0.018556	0.003215	0.003606	0	0.002309
0.017692	0.002887	0.003215	0.001528	0.002309
0.01464	0.003215	0.003215	0.001155	0.002082
0.018556	0.002646	0.002887	0.000577	0.002309
0.014572	0.003215	0.003215	0.001528	0.002082
0.015948	0.002887	0.002887	0	0.002646
0.017692	0.003215	0.002887	0.001155	0.002082
0.01861	0.003215	0.002887	0.000577	0.002309
0.015044	0.002887	0.002887	0.001	0.002309
0.016093	0.002646	0.002887	0.000577	0.001732
0.02	0.003606	0.003606	0.000577	0.002309
0.02248	0.002887	0.003215	0	0.002309
0.021197	0.002646	0.003464	0.001155	0.001528
0.022121	0.002887	0.003786	0.000577	0.002082
0.028537	0.003606	0.003464	0.000577	0.001528
0.020421	0.002887	0.004163	0.000577	0.001528
0.028572	0.003215	0.003464	0	0.001528
0.033867	0.002887	0.003786	0.000577	0.001732
0.041861	0.002887	0.004163	0.000577	0.001528
0.04885	0.003215	0.004041	0.000577	0.001528
0.051507	0.002887	0.003606	0.000577	0.001528
0.051643	0.002887	0.003215	0.000577	0.002082
0.053107	0.002887	0.004583	0.001155	0.002082
0.057012	0.002646	0.003606	0.000577	0.002
0.049521	0.002309	0.004163	0.001155	0.001155
0.053267	0.002887	0.004583	0.002517	0.002082
0.047962	0.002887	0.004726	0.003055	0.003786
0.046501	0.003215	0.003215	0.000577	0.003215
0.04776	0.002887	0.004163	0.001528	0.002646
0.039804	0.003215	0.005132	0.001528	0.002887
0.041861	0.002887	0.004726	0.001	0.004933
0.043616	0.002309	0.005132	0.001732	0.004619
0.038158	0.002082	0.005686	0.002082	0.004359
0.039145	0.002887	0.005132	0.002646	0.004933
0.039311	0.002646	0.005132	0.002082	0.003215

Table B64. Averages of raw data from microtiter plate reader experiments for *S. cerevisiae* in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.139	0.144667	0.150333	0.148	0.129667
0.147667	0.152	0.164	0.165667	0.146
0.166667	0.165667	0.173	0.173	0.150667
0.213333	0.194667	0.190667	0.181333	0.154333
0.309667	0.244333	0.218	0.195	0.158
0.447333	0.326	0.257	0.210333	0.161667
0.560333	0.44	0.309667	0.226333	0.167667
0.663667	0.563	0.377667	0.241667	0.172667
0.757333	0.676	0.454	0.256	0.176667
0.840333	0.773667	0.528667	0.268333	0.179667
0.905333	0.859333	0.591333	0.28	0.182333
0.944333	0.928333	0.641333	0.289	0.184
0.952	0.964667	0.684	0.300333	0.185
0.949667	0.963333	0.724	0.307667	0.186
0.950667	0.954667	0.761667	0.319333	0.187
0.954	0.950333	0.798667	0.326	0.187
0.959	0.948667	0.834333	0.335333	0.188
0.964667	0.949667	0.868667	0.349	0.188333
0.971667	0.952	0.901	0.361	0.188667
0.978333	0.953333	0.929667	0.370667	0.188667
0.984667	0.954333	0.952	0.381667	0.189
0.991333	0.954667	0.968667	0.393333	0.189667
0.997333	0.954	0.977333	0.404	0.189667
1.003333	0.953	0.979	0.417333	0.189667
1.007667	0.950667	0.978333	0.428667	0.19
1.013333	0.949	0.977333	0.44	0.190333
1.016667	0.946	0.976	0.454	0.19
1.02	0.942333	0.975333	0.459	0.190667
1.022667	0.938667	0.974667	0.471333	0.191
1.025333	0.936333	0.972667	0.483333	0.191667
1.027	0.932667	0.970667	0.493667	0.192
1.027333	0.928333	0.967333	0.503667	0.192333
1.029	0.925667	0.965	0.511667	0.192
1.03	0.923	0.963	0.520333	0.193
1.030667	0.919667	0.961	0.530333	0.192667
1.030667	0.916667	0.958667	0.531667	0.193333
1.031333	0.914	0.956333	0.533	0.193333
1.031333	0.912	0.955333	0.540333	0.194
1.031667	0.909333	0.954	0.546333	0.194333

Table B64. Continued

1.031	0.906333	0.952333	0.548333	0.194667
1.030667	0.903667	0.950333	0.555667	0.195
1.030333	0.901667	0.949333	0.557333	0.195333
1.029667	0.899333	0.948667	0.561667	0.196
1.028667	0.897333	0.947	0.562	0.196667
1.028333	0.896	0.945667	0.564	0.196667
1.028	0.893333	0.945	0.568	0.198333
1.026333	0.891333	0.944	0.567	0.198333
1.027	0.89	0.943333	0.569	0.199
1.025667	0.888333	0.941667	0.572	0.199333
1.025	0.887333	0.941	0.574	0.199667
1.024	0.885667	0.940333	0.576333	0.2
1.023333	0.884333	0.939667	0.578667	0.200667
1.022	0.882333	0.937667	0.580333	0.201667
1.021333	0.881333	0.937667	0.580333	0.202333
1.02	0.879	0.936667	0.582	0.203
1.02	0.878333	0.935333	0.581333	0.204
1.019667	0.877	0.935333	0.581333	0.204667
1.017667	0.876	0.934333	0.582	0.205333
1.017667	0.874333	0.933667	0.583333	0.206
1.017333	0.873333	0.933	0.582667	0.207333
1.017333	0.872667	0.932333	0.585	0.207333
1.016	0.871333	0.931667	0.583333	0.208667
1.015667	0.870333	0.931333	0.585	0.209333
1.015667	0.869333	0.930667	0.583	0.210333
1.014667	0.868	0.930333	0.583667	0.211667
1.014	0.867333	0.929333	0.585333	0.212
1.014333	0.866333	0.929	0.582	0.213
1.013667	0.864667	0.928667	0.582	0.214333
1.013333	0.864	0.927667	0.578667	0.215333
1.013333	0.863667	0.927667	0.57	0.216333
1.013333	0.863333	0.927667	0.569	0.218
1.013333	0.862	0.927333	0.567667	0.219
1.013333	0.861333	0.926667	0.569	0.219667

Table B65. Standard deviations of averages of raw data from microtiter plate reader experiments for *S. cerevisiae* in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.004	0.002309	0.003512	0.005292	0.006658
0.005508	0.001	0.003606	0.008386	0.011
0.007095	0.001155	0.003464	0.01044	0.011504
0.01124	0.002082	0.003786	0.01159	0.010017
0.018877	0.004163	0.004359	0.013	0.007937
0.024338	0.007	0.005292	0.015044	0.006807
0.027301	0.010583	0.00611	0.016773	0.006807
0.029366	0.013229	0.007572	0.018009	0.006807
0.032192	0.015133	0.011533	0.020075	0.006807
0.032517	0.017474	0.015503	0.019858	0.006807
0.032192	0.017898	0.018502	0.019468	0.007371
0.029905	0.018877	0.021008	0.019698	0.007
0.029462	0.020108	0.023	0.018717	0.007
0.029023	0.021825	0.026514	0.01823	0.007
0.030006	0.021385	0.029092	0.018009	0.006245
0.029816	0.020526	0.031086	0.014731	0.006245
0.030447	0.020108	0.03371	0.013868	0.006245
0.029366	0.020108	0.035642	0.014731	0.006658
0.030353	0.020664	0.034598	0.016093	0.00611
0.029905	0.020526	0.032005	0.017214	0.00611
0.029366	0.020526	0.023259	0.015822	0.006245
0.029905	0.021385	0.014742	0.016258	0.00611
0.030238	0.021932	0.013577	0.014933	0.00611
0.030238	0.021932	0.013748	0.014742	0.00611
0.030665	0.021385	0.011676	0.010263	0.006245
0.030551	0.020664	0.01115	0.008888	0.006028
0.029687	0.020952	0.011358	0.008718	0.005568
0.030116	0.021502	0.01193	0.017776	0.00611
0.03037	0.021385	0.012662	0.01914	0.005568
0.030238	0.021502	0.012662	0.01914	0.00611
0.03079	0.021385	0.012897	0.022679	0.005568
0.030665	0.02248	0.013317	0.022234	0.006429
0.029547	0.021385	0.013454	0.021455	0.005568
0.029547	0.021284	0.013454	0.023861	0.005568
0.030105	0.021385	0.013454	0.024664	0.005508
0.029143	0.021385	0.012897	0.017926	0.006028
0.029704	0.020952	0.013317	0.021656	0.006028
0.029704	0.020952	0.013317	0.022121	0.006

Table B65. Continued

0.030105	0.020841	0.012767	0.021502	0.006028
0.029547	0.020841	0.013317	0.028095	0.006028
0.029143	0.021385	0.012342	0.028572	0.006
0.028746	0.021385	0.012342	0.033858	0.005508
0.029872	0.020841	0.012897	0.034704	0.006
0.028919	0.021825	0.012767	0.035595	0.006028
0.029704	0.020952	0.012897	0.038039	0.006028
0.028355	0.020841	0.013454	0.040509	0.006028
0.028746	0.020841	0.013454	0.043313	0.006506
0.029309	0.020952	0.013317	0.048693	0.006557
0.028919	0.021825	0.013204	0.048693	0.00611
0.029309	0.020841	0.012767	0.051264	0.006658
0.030265	0.021385	0.012662	0.052786	0.006557
0.029704	0.020841	0.013204	0.052539	0.006658
0.028355	0.020841	0.013204	0.055967	0.006658
0.029484	0.020841	0.013204	0.06274	0.006807
0.029103	0.021284	0.013868	0.064784	0.007
0.029309	0.021825	0.013317	0.067885	0.007
0.028729	0.021284	0.013317	0.069328	0.007234
0.028919	0.020952	0.013317	0.070767	0.006658
0.028729	0.020841	0.013868	0.071675	0.006928
0.028537	0.020841	0.013454	0.070995	0.006658
0.029297	0.020744	0.013317	0.07093	0.007506
0.02816	0.020841	0.012897	0.072666	0.007234
0.028729	0.020841	0.013317	0.071757	0.007572
0.028729	0.021502	0.012897	0.070406	0.007767
0.028729	0.021284	0.013317	0.070002	0.008327
0.02816	0.020841	0.013051	0.070074	0.008185
0.029297	0.020841	0.013454	0.072333	0.008185
0.029501	0.021385	0.012897	0.071526	0.008083
0.029297	0.020952	0.012897	0.073201	0.008505
0.029297	0.021385	0.012897	0.076864	0.008505
0.028537	0.020841	0.012897	0.078715	0.008
0.029484	0.020298	0.013051	0.07845	0.009539
0.029297	0.020841	0.012897	0.078083	0.010066

Table B67. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 73 in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.156	0.135333	0.137333	0.13	0.140333
0.166	0.134667	0.141333	0.128	0.149
0.161	0.132	0.139333	0.129333	0.146333
0.158667	0.135333	0.137667	0.126	0.161667
0.155333	0.136667	0.139333	0.132667	0.163
0.153667	0.137333	0.139	0.130667	0.161
0.151667	0.138667	0.141667	0.128	0.17
0.146333	0.141333	0.138667	0.130333	0.171667
0.146667	0.143	0.133333	0.129	0.165667
0.151	0.146333	0.135	0.132667	0.164667
0.157333	0.151333	0.138667	0.132333	0.170667
0.164667	0.156333	0.140333	0.14	0.175
0.174333	0.163	0.145	0.136667	0.18
0.187667	0.171667	0.150333	0.140667	0.186667
0.205333	0.181667	0.154333	0.143	0.190667
0.229	0.195667	0.159	0.146333	0.189333
0.259	0.214667	0.163333	0.149667	0.193
0.298	0.241333	0.167	0.152333	0.195333
0.345333	0.274333	0.172333	0.153333	0.194333
0.398667	0.311333	0.178333	0.156333	0.195
0.452333	0.349333	0.183667	0.157	0.198333
0.506	0.387333	0.187667	0.159	0.208333
0.555667	0.424	0.192333	0.16	0.217333
0.601333	0.456667	0.197333	0.161333	0.229
0.644333	0.486667	0.203	0.163667	0.238667
0.684	0.515667	0.208	0.164333	0.253667
0.723	0.542667	0.213	0.165333	0.269
0.760333	0.567667	0.218333	0.167333	0.286333
0.796333	0.591333	0.225333	0.169	0.306333
0.830667	0.612667	0.229	0.172	0.328333
0.861667	0.630667	0.234667	0.173667	0.347
0.891	0.645667	0.240667	0.176	0.361333
0.919667	0.663	0.243333	0.178	0.369667
0.946333	0.681	0.248333	0.181	0.377333
0.970667	0.698667	0.251333	0.180333	0.380333
0.993333	0.715667	0.254667	0.181667	0.388
1.015	0.732667	0.257333	0.183667	0.394333
1.035	0.752333	0.258333	0.184333	0.402
1.055	0.771333	0.260333	0.183667	0.408333

Table B67. Continued

1.073	0.789333	0.259667	0.185	0.412667
1.089333	0.806333	0.258667	0.185667	0.415333
1.101667	0.814667	0.257	0.187667	0.418667
1.101333	0.815667	0.252333	0.189333	0.422
1.101333	0.813667	0.249	0.189	0.425667
1.104667	0.814667	0.245	0.187	0.428333
1.107	0.814333	0.244	0.186333	0.430667
1.109667	0.815	0.239667	0.187667	0.432667
1.111	0.816	0.236667	0.187667	0.435
1.112667	0.816667	0.236333	0.187	0.436667
1.113667	0.818333	0.235333	0.186667	0.438667
1.115	0.821667	0.236333	0.186667	0.439
1.116	0.823667	0.237333	0.187333	0.440667
1.116	0.822	0.237	0.19	0.440333
1.117	0.822667	0.236667	0.191	0.440667
1.117	0.823333	0.235667	0.192	0.440333
1.117667	0.823667	0.236	0.197	0.44
1.118667	0.825	0.237	0.196333	0.44
1.118667	0.825	0.237	0.197333	0.438667
1.119	0.826667	0.238333	0.199333	0.439
1.12	0.825667	0.239333	0.203667	0.439
1.121	0.825667	0.241	0.206	0.438333
1.121	0.826	0.247333	0.210333	0.438
1.122	0.825	0.245	0.207333	0.437333
1.122667	0.824	0.249667	0.209667	0.434667
1.123333	0.820667	0.250667	0.212667	0.433667
1.123667	0.820667	0.253	0.211667	0.431667
1.124333	0.820333	0.258333	0.219	0.431333
1.125	0.817667	0.258333	0.220333	0.429333
1.126	0.815333	0.265	0.225333	0.427333
1.126	0.812333	0.264667	0.224	0.425667
1.126667	0.812667	0.264	0.225333	0.422667
1.127333	0.809333	0.269333	0.228333	0.420667
1.129333	0.805	0.274	0.235	0.421667

Table B68. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 73 in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001732	0.001155	0.00611	0.001	0.003786
0.014799	0.004726	0.002082	0.001	0.004
0.024434	0.003606	0.002309	0.003512	0.005859
0.027301	0.01115	0.00611	0.001	0.006506
0.028449	0.013429	0.013317	0.008327	0.001
0.026502	0.012858	0.014799	0.008327	0.003464
0.022301	0.012503	0.010408	0.001	0.001
0.010066	0.01365	0.014154	0.005132	0.003512
0.00611	0.013077	0.003215	0.001732	0.004041
0.006245	0.01365	0.002646	0.004041	0.022679
0.005508	0.015503	0.003055	0.001528	0.015503
0.005508	0.017214	0.003215	0.009849	0.010149
0.006506	0.020075	0.003	0.002082	0.009644
0.007638	0.023861	0.003512	0.002082	0.008737
0.009452	0.028219	0.004509	0.002	0.010693
0.011533	0.035921	0.004583	0.002309	0.008021
0.014177	0.044557	0.005508	0.002082	0.011533
0.016643	0.056924	0.005568	0.000577	0.010786
0.01893	0.069039	0.00611	0.001528	0.007767
0.022143	0.081156	0.008737	0.001528	0.01
0.024906	0.094129	0.011719	0.002	0.016258
0.027875	0.10452	0.009292	0.001732	0.014295
0.028937	0.112588	0.010693	0.001732	0.01701
0.031817	0.118078	0.012662	0.001528	0.017349
0.032655	0.124997	0.014731	0.001528	0.025146
0.033808	0.12933	0.016703	0.000577	0.025325
0.035595	0.133665	0.019313	0.001528	0.026665
0.035275	0.138019	0.019218	0.001528	0.033828
0.036171	0.14003	0.023459	0.002	0.036474
0.035852	0.14236	0.021932	0.002646	0.044859
0.035852	0.144091	0.023029	0.003512	0.049568
0.036428	0.145885	0.027319	0.004	0.052444
0.036747	0.147309	0.026083	0.004583	0.053463
0.037846	0.148233	0.027737	0.004	0.057466
0.037541	0.148544	0.027737	0.005686	0.062644
0.037846	0.150381	0.029263	0.004933	0.064086
0.037269	0.151414	0.032036	0.005859	0.065248
0.037269	0.150918	0.032036	0.006429	0.067557

Table B68. Continued

0.037242	0.151097	0.03371	0.005859	0.068734
0.037269	0.150497	0.031214	0.005292	0.072501
0.037846	0.1473	0.033561	0.004933	0.077468
0.036692	0.146118	0.034828	0.005859	0.080407
0.037287	0.147595	0.03037	0.004041	0.082456
0.037978	0.150098	0.028844	0.003606	0.084831
0.038475	0.151583	0.026211	0.003464	0.087065
0.037403	0.152179	0.028844	0.003786	0.088218
0.037647	0.152568	0.023352	0.002082	0.089946
0.037403	0.153743	0.025325	0.002082	0.091995
0.037647	0.153913	0.02444	0.002	0.093351
0.036828	0.155262	0.02444	0.002309	0.095133
0.037403	0.153913	0.02444	0.003215	0.09718
0.037403	0.153913	0.023798	0.001528	0.098653
0.037403	0.155213	0.024556	0.002646	0.100898
0.037403	0.155924	0.024007	0.003606	0.10289
0.038314	0.157469	0.023352	0.004359	0.104414
0.03774	0.158033	0.023302	0.005568	0.10499
0.03774	0.157439	0.022913	0.005859	0.10499
0.03774	0.159339	0.022913	0.00611	0.106463
0.03751	0.159726	0.02444	0.005859	0.106719
0.03751	0.162371	0.022811	0.007371	0.107615
0.03751	0.163323	0.02265	0.010583	0.109665
0.03751	0.16463	0.024173	0.010116	0.111969
0.03751	0.166325	0.023259	0.008386	0.112367
0.036828	0.169717	0.024705	0.008083	0.111791
0.037166	0.174245	0.024111	0.008963	0.114422
0.03774	0.176512	0.024062	0.008327	0.115327
0.037166	0.178231	0.025007	0.009165	0.11582
0.037403	0.182358	0.024007	0.008386	0.115902
0.036592	0.185074	0.02265	0.010066	0.116578
0.037403	0.189867	0.022591	0.010149	0.115889
0.03774	0.192461	0.021284	0.011676	0.116835
0.037978	0.195638	0.023007	0.012342	0.115941
0.037005	0.198008	0.024515	0.014422	0.115941

Table B69. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 96 in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.117667	0.116333	0.115	0.112667	0.124333
0.156667	0.113333	0.113	0.116667	0.125
0.151667	0.112667	0.112667	0.120667	0.125667
0.151667	0.112	0.112667	0.122	0.130667
0.147667	0.111	0.111667	0.123333	0.127667
0.143333	0.112	0.112	0.124333	0.126667
0.136	0.114667	0.112333	0.124667	0.124667
0.123667	0.117667	0.112333	0.124667	0.122333
0.121667	0.122	0.113	0.124333	0.124
0.124333	0.128	0.113	0.124333	0.122667
0.129	0.134333	0.114333	0.123333	0.123
0.133333	0.143	0.115333	0.123	0.123333
0.139	0.149	0.117667	0.122333	0.121333
0.144	0.159667	0.120333	0.121667	0.121333
0.149	0.17	0.121667	0.12	0.122
0.154	0.185333	0.125	0.119333	0.122333
0.158667	0.197	0.128333	0.118333	0.121
0.162333	0.209333	0.132	0.117667	0.121333
0.166333	0.222333	0.137	0.117	0.121
0.166	0.237667	0.142	0.116667	0.121
0.165667	0.253667	0.147667	0.115333	0.119
0.169333	0.282333	0.156333	0.114667	0.119667
0.172667	0.307667	0.163667	0.114	0.119
0.174667	0.329667	0.175	0.113	0.118
0.176333	0.349	0.186	0.113667	0.118333
0.182333	0.371	0.198333	0.114333	0.118667
0.188667	0.385333	0.213333	0.115667	0.118667
0.189333	0.404667	0.228667	0.115667	0.119
0.193667	0.421	0.247333	0.117	0.118333
0.199	0.432333	0.264	0.117667	0.119
0.202	0.441	0.285333	0.118333	0.119
0.213	0.456667	0.304	0.119	0.117
0.226	0.47	0.328667	0.121667	0.117
0.244	0.497	0.351667	0.122667	0.118667
0.266333	0.511667	0.381333	0.123667	0.115333
0.283667	0.533333	0.403667	0.126	0.115667
0.298	0.533667	0.432667	0.127333	0.117333
0.313	0.56	0.462667	0.128	0.117333
0.318	0.535333	0.492667	0.130667	0.117

Table B69. Continued

0.334667	0.566	0.53	0.132667	0.116667
0.349333	0.591667	0.559667	0.132667	0.115
0.371	0.604	0.595333	0.137333	0.114667
0.391	0.631667	0.625333	0.138333	0.115
0.410333	0.638667	0.656333	0.141333	0.115
0.429333	0.653333	0.678333	0.141	0.115667
0.437667	0.639333	0.703	0.146	0.114667
0.447	0.636667	0.723333	0.149	0.115333
0.446	0.619333	0.734333	0.152333	0.115
0.481333	0.652	0.768333	0.155	0.114333
0.486	0.632333	0.773	0.16	0.115333
0.492667	0.632	0.793667	0.161	0.115333
0.503667	0.605667	0.796333	0.167667	0.115333
0.536	0.634	0.833	0.170667	0.115
0.556667	0.644	0.854	0.18	0.114333
0.561	0.605667	0.862333	0.187333	0.114667
0.578	0.610333	0.883667	0.19	0.115333
0.583	0.596	0.903333	0.202	0.114
0.584667	0.577	0.922667	0.208333	0.114667
0.582333	0.553667	0.914	0.22	0.114667
0.592667	0.563	0.924333	0.233667	0.115333
0.608	0.572667	0.923667	0.246333	0.114667
0.606667	0.585333	0.939667	0.267	0.115
0.599	0.561	0.927333	0.283	0.115667
0.611	0.565333	0.942	0.301667	0.114
0.615333	0.563333	0.95	0.325333	0.115333
0.610333	0.555333	0.946333	0.345	0.114667
0.611333	0.567667	0.950667	0.378667	0.114
0.606333	0.556667	0.955333	0.399333	0.115333
0.626333	0.583333	0.974667	0.423667	0.114667
0.610333	0.561	0.949	0.452667	0.115
0.609	0.558667	0.962667	0.482333	0.114333
0.620333	0.572	0.962667	0.514667	0.116
0.621	0.586333	0.965667	0.542333	0.115

Table B70. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 96 in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.006506	0.003215	0.001732	0.000577	0.00611
0.040772	0.001528	0.001	0.010693	0.005292
0.053454	0.002082	0.000577	0.015885	0.004041
0.057622	0.001	0.000577	0.019925	0.003215
0.05404	0.001732	0.000577	0.022234	0.002517
0.045709	0.001732	0.001	0.023965	0.003512
0.031321	0.002082	0.000577	0.024542	0.003055
0.006658	0.002082	0.001528	0.023692	0.004041
0.002082	0.002646	0.001	0.023116	0.003606
0.001528	0.002646	0.001	0.023094	0.004619
0.001	0.002309	0.000577	0.022234	0.003464
0.001155	0.001732	0.001528	0.021656	0.003215
0.001	0.001	0.001155	0.01963	0.004041
0.001	0.001155	0.001528	0.017616	0.004041
0.001732	0.001	0.001155	0.015588	0.003464
0.002	0.000577	0.001	0.013577	0.003215
0.002517	0.002	0.001528	0.011846	0.003464
0.004619	0.004041	0.002646	0.010693	0.004041
0.005033	0.002887	0.001732	0.009539	0.003464
0.005292	0.002309	0.001	0.008145	0.004359
0.004726	0.004041	0.001155	0.005774	0.003464
0.005774	0.009609	0.001528	0.003786	0.003786
0.007371	0.01115	0.003786	0.001732	0.003606
0.010263	0.014012	0.001	0.001	0.003606
0.010408	0.022517	0.001732	0.000577	0.003215
0.011676	0.020224	0.002082	0.001155	0.003786
0.011015	0.025106	0.001528	0.000577	0.003055
0.013204	0.035105	0.004933	0.001528	0.003606
0.012342	0.032047	0.007638	0.001	0.003512
0.014731	0.041356	0.003	0.001155	0.003606
0.015588	0.052887	0.005132	0.001155	0.003606
0.017436	0.047931	0.003464	0.002	0.004
0.019157	0.052849	0.001155	0.001528	0.004
0.018248	0.068418	0.006807	0.001528	0.005033
0.019399	0.077423	0.006658	0.001528	0.004509
0.023094	0.093468	0.009292	0.002	0.005033
0.024269	0.103963	0.004509	0.001528	0.005033
0.021794	0.1117	0.004619	0.001	0.004509

Table B70. Continued

0.024576	0.111051	0.004933	0.002309	0.005
0.025813	0.114162	0.002646	0.003512	0.004509
0.029738	0.12344	0.007506	0.003215	0.004583
0.034641	0.123503	0.017559	0.002887	0.005686
0.034655	0.125157	0.010408	0.004041	0.004583
0.036143	0.131165	0.011676	0.003786	0.004583
0.039119	0.129114	0.011015	0.002646	0.005033
0.036254	0.115474	0.010536	0.004583	0.005033
0.041243	0.119839	0.015948	0.004583	0.004509
0.037987	0.096423	0.014572	0.003786	0.004583
0.048686	0.105929	0.023159	0.003	0.004509
0.046508	0.086985	0.018735	0.004359	0.004509
0.047606	0.073668	0.014364	0.006	0.004163
0.045214	0.067892	0.020648	0.006028	0.005033
0.053113	0.080293	0.017578	0.009713	0.004583
0.053304	0.063836	0.007937	0.013229	0.005132
0.052259	0.073112	0.01861	0.007095	0.005033
0.048539	0.068603	0.017954	0.013892	0.004509
0.047508	0.064156	0.024846	0.01852	0.004583
0.047163	0.039611	0.024007	0.021548	0.004509
0.043409	0.043616	0.021932	0.022271	0.004509
0.037287	0.054507	0.029263	0.026006	0.005033
0.043209	0.046361	0.025968	0.033005	0.005033
0.042028	0.049662	0.017954	0.036592	0.004583
0.041328	0.047508	0.025813	0.047032	0.005033
0.043555	0.043501	0.027185	0.058046	0.005568
0.038553	0.048398	0.027514	0.059181	0.005033
0.035726	0.048387	0.035921	0.066091	0.005508
0.035076	0.038436	0.030665	0.075798	0.004583
0.032868	0.053799	0.030105	0.085676	0.006028
0.038553	0.059534	0.025697	0.0879	0.005508
0.033501	0.065818	0.030806	0.088557	0.004583
0.034395	0.057744	0.032332	0.088047	0.005033
0.028537	0.054836	0.030989	0.087558	0.005568
0.041328	0.050083	0.025106	0.089366	0.004583

Table B71. Averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 216 in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.154	0.151667	0.140667	0.139	0.129
0.159	0.156	0.146667	0.146	0.139667
0.161667	0.158	0.150667	0.150667	0.147333
0.167	0.16	0.151	0.151667	0.153
0.175	0.163667	0.153	0.154333	0.157667
0.188	0.169667	0.154	0.158	0.160333
0.207333	0.179333	0.156333	0.162667	0.160667
0.235333	0.192333	0.159667	0.162	0.158667
0.267667	0.211333	0.160333	0.163	0.157
0.300667	0.236	0.163333	0.162	0.158
0.328	0.266	0.166667	0.161333	0.160667
0.349333	0.298	0.171	0.162333	0.158667
0.373667	0.339	0.177	0.163	0.159
0.400667	0.381	0.184667	0.164	0.158
0.431667	0.427667	0.193333	0.164333	0.157333
0.465667	0.485667	0.206333	0.165	0.158
0.498	0.544333	0.221	0.165667	0.157
0.529667	0.605	0.239667	0.168333	0.156667
0.564	0.663333	0.262	0.17	0.157333
0.595333	0.717333	0.288333	0.172	0.156667
0.625667	0.766667	0.319667	0.173667	0.157
0.652667	0.811333	0.356333	0.176	0.159333
0.68	0.853667	0.396333	0.178	0.161667
0.708333	0.894333	0.435667	0.180667	0.159
0.735333	0.934	0.477	0.182	0.162
0.760333	0.971	0.522	0.185	0.168
0.786	1.007	0.571	0.187	0.169
0.812333	1.039333	0.622333	0.188333	0.175
0.835	1.070333	0.670333	0.192	0.160333
0.859	1.100667	0.712	0.194667	0.170333
0.880333	1.128	0.752333	0.199667	0.181333
0.895333	1.145667	0.788333	0.202667	0.173333
0.914	1.148	0.823667	0.208	0.186
0.929667	1.156333	0.856333	0.212667	0.178667
0.939333	1.164667	0.888667	0.215667	0.186667
0.935333	1.171333	0.918667	0.218667	0.179667
0.925667	1.175667	0.946667	0.221667	0.170667
0.915	1.179667	0.975	0.224333	0.175333
0.91	1.182333	0.999	0.227333	0.173667

Table B71. Continued

0.904333	1.183667	1.022667	0.232	0.178333
0.895667	1.185333	1.044	0.235	0.175
0.889333	1.185667	1.065333	0.239	0.178
0.885333	1.190333	1.075667	0.241667	0.18
0.876	1.192	1.085333	0.252	0.181333
0.871	1.193	1.104	0.254333	0.184
0.867333	1.192	1.114667	0.256333	0.187333
0.862667	1.193	1.119	0.261333	0.189333
0.858667	1.192	1.123	0.262667	0.193333
0.852667	1.192333	1.124	0.266	0.198
0.848333	1.193333	1.123333	0.268	0.201
0.845	1.194667	1.118333	0.264333	0.206667
0.842667	1.195	1.113667	0.271	0.214
0.838667	1.194667	1.107333	0.270667	0.214333
0.832333	1.194333	1.102333	0.266333	0.215667
0.827	1.195667	1.098	0.266	0.221667
0.818667	1.197667	1.093667	0.267667	0.227333
0.811667	1.197333	1.089667	0.269667	0.229
0.804	1.195333	1.085	0.273667	0.233667
0.801	1.199667	1.084667	0.282	0.237333
0.789	1.195	1.083	0.282	0.240333
0.783333	1.196	1.077333	0.284333	0.241667
0.777	1.193667	1.080667	0.281667	0.246333
0.760333	1.194	1.082667	0.278	0.248
0.749	1.194	1.082333	0.281333	0.241333
0.734	1.196333	1.082667	0.283667	0.237
0.723	1.198	1.085667	0.285	0.235333
0.718667	1.194667	1.088333	0.292333	0.236333
0.708	1.198667	1.086	0.29	0.246667
0.715333	1.197333	1.088333	0.297667	0.283333
0.705667	1.195667	1.090333	0.299667	0.292333
0.698667	1.198333	1.092	0.303	0.305
0.703333	1.200333	1.092333	0.306	0.328667
0.718333	1.203	1.098	0.319333	0.337667

Table B72. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. bruxellensis* 216 in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.005	0.002082	0.001528	0.002	0.002
0.002	0.002	0.002517	0.001732	0.001155
0.001528	0.002646	0.001528	0.000577	0.003512
0.001732	0.002646	0.004	0.003215	0.005
0.002	0.002517	0.001732	0.003786	0.004726
0.003	0.002517	0.003	0.004359	0.004041
0.002517	0.003055	0.002517	0.001528	0.005686
0.003512	0.003055	0.002082	0.005196	0.007371
0.004509	0.004726	0.003512	0.001	0.006557
0.004041	0.004583	0.004041	0.005568	0.004359
0.003464	0.006083	0.003512	0.004619	0.007371
0.003215	0.006557	0.004	0.004619	0.005508
0.002517	0.008544	0.004	0.003606	0.004359
0.003512	0.011	0.004509	0.001732	0.005292
0.005686	0.012503	0.005033	0.005508	0.006506
0.007371	0.014048	0.004509	0.004359	0.005292
0.008718	0.015011	0.005	0.004163	0.006
0.008963	0.016523	0.005508	0.003055	0.006028
0.010392	0.018009	0.006	0.004359	0.00611
0.012702	0.018556	0.006506	0.004359	0.006028
0.014364	0.019035	0.007024	0.004041	0.006
0.018448	0.019009	0.008505	0.004359	0.005132
0.020075	0.019502	0.009504	0.004359	0.004619
0.022502	0.020008	0.011015	0.004041	0.006
0.02318	0.020518	0.011533	0.004359	0.007211
0.026026	0.02	0.011533	0.003464	0.004359
0.027	0.020518	0.012124	0.003606	0.015588
0.02669	0.020551	0.012662	0.003786	0.009539
0.026627	0.020551	0.01365	0.003606	0.006658
0.02623	0.020599	0.013528	0.004163	0.010017
0.025968	0.020518	0.013051	0.004933	0.004163
0.025716	0.020133	0.014048	0.004041	0.016803
0.025357	0.021071	0.015011	0.001	0.008888
0.028308	0.019604	0.015503	0.000577	0.009292
0.028885	0.020133	0.016563	0.006429	0.002309
0.028361	0.020207	0.015567	0.006658	0.009866
0.025929	0.020551	0.015011	0.005686	0.008505
0.024759	0.020133	0.016093	0.00611	0.004726

Table B72. Continued

0.024021	0.020599	0.016	0.006028	0.00611
0.02442	0.020744	0.015503	0.008718	0.006028
0.023587	0.019604	0.015	0.007211	0.005568
0.023116	0.020551	0.015044	0.007937	0.008185
0.023029	0.017243	0.014572	0.005686	0.004359
0.019975	0.015875	0.017039	0.00755	0.005859
0.018358	0.014731	0.020952	0.005686	0.003606
0.017673	0.014422	0.019425	0.003786	0.002082
0.014468	0.016093	0.01833	0.003512	0.002082
0.01365	0.016371	0.017088	0.002082	0.001528
0.011015	0.015948	0.017521	0.006557	0.001732
0.009074	0.015948	0.01701	0.007211	0.005568
0.009165	0.017474	0.018339	0.004933	0.008083
0.009074	0.016371	0.018717	0.00755	0.009644
0.008505	0.012897	0.018148	0.008386	0.007506
0.006658	0.015695	0.018009	0.007371	0.004163
0.006	0.017214	0.018248	0.007	0.007024
0.004619	0.017954	0.018583	0.004509	0.002309
0.004726	0.019088	0.017786	0.004041	0.002
0.004583	0.016289	0.015588	0.010504	0.003055
0.00781	0.017673	0.018502	0.010817	0.003215
0.013892	0.012166	0.019287	0.013454	0.002517
0.021221	0.008544	0.013051	0.012662	0.000577
0.025515	0.008963	0.015144	0.011015	0.003512
0.030746	0.008888	0.009074	0.00755	0.001732
0.032187	0.00866	0.016042	0.007371	0.003512
0.035086	0.007095	0.017474	0.004619	0.003606
0.039661	0.007	0.01222	0.005196	0.004726
0.040452	0.005508	0.015631	0.01124	0.006658
0.032078	0.010786	0.015524	0.003606	0.014224
0.033501	0.007095	0.015822	0.002309	0.015275
0.025325	0.006506	0.017474	0.003786	0.028919
0.023965	0.008021	0.0151	0.010149	0.023
0.020232	0.010504	0.017559	0.005196	0.016803
0.010263	0.016093	0.012124	0.005508	0.017474

Table B73. Averages of raw data from microtiter plate reader experiments for *Z. rouxii* in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.125	0.112	0.11	0.100333	0.102
0.123333	0.115667	0.111333	0.104333	0.105667
0.133667	0.118333	0.113	0.105667	0.107667
0.153	0.121667	0.114667	0.106667	0.108667
0.183333	0.125333	0.116	0.107333	0.108667
0.226667	0.13	0.116333	0.108667	0.11
0.284333	0.134	0.117333	0.109	0.11
0.344	0.137667	0.117667	0.110333	0.111333
0.418667	0.143333	0.118	0.109333	0.111333
0.495	0.148333	0.118667	0.109333	0.111
0.572333	0.153667	0.119333	0.109667	0.111667
0.646333	0.16	0.119667	0.110333	0.110333
0.713333	0.166	0.121	0.110333	0.111333
0.776667	0.169333	0.121667	0.110333	0.111
0.833667	0.179667	0.122	0.111	0.111667
0.886333	0.183667	0.122667	0.111	0.111667
0.934333	0.190333	0.123667	0.111333	0.111333
0.971667	0.196667	0.123667	0.111667	0.111667
1.005667	0.202333	0.124333	0.111667	0.111333
1.032667	0.206	0.124333	0.111	0.111333
1.054667	0.212667	0.124333	0.111	0.111333
1.072333	0.218667	0.124667	0.111667	0.111333
1.086667	0.224333	0.125333	0.111333	0.111333
1.097	0.233	0.125667	0.111333	0.111333
1.102667	0.237333	0.126333	0.111333	0.111333
1.108	0.242667	0.129	0.111333	0.111333
1.109667	0.248667	0.130667	0.111333	0.111333
1.11	0.255667	0.132667	0.111667	0.111333
1.107333	0.263333	0.135333	0.111	0.111333
1.100333	0.270333	0.139667	0.111667	0.111333
1.094667	0.279667	0.145667	0.111333	0.111333
1.088333	0.297667	0.156	0.111667	0.111333
1.081667	0.310667	0.193667	0.111	0.111333
1.076667	0.330333	0.198333	0.111667	0.111
1.067	0.364667	0.174333	0.111667	0.111333
1.060667	0.398	0.241667	0.112	0.111333
1.055	0.433667	0.259333	0.112	0.111333
1.049667	0.485667	0.255	0.112	0.111333
1.045667	0.525333	0.280333	0.111667	0.111333

Table B73. Continued

1.042667	0.565	0.291333	0.112	0.111333
1.037	0.610333	0.308333	0.112	0.111333
1.032333	0.645333	0.345	0.112	0.111
1.029	0.677667	0.395333	0.112	0.111333
1.025333	0.704	0.432	0.112333	0.111333
1.02	0.731667	0.464	0.112	0.111333
1.016667	0.753	0.506	0.112333	0.111333
1.012667	0.767667	0.543	0.112333	0.111333
1.009667	0.782	0.574667	0.112333	0.111333
1.006	0.785667	0.587667	0.113	0.111333
1.003667	0.793	0.618	0.114	0.111333
1.001333	0.786667	0.640667	0.114	0.111333
1.002	0.796333	0.651667	0.115	0.111333
0.999	0.798	0.668667	0.115333	0.111
0.996	0.801667	0.688667	0.116	0.111
0.994333	0.811667	0.694333	0.117	0.111
0.993	0.814333	0.683	0.117667	0.111
0.989333	0.814333	0.694667	0.118667	0.110667
0.987333	0.820333	0.692	0.121667	0.111
0.985667	0.823333	0.691	0.124333	0.111
0.983667	0.824	0.676	0.129333	0.111
0.978667	0.820667	0.685333	0.132	0.111
0.976	0.819	0.684333	0.134333	0.111
0.973	0.829333	0.678	0.138333	0.111333
0.97	0.823	0.672333	0.145667	0.111
0.970667	0.821667	0.672	0.151	0.110667
0.968333	0.818667	0.669333	0.162667	0.110333
0.967333	0.822333	0.674667	0.164	0.111
0.964	0.812333	0.658	0.172667	0.110667
0.962667	0.809667	0.657333	0.181333	0.110667
0.960333	0.817333	0.675667	0.190667	0.110667
0.956667	0.815333	0.662	0.204333	0.111
0.954333	0.817667	0.665	0.218667	0.110667
0.952333	0.814333	0.660667	0.230667	0.110333

Table B74. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. rouxii* in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001732	0.001	0.001	0.001155	0.001
0.002082	0.001528	0.002082	0.001528	0.001528
0.002517	0.001528	0.002	0.001528	0.001528
0.003	0.001528	0.001528	0.001528	0.002309
0.003215	0.001528	0.001732	0.001155	0.002309
0.004619	0.002	0.002082	0.000577	0.002646
0.003215	0.002	0.002887	0	0.002646
0.007	0.002082	0.003512	0.000577	0.004041
0.01193	0.002517	0.003	0.000577	0.003055
0.012166	0.001155	0.001528	0.002082	0.002646
0.01222	0.003055	0.002082	0.001528	0.003215
0.013868	0.002646	0.002517	0.001155	0.002517
0.014572	0.003606	0.002	0.001155	0.002887
0.013317	0.002517	0.002517	0.001155	0.002
0.012858	0.003512	0.003	0.001732	0.002517
0.01193	0.002309	0.002517	0.001732	0.002517
0.013317	0.001528	0.002517	0.001155	0.002517
0.014978	0.001528	0.002517	0.001528	0.002517
0.016653	0.003215	0.002082	0.001528	0.002517
0.016258	0.006083	0.001528	0.001732	0.002517
0.017243	0.004509	0.002082	0.001732	0.002517
0.018148	0.005508	0.001528	0.001528	0.002517
0.017039	0.003786	0.002082	0.001155	0.002517
0.014	0.005	0.001528	0.001155	0.002517
0.014572	0.004041	0.001155	0.001155	0.002517
0.014526	0.002887	0	0.001155	0.002517
0.012503	0.003055	0.001528	0.001155	0.002517
0.012124	0.001155	0.001528	0.001528	0.002517
0.009713	0.001528	0.001528	0.001732	0.002517
0.010693	0.002082	0.003055	0.001528	0.002517
0.01124	0.003215	0.008327	0.001155	0.002517
0.015503	0.012097	0.018358	0.001528	0.002517
0.015308	0.018824	0.079154	0.001732	0.002517
0.013317	0.026312	0.077732	0.001528	0.003
0.016371	0.044061	0.021502	0.001528	0.002517
0.013429	0.068432	0.015275	0.001732	0.002517
0.011533	0.092002	0.046929	0.001732	0.002517
0.012897	0.119308	0.012166	0.001732	0.002517

Table B74. Continued

0.011719	0.139055	0.047648	0.001528	0.002517
0.011719	0.169753	0.038527	0.001732	0.002517
0.010583	0.183195	0.07171	0.001732	0.002517
0.014295	0.19694	0.084285	0.001732	0.002646
0.012124	0.194631	0.0855	0.001732	0.002517
0.011504	0.191539	0.079618	0.001155	0.002517
0.010536	0.181776	0.074726	0.001732	0.002517
0.010504	0.170317	0.052602	0.001155	0.002517
0.010017	0.160454	0.049568	0.001155	0.002517
0.011015	0.135724	0.045004	0.001155	0.002517
0.011	0.123322	0.041259	0.001	0.002517
0.01106	0.108862	0.034771	0.001	0.002517
0.010017	0.099806	0.015011	0.001	0.002517
0.009539	0.088574	0.029501	0	0.002517
0.011	0.071084	0.024132	0.000577	0.003
0.01253	0.070302	0.018556	0.001	0.003
0.01106	0.063319	0.015308	0.002646	0.003
0.008888	0.064073	0.013	0.003786	0.003
0.012014	0.048263	0.014742	0.002517	0.002517
0.01106	0.041235	0.014526	0.002887	0.003
0.010504	0.045523	0.018735	0.002517	0.003
0.011504	0.032078	0.021656	0.003512	0.003
0.01823	0.039552	0.017954	0.005	0.003
0.019	0.029138	0.020207	0.006807	0.003
0.019	0.032868	0.019975	0.008505	0.002517
0.018735	0.027495	0.032192	0.003786	0.003
0.018583	0.024786	0.021	0.006083	0.002517
0.019502	0.037687	0.017214	0.01097	0.002517
0.017954	0.02635	0.027392	0.007	0.003
0.016823	0.032501	0.027713	0.016166	0.002517
0.019088	0.035076	0.018148	0.015373	0.002517
0.021362	0.026312	0.008505	0.018475	0.002517
0.020648	0.033858	0.019313	0.013317	0.003
0.020429	0.035698	0.015524	0.025325	0.002517
0.021079	0.03188	0.01115	0.011719	0.002517

Table B75. Averages of raw data from microtiter plate reader experiments for *Z. bailii* 159 in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.172	0.134	0.134667	0.107333	0.106667
0.172	0.139	0.135	0.113	0.111667
0.168667	0.142	0.136667	0.115333	0.112667
0.177	0.145667	0.138667	0.116333	0.115333
0.192667	0.152333	0.141	0.118667	0.117333
0.211667	0.162333	0.145	0.120667	0.118667
0.231	0.174333	0.149333	0.122	0.12
0.258	0.188	0.155	0.122333	0.119333
0.298	0.206333	0.161333	0.122667	0.119333
0.342667	0.223	0.169	0.123333	0.120667
0.388	0.245667	0.176	0.126667	0.119667
0.429	0.276333	0.182667	0.126	0.12
0.473667	0.309333	0.189333	0.126333	0.120333
0.496667	0.343	0.197	0.126333	0.121333
0.515667	0.386333	0.204	0.123333	0.121
0.532333	0.421333	0.214	0.124667	0.122333
0.549	0.463	0.223333	0.126	0.122
0.553667	0.489333	0.231333	0.127333	0.121
0.566333	0.527667	0.237333	0.126	0.120667
0.577333	0.561667	0.246667	0.127667	0.121333
0.588	0.597333	0.263333	0.126333	0.121333
0.588333	0.626333	0.271333	0.127	0.120667
0.589333	0.658333	0.285	0.125667	0.119667
0.582	0.696333	0.301667	0.125333	0.120667
0.583333	0.713667	0.31	0.126	0.120333
0.582667	0.713667	0.326	0.125667	0.119667
0.572333	0.715667	0.340333	0.127333	0.120667
0.573333	0.723667	0.353333	0.128	0.12
0.568667	0.735667	0.369	0.127333	0.119333
0.566667	0.734667	0.383667	0.128333	0.120333
0.550333	0.729333	0.399667	0.127667	0.121333
0.56	0.73	0.425333	0.126667	0.121333
0.549667	0.736333	0.436	0.126667	0.121
0.554333	0.735	0.457667	0.127667	0.119333
0.551	0.731667	0.489333	0.128333	0.120333
0.549	0.727667	0.502333	0.128333	0.120333
0.545667	0.728333	0.519333	0.129	0.12
0.543	0.732333	0.537	0.128	0.121667
0.539667	0.732	0.551	0.129	0.12

Table B75. Continued

0.538	0.731667	0.575333	0.128667	0.119667
0.543667	0.731667	0.587	0.131	0.120333
0.540333	0.728	0.596333	0.131333	0.12
0.536	0.726	0.600333	0.131333	0.120333
0.540667	0.727	0.622	0.134667	0.120333
0.531	0.724	0.627	0.133333	0.12
0.529667	0.722333	0.636333	0.133667	0.120333
0.532	0.720333	0.649667	0.138	0.120667
0.534	0.728	0.643333	0.138333	0.120333
0.525333	0.722667	0.652333	0.138667	0.119667
0.524	0.728	0.644333	0.136333	0.120333
0.525667	0.719	0.649333	0.139333	0.120333
0.53	0.717	0.654	0.141667	0.121333
0.514667	0.723	0.652	0.139667	0.121
0.520667	0.724667	0.654333	0.141	0.121
0.521333	0.723	0.658	0.141333	0.122
0.517	0.725	0.656667	0.141	0.120667
0.523667	0.729	0.653667	0.143	0.124
0.515333	0.727333	0.652667	0.145	0.122333
0.511333	0.718667	0.651333	0.144667	0.123
0.515667	0.727	0.654667	0.147	0.121
0.513333	0.725	0.652667	0.148667	0.121667
0.515667	0.716333	0.649667	0.15	0.121
0.513667	0.724	0.658	0.150333	0.122667
0.514667	0.721667	0.655333	0.153	0.123
0.511667	0.726	0.662667	0.154	0.121333
0.511333	0.726	0.654667	0.155	0.121
0.508	0.725	0.654	0.156333	0.122
0.508333	0.728667	0.659667	0.158667	0.122333
0.507	0.723333	0.658333	0.160333	0.122333
0.504333	0.727667	0.651667	0.162333	0.122667
0.508667	0.727333	0.657333	0.164	0.123
0.499667	0.727667	0.659	0.166	0.123333
0.502	0.727333	0.658333	0.167333	0.122333

Table B76. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. bailii* 159 in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.009165	0.002646	0.004619	0.001155	0.001528
0.007	0.002646	0.006	0.001732	0.003055
0.006028	0.002646	0.006506	0.000577	0.002887
0.006557	0.003215	0.007506	0.000577	0.003215
0.007371	0.003786	0.00755	0.002082	0.003215
0.006028	0.002082	0.00755	0.002517	0.003786
0.006245	0.003055	0.008021	0.003	0.003464
0.003464	0.003606	0.00755	0.003215	0.001528
0.003464	0.002517	0.008021	0.005508	0.001528
0.002082	0.005	0.008544	0.003215	0.004041
0.001732	0.000577	0.008544	0.004163	0.003786
0.004583	0.001528	0.009074	0.004583	0.003464
0.006429	0.007638	0.008327	0.004509	0.004509
0.007638	0.005568	0.006	0.007572	0.002887
0.000577	0.007506	0.005292	0.001528	0.001
0.007506	0.013204	0.005196	0.002082	0.002517
0.005568	0.015875	0.005033	0.007937	0.002
0.004933	0.013429	0.005686	0.009452	0.001732
0.005508	0.022368	0.004619	0.007211	0.003055
0.003512	0.012662	0.007506	0.010017	0.002887
0.009539	0.024028	0.002082	0.007767	0.003786
0.004163	0.015567	0.005508	0.008185	0.003215
0.013051	0.021127	0.002646	0.006028	0.003055
0.00755	0.019858	0.008083	0.004509	0.002082
0.006429	0.013051	0.01044	0.006557	0.002517
0.014224	0.022189	0.013748	0.004509	0.003055
0.010017	0.020841	0.012503	0.007095	0.003215
0.009018	0.025007	0.015503	0.007211	0.002646
0.009018	0.018009	0.015133	0.007095	0.002517
0.009609	0.029195	0.017214	0.007767	0.002517
0.001528	0.021362	0.012423	0.005033	0.002887
0.015395	0.033956	0.017156	0.004509	0.004933
0.010017	0.025968	0.018028	0.004509	0.003
0.012342	0.034771	0.019553	0.006028	0.003215
0.01253	0.033081	0.021825	0.005508	0.002309
0.004359	0.024846	0.016921	0.005508	0.003215
0.007572	0.030616	0.005508	0.005	0.002646
0.008544	0.028589	0.013748	0.003606	0.004619

Table B76. Continued

0.010017	0.03148	0.015133	0.004	0.002646
0.006557	0.030022	0.012702	0.003512	0.003055
0.008505	0.030827	0.011358	0.007	0.004041
0.012014	0.037643	0.012702	0.004509	0.002646
0.009849	0.030265	0.012055	0.005132	0.003215
0.006429	0.031225	0.017578	0.007638	0.002309
0.008	0.036715	0.016371	0.00611	0.003464
0.00611	0.033501	0.009292	0.004726	0.002517
0.015524	0.032347	0.014189	0.013077	0.002082
0.012288	0.032909	0.014295	0.009452	0.003215
0.011846	0.033005	0.014468	0.009074	0.003055
0.018358	0.03422	0.01159	0.006807	0.003215
0.014189	0.032078	0.009815	0.010408	0.003215
0.011269	0.031607	0.006083	0.012503	0.004041
0.013429	0.033287	0.002	0.008327	0.003
0.01914	0.040673	0.004726	0.011533	0.003464
0.012583	0.039509	0.003606	0.01115	0.002646
0.012767	0.030116	0.006506	0.010583	0.003055
0.017559	0.035791	0.005859	0.010817	0.003
0.014189	0.034152	0.013868	0.011358	0.002309
0.012662	0.038553	0.007234	0.010786	0.003
0.010693	0.036715	0.005686	0.010583	0.003
0.014012	0.041569	0.004726	0.01193	0.002082
0.015567	0.037647	0.012858	0.011358	0.003
0.01701	0.041617	0.006083	0.013051	0.002887
0.014012	0.043662	0.008145	0.014	0.002646
0.017039	0.044677	0.003215	0.015716	0.002517
0.01893	0.03629	0.008021	0.014	0.003
0.009539	0.043347	0.009165	0.014012	0.002646
0.02248	0.035642	0.005508	0.013868	0.003512
0.013892	0.042442	0.004726	0.015503	0.003512
0.014572	0.039929	0.007371	0.01893	0.004041
0.01701	0.040501	0.012055	0.016643	0.004583
0.014572	0.045369	0.012767	0.017578	0.005033
0.014177	0.048087	0.006351	0.022368	0.004041

Table B77. Averages of raw data from microtiter plate reader experiments for *Z. bailii* 158 in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.218333	0.150333	0.146667	0.151667	0.141
0.195	0.15	0.135	0.152	0.142333
0.209	0.153667	0.135333	0.152667	0.139
0.25	0.164333	0.136	0.154333	0.137667
0.312667	0.181	0.137333	0.155	0.137
0.402	0.204667	0.139	0.156	0.136333
0.492667	0.236667	0.142333	0.158	0.136
0.576333	0.276667	0.144667	0.159	0.136333
0.645333	0.325	0.148667	0.159667	0.135667
0.688333	0.378333	0.152667	0.161	0.135667
0.727333	0.430667	0.157	0.162667	0.135667
0.752	0.491667	0.164	0.164	0.136333
0.771	0.549667	0.171333	0.164667	0.135667
0.785333	0.590667	0.177667	0.166333	0.135667
0.802333	0.632	0.186333	0.167333	0.135333
0.814667	0.674667	0.195	0.169	0.135667
0.832333	0.711	0.205	0.170333	0.135333
0.835333	0.743667	0.212667	0.171	0.136
0.840667	0.768667	0.223667	0.171333	0.135333
0.848	0.786667	0.237333	0.172	0.136
0.845	0.806	0.249667	0.172667	0.135667
0.842667	0.804333	0.260333	0.173667	0.136333
0.835	0.795	0.276	0.174	0.136
0.828333	0.794667	0.287667	0.174	0.136
0.823333	0.792333	0.299333	0.175	0.136333
0.820667	0.788333	0.310333	0.175	0.136333
0.809	0.780667	0.322	0.175333	0.136333
0.808667	0.774333	0.329667	0.175	0.136667
0.797667	0.773333	0.341	0.174667	0.137
0.796333	0.762667	0.353333	0.175333	0.136667
0.787667	0.760333	0.367333	0.175	0.136667
0.797333	0.755333	0.377	0.174333	0.136667
0.790333	0.759	0.392667	0.174333	0.136667
0.785333	0.753667	0.405667	0.174333	0.136667
0.793	0.753333	0.423333	0.174333	0.137333
0.79	0.756333	0.440667	0.174333	0.137
0.787	0.753667	0.452667	0.174	0.137
0.781333	0.744667	0.464333	0.174	0.136667
0.779667	0.745	0.478333	0.174	0.136667

Table B77. Continued

0.782667	0.745333	0.493333	0.173667	0.136667
0.785	0.745333	0.506667	0.174	0.136667
0.784	0.748333	0.519	0.173667	0.136667
0.793333	0.747	0.540667	0.173333	0.136667
0.787	0.742	0.557667	0.173667	0.136667
0.781333	0.744	0.57	0.173	0.136667
0.782	0.737667	0.583	0.173	0.136667
0.778667	0.738	0.599	0.173	0.136333
0.781333	0.735667	0.618	0.173	0.136333
0.783	0.735	0.629667	0.172667	0.136667
0.783333	0.733333	0.631667	0.173	0.136333
0.782333	0.731	0.639333	0.172667	0.136
0.778667	0.732333	0.649	0.172667	0.136
0.780667	0.728667	0.647	0.172	0.136
0.783333	0.728	0.651333	0.172	0.136333
0.778	0.727667	0.655667	0.172	0.136
0.779333	0.725333	0.649667	0.172	0.135667
0.78	0.730333	0.652667	0.172	0.135333
0.778333	0.733667	0.646667	0.172	0.136
0.774333	0.725	0.649333	0.171667	0.135333
0.775	0.724	0.648	0.172	0.135333
0.777333	0.722333	0.65	0.172	0.135333
0.783	0.722	0.644333	0.171667	0.135333
0.766667	0.721333	0.643667	0.171333	0.135333
0.770667	0.719333	0.642333	0.171	0.134667
0.769333	0.719333	0.645333	0.171	0.134667
0.769667	0.719	0.640333	0.171	0.134333
0.766	0.713333	0.637	0.171	0.134333
0.761667	0.719	0.639667	0.171	0.134667
0.765667	0.718667	0.637667	0.170333	0.134
0.762	0.722	0.640333	0.171	0.134333
0.768	0.715333	0.639	0.170667	0.134
0.757667	0.719	0.634	0.170333	0.134
0.765667	0.723	0.633	0.170333	0.134

Table B78. Standard deviations of averages of raw data from microtiter plate reader experiments for *Z. bailii* 158 in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.021032	0.004163	0.000577	0.02248	0.002
0.017088	0.017436	0.007	0.018028	0.001528
0.015524	0.017786	0.008021	0.018877	0.001732
0.019519	0.020793	0.00755	0.019425	0.001528
0.026539	0.026287	0.008021	0.019975	0.001
0.034598	0.031786	0.008544	0.01833	0.002082
0.05054	0.040649	0.009018	0.016703	0.001732
0.049166	0.048003	0.009504	0.016703	0.002082
0.053529	0.049153	0.010017	0.017243	0.001528
0.047962	0.060003	0.009504	0.016703	0.002517
0.04319	0.05577	0.010536	0.017243	0.002517
0.041037	0.061809	0.01253	0.017692	0.001528
0.046872	0.054885	0.010599	0.017616	0.003215
0.049339	0.045347	0.011504	0.018148	0.003215
0.041041	0.039051	0.010504	0.018148	0.004041
0.048604	0.03926	0.008	0.018682	0.003512
0.045797	0.037242	0.010536	0.017559	0.004041
0.046047	0.038475	0.010017	0.018682	0.004
0.043317	0.035852	0.008083	0.01914	0.004041
0.043278	0.032716	0.007024	0.019672	0.004
0.043347	0.029462	0.004163	0.020207	0.003512
0.039929	0.033486	0.001528	0.020207	0.003512
0.046228	0.032187	0.004	0.020298	0.004
0.043662	0.028219	0.006807	0.020298	0.004
0.043662	0.030989	0.009866	0.020298	0.004509
0.037314	0.033975	0.007024	0.020298	0.003512
0.045574	0.034064	0.011	0.020744	0.004509
0.044163	0.035572	0.014572	0.020298	0.004509
0.035162	0.032655	0.01253	0.020841	0.004
0.041765	0.026102	0.018009	0.020744	0.004509
0.041956	0.032747	0.016197	0.020664	0.004509
0.035218	0.039552	0.020664	0.020744	0.004509
0.042004	0.027713	0.018448	0.020744	0.004509
0.042194	0.028042	0.019425	0.020744	0.004509
0.036715	0.029366	0.012741	0.020744	0.004509
0.034073	0.031565	0.021221	0.020744	0.004
0.043	0.033501	0.016653	0.020664	0.004
0.037233	0.03536	0.020502	0.020664	0.004509

Table B78. Continued

0.034429	0.02816	0.025541	0.020664	0.004509
0.040919	0.028711	0.027574	0.021197	0.004509
0.035791	0.037072	0.026839	0.020664	0.004509
0.04531	0.028572	0.031796	0.020599	0.004509
0.038657	0.035086	0.031896	0.021127	0.004509
0.043966	0.035511	0.038136	0.020599	0.004509
0.043016	0.031193	0.035369	0.020664	0.004509
0.043863	0.032192	0.037323	0.020664	0.004509
0.041405	0.03751	0.037643	0.020664	0.005033
0.042028	0.03086	0.037242	0.020664	0.005033
0.041581	0.027185	0.027209	0.020599	0.004509
0.046715	0.030616	0.024542	0.020664	0.005033
0.047983	0.030643	0.017502	0.020599	0.005
0.044523	0.033005	0.015524	0.021197	0.005
0.041885	0.026502	0.011533	0.020664	0.005
0.040067	0.031432	0.008505	0.020664	0.004509
0.043555	0.033232	0.005132	0.020664	0.005
0.043294	0.032655	0.005508	0.020664	0.004509
0.048446	0.036171	0.007767	0.020664	0.005033
0.038812	0.033201	0.010504	0.020664	0.005
0.044613	0.033287	0.005859	0.020599	0.005033
0.046184	0.032047	0.006083	0.020664	0.005033
0.044117	0.033546	0.002	0.020664	0.005033
0.039737	0.027074	0.007506	0.020207	0.005033
0.045829	0.03362	0.011504	0.021127	0.005033
0.038527	0.033501	0.007572	0.020664	0.005508
0.035233	0.039501	0.001528	0.020664	0.005508
0.044792	0.027074	0.003055	0.020664	0.005033
0.043486	0.032808	0.012124	0.020664	0.005033
0.041645	0.038158	0.006028	0.020664	0.005508
0.038553	0.036937	0.010017	0.021127	0.005568
0.038354	0.034655	0.008083	0.020664	0.005033
0.038	0.032005	0.006245	0.021197	0.005568
0.040501	0.032909	0.014933	0.021127	0.005568
0.040919	0.035539	0.015875	0.021127	0.005568

Table B79. Averages of raw data from microtiter plate reader experiments for *K. lactis* in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.102	0.095333	0.097667	0.095333	0.092667
0.108667	0.099	0.1	0.099	0.095333
0.107333	0.105	0.104667	0.101	0.097333
0.132	0.123333	0.109333	0.102333	0.098333
0.178333	0.150667	0.122333	0.102	0.098
0.226667	0.182333	0.156	0.102667	0.098
0.273667	0.213333	0.155333	0.103333	0.098333
0.309667	0.232667	0.165333	0.103	0.098333
0.34	0.247	0.167667	0.103	0.098333
0.368333	0.248	0.169667	0.103	0.098333
0.399333	0.264333	0.149	0.103333	0.098
0.420333	0.268667	0.150667	0.102333	0.098
0.444	0.266333	0.140667	0.102333	0.098333
0.461333	0.270667	0.134333	0.102667	0.098
0.473333	0.27	0.140667	0.103	0.098333
0.488667	0.277	0.146	0.103333	0.098
0.493667	0.287	0.150333	0.102333	0.098
0.508667	0.312	0.151667	0.102667	0.098333
0.509333	0.332333	0.16	0.102667	0.098333
0.507667	0.377	0.156	0.102667	0.098333
0.517333	0.433333	0.165	0.102667	0.098333
0.53	0.518667	0.168	0.102667	0.098333
0.535667	0.582333	0.174	0.103	0.098333
0.530333	0.626	0.179	0.102667	0.098333
0.530667	0.662667	0.181667	0.102667	0.098333
0.522	0.696	0.191	0.102667	0.098333
0.523667	0.718	0.198333	0.102333	0.098333
0.519	0.717667	0.202667	0.102	0.098333
0.518333	0.73	0.208	0.103	0.098333
0.528	0.780333	0.218333	0.102	0.098333
0.531333	0.776333	0.225	0.102667	0.098333
0.529333	0.782333	0.230667	0.102667	0.098333
0.543667	0.812	0.234667	0.102667	0.098333
0.542667	0.815333	0.239333	0.102667	0.098333
0.536333	0.845667	0.244667	0.102	0.098333
0.543667	0.849333	0.246	0.102333	0.098333
0.543667	0.839667	0.247	0.102333	0.098333
0.562	0.879	0.253333	0.102	0.098333
0.567	0.886	0.253	0.102333	0.098333

Table B79. Continued

0.561333	0.888667	0.255	0.102667	0.098333
0.561	0.894333	0.268333	0.102	0.098333
0.561	0.902	0.267667	0.102333	0.098333
0.556	0.895333	0.266	0.102	0.098333
0.563667	0.91	0.266	0.102	0.099
0.554667	0.913333	0.267333	0.102333	0.098333
0.560667	0.914333	0.267667	0.102	0.098333
0.576333	0.915667	0.266	0.102	0.098333
0.579333	0.924	0.264333	0.102	0.098333
0.582333	0.93	0.265	0.102	0.098333
0.605	0.931667	0.262333	0.102	0.098667
0.608667	0.938333	0.265	0.102	0.098667
0.594	0.945	0.272333	0.102	0.098333
0.599	0.947333	0.277667	0.102	0.098333
0.605333	0.956667	0.284333	0.102	0.098333
0.610667	0.959667	0.282	0.102	0.098333
0.617667	0.963667	0.308	0.102	0.098333
0.609667	0.966667	0.322667	0.101667	0.098333
0.624	0.970667	0.325667	0.102	0.098333
0.619333	0.976	0.323667	0.102	0.098667
0.622	0.980333	0.328667	0.101667	0.098333
0.632667	0.984	0.334333	0.102	0.098333
0.636667	0.991	0.340333	0.102	0.098333
0.628333	0.992667	0.36	0.102	0.098333
0.633667	1.000333	0.360333	0.101667	0.098333
0.64	1.001667	0.362	0.102	0.098333
0.642333	1.007	0.366	0.102	0.098333
0.656	1.006333	0.371	0.102333	0.098333
0.653	1.015	0.368667	0.102	0.098333
0.660333	1.017667	0.375667	0.102	0.098333
0.658333	1.021667	0.379667	0.102	0.099
0.678	1.025	0.380667	0.102	0.098333
0.684667	1.022667	0.382667	0.102	0.098333
0.702667	1.032	0.39	0.101667	0.098333

Table B80. Standard deviations of averages of raw data from microtiter plate reader experiments for *K. lactis* in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.006083	0.000577	0.000577	0.001155	0.000577
0.004619	0.001	0.002646	0.003	0.001155
0.002309	0.001	0.003215	0.002646	0.001155
0.003	0.002082	0.003786	0.003055	0.001155
0.003055	0.003215	0.007638	0.002646	0.001
0.007095	0.003786	0.001	0.003512	0.001
0.017214	0.004163	0.004726	0.002517	0.001155
0.032146	0.005132	0.008327	0.003	0.001155
0.049325	0.004583	0.004726	0.003	0.001155
0.060929	0.005	0.005508	0.002646	0.001155
0.079223	0.007024	0.010536	0.003055	0.001
0.087922	0.017786	0.013317	0.002082	0.001
0.10641	0.01861	0.01222	0.002082	0.001155
0.111912	0.026502	0.003786	0.002517	0.001
0.120902	0.026889	0.003786	0.002646	0.001155
0.138023	0.033867	0.008718	0.003055	0.001
0.133781	0.033808	0.007371	0.002082	0.001732
0.153239	0.03985	0.003215	0.002309	0.001155
0.165742	0.041429	0.003464	0.003215	0.001155
0.167157	0.044396	0.001732	0.002517	0.001155
0.190288	0.031374	0.00755	0.002517	0.001155
0.21612	0.009504	0.012166	0.002309	0.001155
0.224342	0.02203	0.013	0.002646	0.001155
0.240504	0.009644	0.017776	0.002517	0.001155
0.248093	0.007506	0.021572	0.002309	0.001155
0.251394	0.015395	0.021	0.002309	0.001155
0.263532	0.01044	0.021127	0.003055	0.001155
0.267754	0.018717	0.026274	0.002646	0.001155
0.281944	0.014422	0.032187	0.002646	0.001155
0.284317	0.009074	0.032192	0.002646	0.001155
0.298185	0.020008	0.030447	0.003215	0.001155
0.298658	0.022898	0.033322	0.003215	0.001155
0.311513	0.014107	0.036556	0.003215	0.001155
0.310213	0.021939	0.036199	0.003215	0.001155
0.31373	0.007638	0.029738	0.002646	0.001155
0.324457	0.009452	0.038691	0.003055	0.001155
0.326292	0.015177	0.043209	0.002082	0.001155
0.340357	0.006245	0.046608	0.002646	0.001155

Table B80. Continued

0.344431	0.006245	0.049759	0.003055	0.001155
0.345979	0.002082	0.04979	0.003215	0.001155
0.347562	0.004933	0.045633	0.002646	0.001155
0.34972	0.002646	0.051248	0.002887	0.001155
0.349404	0.001528	0.055678	0.002646	0.001155
0.35481	0.004	0.052716	0.002646	0.002
0.356124	0.003215	0.059534	0.002887	0.001155
0.360728	0.004933	0.060871	0.002646	0.001155
0.369652	0.004509	0.05866	0.002646	0.001155
0.368226	0.009849	0.065493	0.002646	0.001155
0.368106	0.00781	0.065338	0.002646	0.001155
0.373947	0.014468	0.070777	0.002646	0.001528
0.372866	0.008145	0.079994	0.002646	0.001528
0.369627	0.004	0.084884	0.002646	0.001155
0.371566	0.007638	0.095133	0.002646	0.001155
0.371718	0.009452	0.101854	0.002646	0.001155
0.372591	0.007572	0.100955	0.002646	0.001155
0.37141	0.011015	0.103	0.002646	0.001155
0.372866	0.010214	0.088297	0.002309	0.001155
0.377437	0.009504	0.072858	0.002646	0.001155
0.378272	0.006557	0.093029	0.002646	0.001528
0.378723	0.007638	0.096811	0.002309	0.001155
0.390149	0.003	0.103423	0.002646	0.001155
0.386907	0.005196	0.10681	0.002646	0.001155
0.380421	0.007095	0.090067	0.002646	0.001155
0.387052	0.007371	0.095322	0.002309	0.001155
0.388213	0.007024	0.111014	0.002646	0.001155
0.387099	0.006	0.12216	0.002646	0.001155
0.392126	0.007095	0.124724	0.003055	0.001155
0.390138	0.006245	0.136654	0.002646	0.001155
0.395897	0.006807	0.146124	0.002646	0.001155
0.40105	0.006506	0.153158	0.002646	0.002
0.404093	0.008888	0.160079	0.002646	0.001155
0.413754	0.008622	0.162525	0.002646	0.001155
0.418918	0.007211	0.167311	0.002309	0.001155

Table B81. Averages of raw data from microtiter plate reader experiments for *S. passalidarum* in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.114	0.097667	0.098333	0.097667	0.093
0.116	0.099333	0.102333	0.099	0.096
0.117	0.105333	0.108333	0.100667	0.097667
0.151	0.12	0.111333	0.102	0.098
0.201	0.142	0.114667	0.101333	0.098
0.258	0.167667	0.12	0.101333	0.097333
0.314333	0.201667	0.120333	0.104667	0.097667
0.361667	0.225333	0.127333	0.101	0.097667
0.400667	0.246667	0.139333	0.101333	0.097
0.442	0.253667	0.146333	0.101667	0.097
0.481667	0.276667	0.147667	0.104667	0.097
0.516667	0.278333	0.152	0.101333	0.097
0.547667	0.281333	0.151	0.100667	0.097
0.571667	0.292	0.15	0.101	0.097
0.590667	0.290667	0.145667	0.101	0.097333
0.627333	0.297667	0.142333	0.101	0.097
0.642333	0.311667	0.134	0.100667	0.097333
0.657333	0.317333	0.141	0.101333	0.097333
0.659667	0.322	0.138667	0.100667	0.097
0.692667	0.333667	0.132333	0.101333	0.097
0.689667	0.338667	0.14	0.101	0.097
0.708	0.353333	0.141	0.100667	0.097
0.734667	0.363	0.144667	0.101	0.097
0.720333	0.367333	0.147667	0.100667	0.097333
0.731	0.357333	0.149	0.100667	0.097
0.747667	0.367333	0.152	0.101	0.097
0.749	0.377	0.151	0.100333	0.097333
0.754	0.370333	0.150667	0.100667	0.097
0.763	0.374333	0.151	0.101333	0.097
0.763	0.388	0.152	0.100667	0.097
0.783333	0.381	0.151	0.100667	0.097
0.789667	0.379	0.151333	0.099667	0.097
0.814	0.389333	0.152333	0.1	0.097
0.812	0.379667	0.149333	0.101333	0.099333
0.81	0.388333	0.148333	0.100333	0.097
0.823667	0.381333	0.148333	0.101	0.097
0.830667	0.378333	0.146333	0.101333	0.097
0.86	0.377333	0.149333	0.103667	0.097333
0.863333	0.380333	0.146667	0.101	0.097

Table B81. Continued

0.872667	0.385333	0.147	0.104	0.097333
0.874333	0.385667	0.145	0.101	0.097
0.877	0.393667	0.146667	0.101	0.097
0.885667	0.400667	0.148	0.100667	0.097333
0.902333	0.417333	0.148333	0.101667	0.097333
0.905667	0.403	0.147333	0.105	0.097
0.924333	0.406667	0.147333	0.102667	0.098333
0.944667	0.412	0.148	0.103	0.097
0.939	0.408667	0.148	0.104	0.097333
0.945667	0.410333	0.147667	0.104333	0.097667
0.954333	0.416667	0.148	0.104667	0.098
0.947667	0.421333	0.147667	0.105667	0.098
0.942	0.423	0.149	0.106333	0.097333
0.953667	0.421667	0.147667	0.107333	0.097333
0.952	0.42	0.148667	0.107667	0.097333
0.961667	0.424	0.146	0.108667	0.097667
0.96	0.425667	0.145667	0.108667	0.097667
0.95	0.421333	0.146	0.109667	0.097
0.943	0.424667	0.145333	0.109333	0.097
0.95	0.427667	0.146667	0.11	0.097
0.934333	0.424	0.145333	0.114	0.097
0.932667	0.421	0.145667	0.110667	0.097
0.934	0.420667	0.144667	0.110333	0.097667
0.933333	0.423	0.143333	0.111	0.097
0.934667	0.417333	0.143	0.111333	0.097
0.924	0.422333	0.144	0.111	0.097
0.931333	0.416667	0.144	0.111	0.097667
0.929667	0.414	0.143333	0.111	0.098
0.922333	0.418	0.143333	0.110333	0.097333
0.921	0.415333	0.143	0.110333	0.097333
0.930333	0.415333	0.142667	0.111333	0.097667
0.936	0.416	0.142667	0.110667	0.097333
0.933333	0.414	0.142	0.110333	0.097
0.928333	0.415	0.142	0.11	0.098667

Table B82. Standard deviations of averages of raw data from microtiter plate reader experiments for *S. passalidarum* in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.005196	0.000577	0.000577	0.002887	1.69967E-17
0.008888	0.000577	0.000577	1.7E-17	0.001
0.008718	0.000577	0.001528	0.000577	0.00057735
0.013856	0.001	0.002517	0	0.001
0.019287	0.001	0.003055	0.000577	0.001
0.031193	0.002309	0.002	0.000577	0.00057735
0.045523	0.002082	0.005774	0.006351	0.001527525
0.064733	0.005774	0.007024	1.7E-17	0.00057735
0.083032	0.009815	0.000577	0.001528	0.001
0.09824	0.010017	0.001528	0.000577	0.001
0.102666	0.01193	0.003786	0.006351	0.001
0.118298	0.014978	0.003	0.000577	0.001
0.130024	0.018771	0.001732	0.000577	0.001
0.136078	0.019079	0.004	1.7E-17	0.001
0.130424	0.027135	0.006506	1.7E-17	0.00057735
0.144189	0.028868	0.007371	1.7E-17	0.001
0.139658	0.037859	0.007211	0.000577	0.001527525
0.164564	0.040612	0	0.000577	0.00057735
0.158184	0.039887	0.001528	0.000577	0.001
0.184785	0.05154	0.000577	0.001155	0.001
0.184503	0.053257	0.006557	1.7E-17	0.001
0.208317	0.064384	0.002646	0.000577	0.001
0.22646	0.060108	0.003786	1.7E-17	0.001
0.264655	0.068995	0.005774	0.000577	0.001527525
0.279319	0.062115	0.001732	0.000577	0.001
0.292654	0.074232	0.001	1.7E-17	0.001
0.314577	0.084042	0.003	0.000577	0.001527525
0.314419	0.080258	0.001155	0.000577	0.001
0.340071	0.087323	0.001732	0.000577	0.001
0.362861	0.087504	0.004359	0.000577	0.001
0.37581	0.096286	0.002646	0.000577	0.001
0.3868	0.097	0.000577	0.000577	0.001
0.410048	0.099324	0.003055	1.7E-17	0.001
0.403847	0.105945	0.002309	0.000577	0.004163332
0.412847	0.101904	0.001155	0.000577	0.001
0.422985	0.11491	0.001528	1.7E-17	0.001
0.425194	0.121039	0.006351	0.000577	0.001
0.441331	0.129624	0.004509	0.004619	0.00057735

Table B82. Continued

0.433544	0.13571	0.003512	0.001	0.001
0.443987	0.141762	0.003606	0.003	0.001527525
0.443018	0.149346	0.003	0.001732	0.001
0.438265	0.167435	0.001155	0.001	0.001
0.448393	0.166602	0.001732	0.001155	0.00057735
0.452527	0.178422	0.001528	0.002887	0.001527525
0.459163	0.179324	0.004163	0.00866	0.001
0.471769	0.182237	0.004163	0.004619	0.001527525
0.457019	0.20104	0.001732	0.005196	0.001
0.455534	0.192563	0.001	0.006928	0.00057735
0.46045	0.205831	0.002082	0.007506	0.00057735
0.440278	0.200341	0.001	0.008083	0.001
0.441591	0.217964	0.000577	0.009815	0.001732051
0.440105	0.222614	0.002646	0.01097	0.00057735
0.4365	0.220355	0.001528	0.012702	0.00057735
0.439601	0.217387	0.002517	0.013279	0.001154701
0.42324	0.231234	0.002646	0.015011	0.00057735
0.430596	0.233252	0.002309	0.015011	0.001154701
0.433346	0.243972	0.005292	0.016743	0.001
0.414106	0.24191	0.001528	0.016166	0.001
0.421059	0.247124	0.001155	0.017321	0.001
0.411041	0.248562	0.004933	0.0151	0.001
0.406879	0.245959	0.001155	0.018475	0.001
0.404627	0.24365	0.003055	0.017898	0.00057735
0.41627	0.239952	0.003215	0.019053	0.001
0.418121	0.246531	0.003464	0.01963	0.001
0.407239	0.242203	0.003464	0.019053	0.001
0.403234	0.235016	0.005292	0.019053	0.001527525
0.39553	0.238183	0.005774	0.019053	0.001
0.382312	0.240857	0.005859	0.017898	0.001154701
0.382062	0.237887	0.008185	0.01963	0.001527525
0.39	0.242199	0.006658	0.01963	0.00057735
0.389758	0.235593	0.008145	0.018475	0.001154701
0.3762	0.230441	0.009849	0.018771	0.001
0.371826	0.228685	0.010817	0.019053	0.002516611

Table B83. Averages of raw data from microtiter plate reader experiments for *P. stipitis* in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.113667	0.090667	0.093	0.092	0.092
0.125333	0.091	0.103333	0.094333	0.093667
0.127333	0.091667	0.109333	0.094667	0.095
0.138333	0.092667	0.113333	0.095333	0.095333
0.165333	0.093333	0.116	0.095	0.094333
0.214667	0.096667	0.118667	0.096	0.096
0.287333	0.106667	0.121	0.096333	0.094667
0.359	0.124333	0.123667	0.096333	0.094667
0.422667	0.159	0.126667	0.097333	0.094667
0.468333	0.205667	0.130667	0.097667	0.094667
0.502	0.266667	0.135	0.097	0.094667
0.523333	0.332667	0.138667	0.097667	0.094667
0.535333	0.400667	0.151	0.098333	0.094667
0.545333	0.468667	0.165667	0.103333	0.094667
0.552667	0.540667	0.176667	0.104	0.095
0.554667	0.605333	0.201	0.109	0.095
0.559667	0.664333	0.230333	0.110333	0.095333
0.564333	0.711	0.260667	0.114	0.094667
0.566	0.751	0.265	0.115333	0.095
0.568667	0.785333	0.266333	0.123	0.096333
0.571333	0.816	0.296	0.139333	0.096
0.574	0.842	0.276	0.154333	0.096333
0.575667	0.866333	0.311667	0.154	0.095667
0.578667	0.882667	0.352667	0.179667	0.095667
0.579667	0.901667	0.398333	0.203333	0.096
0.583333	0.914333	0.452	0.214667	0.096
0.586667	0.928333	0.502667	0.224333	0.096
0.590667	0.940333	0.561667	0.236333	0.096333
0.596333	0.950667	0.615667	0.209	0.097
0.605	0.962667	0.666	0.212	0.097333
0.612333	0.970667	0.713667	0.218333	0.098333
0.621	0.981	0.758667	0.232	0.097667
0.624	0.990667	0.801667	0.257333	0.098
0.630333	1.000667	0.843667	0.282667	0.1
0.633667	1.010333	0.883333	0.327	0.099333
0.636	1.017333	0.922	0.367	0.1
0.638	1.026	0.956	0.407	0.102
0.636333	1.035333	0.991	0.453	0.103667
0.633667	1.044333	1.020333	0.501333	0.107

Table B83. Continued

0.631667	1.053667	1.049	0.554	0.110333
0.631667	1.061333	1.075333	0.604	0.114667
0.63	1.067667	1.099	0.651667	0.126333
0.63	1.075333	1.119	0.698667	0.132667
0.628	1.081333	1.128	0.740667	0.149333
0.627667	1.084667	1.139	0.779333	0.143
0.627667	1.089667	1.151	0.823333	0.138
0.627	1.096	1.157	0.86	0.131333
0.618	1.1	1.160667	0.898	0.175333
0.609	1.102333	1.160667	0.93	0.167333
0.592	1.101333	1.158667	0.959333	0.175
0.581	1.103333	1.156667	0.979333	0.178333
0.574333	1.101	1.153333	0.998333	0.194
0.564	1.097333	1.149333	1.024333	0.203333
0.556333	1.085667	1.146	1.029333	0.207
0.547667	1.077333	1.143	1.025	0.223333
0.541	1.062	1.141667	1.014667	0.238333
0.537667	1.049333	1.139667	1.006667	0.257333
0.536667	1.042667	1.139333	0.999	0.280667
0.534333	1.03	1.138667	0.993	0.298
0.533	1.023667	1.139333	0.985667	0.317667
0.533333	1.018333	1.139	0.981	0.339
0.534333	1.009667	1.141	0.977667	0.363
0.533667	1.007333	1.141	0.974333	0.387667
0.536	0.997	1.144	0.973667	0.411
0.536333	0.996	1.144333	0.971	0.431667
0.539667	0.994333	1.146333	0.969667	0.451333
0.539333	0.993667	1.150333	0.97	0.473
0.539	0.992667	1.150667	0.970333	0.490667
0.543333	0.990333	1.151333	0.968333	0.508333
0.545	0.992	1.152333	0.969333	0.520333
0.548333	0.990667	1.153667	0.969	0.539
0.548	0.986667	1.156	0.969	0.549667
0.551	0.988667	1.157	0.969	0.566333

Table B84. Standard deviations of averages of raw data from microtiter plate reader experiments for *P. stipitis* in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.004041	0.001528	0.001	0.001	0.001732
0.014978	1.7E-17	0.016197	0.000577	0.002887
0.012055	0.000577	0.025697	0.000577	0.003464
0.017039	0.000577	0.030892	0.000577	0.004041
0.023007	0.000577	0.035511	0.001	0.002309
0.029023	0.000577	0.038397	0.001	0.005196
0.037873	0.002082	0.038974	0.000577	0.002887
0.041073	0.001155	0.041861	0.000577	0.002887
0.045004	0.001	0.043616	0.000577	0.002887
0.047258	0.003055	0.042736	0.002517	0.002887
0.04979	0.005686	0.040731	0.001	0.002887
0.046458	0.002887	0.043593	0.001528	0.002887
0.037647	0.002309	0.036592	0.001528	0.002887
0.029023	0.003786	0.035019	0.002082	0.002887
0.023629	0.005508	0.023714	0.001732	0.003464
0.016623	0.007572	0.01562	0.003	0.003464
0.012014	0.008737	0.034078	0.004726	0.004041
0.010693	0.012124	0.013614	0.00781	0.002887
0.011533	0.012	0.026058	0.009074	0.003464
0.014012	0.013051	0.045622	0.011136	0.004933
0.018009	0.014107	0.059355	0.011372	0.003464
0.021071	0.014	0.02498	0.011372	0.004041
0.026764	0.014503	0.020429	0.01044	0.002887
0.030353	0.015011	0.023029	0.022723	0.002887
0.03296	0.014572	0.026083	0.019655	0.003464
0.034239	0.017502	0.024269	0.02203	0.003464
0.034122	0.013051	0.029484	0.015885	0.003464
0.035019	0.013051	0.028746	0.01701	0.003215
0.036501	0.015503	0.028219	0.035157	0.003464
0.038974	0.013577	0.028583	0.024249	0.003215
0.040278	0.013013	0.027154	0.023029	0.004933
0.044396	0.014526	0.027429	0.019	0.002887
0.043589	0.013577	0.026102	0.019858	0.002646
0.045391	0.013013	0.026102	0.01222	0.004359
0.048274	0.012662	0.025106	0.021166	0.003215
0.052	0.012662	0.024556	0.021703	0.002646
0.051118	0.012124	0.026851	0.021166	0.003
0.053267	0.012342	0.023896	0.021932	0.001528

Table B84. Continued

0.051695	0.011676	0.023587	0.026102	0.003606
0.049943	0.010599	0.024515	0.026665	0.003786
0.049943	0.009292	0.024111	0.025239	0.006506
0.050239	0.008963	0.02265	0.028148	0.004509
0.049386	0.008505	0.025534	0.03213	0.014572
0.051293	0.008505	0.029206	0.032563	0.008737
0.053003	0.007371	0.022913	0.034501	0.017436
0.052539	0.007638	0.021932	0.028572	0.015716
0.054065	0.006245	0.028844	0.031512	0.007371
0.061992	0.004359	0.029872	0.028827	0.024379
0.068352	0.004933	0.028729	0.028618	0.023459
0.076896	0.007767	0.030105	0.03037	0.035553
0.08873	0.008737	0.028919	0.030925	0.020108
0.098338	0.008718	0.034034	0.031342	0.024062
0.111517	0.009452	0.029956	0.033081	0.023861
0.123618	0.016073	0.034117	0.029195	0.032078
0.138363	0.017098	0.032187	0.031193	0.03213
0.150722	0.018735	0.031342	0.028042	0.034847
0.162666	0.022591	0.029687	0.027592	0.041789
0.171261	0.023007	0.029569	0.027875	0.052013
0.182621	0.035679	0.028378	0.029597	0.059025
0.190376	0.039954	0.028589	0.025891	0.063532
0.196047	0.040054	0.028827	0.027074	0.067506
0.197627	0.037314	0.028478	0.028219	0.075624
0.201659	0.037233	0.027839	0.027025	0.079034
0.200731	0.028618	0.027839	0.026652	0.079542
0.206268	0.02816	0.025541	0.028	0.082519
0.206911	0.028537	0.030089	0.027592	0.085967
0.211193	0.02797	0.02928	0.029309	0.085633
0.214007	0.029501	0.030139	0.028431	0.092425
0.214533	0.020429	0.028095	0.02797	0.092197
0.219173	0.022869	0.028537	0.028431	0.090357
0.220584	0.024379	0.030022	0.028583	0.096763
0.226046	0.036364	0.029614	0.027875	0.097007
0.227765	0.037072	0.032604	0.026907	0.088376

Table B85. Averages of raw data from microtiter plate reader experiments for *D. hansenii* in lactic acid taken every 2 hours over 6 days

Control	25mM	50mM	75mM	100mM
0.103	0.098667	0.100333	0.101	0.093333
0.107333	0.098667	0.105667	0.109333	0.095667
0.110333	0.099333	0.105	0.108	0.099333
0.115333	0.099333	0.106333	0.110333	0.098
0.122	0.099	0.109667	0.112667	0.099
0.132	0.100667	0.110667	0.119667	0.106333
0.144	0.100333	0.115333	0.124667	0.098
0.156333	0.100667	0.108	0.120333	0.100333
0.169667	0.101333	0.119667	0.122	0.103667
0.181667	0.105667	0.121	0.129	0.099333
0.193667	0.105667	0.119667	0.128667	0.097667
0.203667	0.108	0.121667	0.120333	0.103
0.214333	0.107	0.121	0.130667	0.1
0.224333	0.109	0.123667	0.133	0.101
0.234667	0.114333	0.120667	0.122667	0.103333
0.244	0.115667	0.124	0.128	0.099333
0.251667	0.111667	0.124	0.131333	0.097667
0.262	0.112	0.121333	0.125667	0.099333
0.274667	0.116	0.123	0.123333	0.098667
0.288333	0.121667	0.123333	0.126	0.102667
0.307333	0.130667	0.125333	0.128	0.101333
0.334333	0.128333	0.124667	0.126333	0.093667
0.363333	0.146	0.125667	0.127333	0.100333
0.395333	0.135333	0.125	0.123667	0.100667
0.423333	0.172	0.123667	0.13	0.098
0.444	0.151	0.124333	0.130333	0.095667
0.458667	0.13	0.125	0.123	0.098
0.474667	0.144667	0.125333	0.128667	0.095667
0.489667	0.145667	0.125	0.124	0.096667
0.506	0.129333	0.126	0.125	0.099
0.522667	0.129	0.124667	0.127	0.094333
0.532	0.139333	0.124	0.120333	0.094667
0.548333	0.130333	0.121333	0.129	0.094
0.566	0.134	0.125333	0.125667	0.093667
0.582333	0.136667	0.125333	0.128667	0.100667
0.6	0.134	0.124	0.123	0.094667
0.618667	0.135333	0.127333	0.126667	0.099
0.630667	0.139333	0.121	0.124667	0.096
0.643667	0.140333	0.125	0.125333	0.093667

Table B85. Continued

0.653	0.145	0.125667	0.121	0.1
0.665	0.147	0.126667	0.120333	0.096333
0.673333	0.152333	0.123667	0.120333	0.095
0.679333	0.159	0.129333	0.117333	0.095
0.688	0.16	0.128	0.123667	0.095
0.696667	0.164667	0.131333	0.123	0.093667
0.705	0.167	0.129667	0.122333	0.095
0.711	0.172333	0.127667	0.118333	0.095667
0.723333	0.178	0.131667	0.124333	0.097
0.731667	0.175667	0.130333	0.120667	0.094667
0.737333	0.184667	0.125	0.115	0.094333
0.743	0.186667	0.128667	0.121667	0.093667
0.749	0.194	0.124	0.123	0.095333
0.751667	0.193667	0.132333	0.120333	0.095333
0.757	0.202667	0.133667	0.12	0.095
0.765333	0.203	0.125667	0.120667	0.097333
0.766333	0.207667	0.135667	0.119	0.094333
0.771	0.207	0.137	0.119333	0.096
0.774333	0.213667	0.131333	0.123	0.096333
0.776	0.220333	0.135	0.121667	0.094667
0.777333	0.224	0.13	0.119333	0.094667
0.779333	0.219667	0.13	0.115333	0.094
0.78	0.228667	0.13	0.116667	0.094667
0.779	0.229667	0.129667	0.119333	0.096
0.779333	0.234333	0.123667	0.123333	0.095333
0.783333	0.233667	0.136	0.116667	0.094
0.781	0.237	0.142333	0.113333	0.096333
0.784	0.241667	0.136	0.121333	0.096667
0.782333	0.243667	0.132667	0.116667	0.095
0.785333	0.251333	0.130667	0.116333	0.094
0.781667	0.251667	0.123	0.115667	0.095667
0.783667	0.251	0.135	0.113667	0.094
0.782667	0.259	0.140667	0.108	0.093
0.781667	0.262333	0.135	0.116	0.093

Table B86. Standard deviations of averages of raw data from microtiter plate reader experiments for *D. hansenii* in lactic acid taken every 2 hours over 6 days

Std. Dev. Control	Std. Dev. 25	Std. Dev. 50	Std. Dev. 75	Std. Dev. 100
0.001	0.002309	0.001528	0.005	0.00152753
0.001528	0.001528	0.002082	0.016653	0.00251661
0.001528	0.001155	0.001732	0.020809	0.0057735
0.002517	0.001155	0.000577	0.023094	0.00360555
0.003	0.001	0.000577	0.023072	0.00173205
0.004	0.001528	0.005859	0.020207	0.00472582
0.005568	0.001155	0.002887	0.028006	0.001
0.007638	0.001528	0.004359	0.026083	0.00585947
0.010408	0.001528	0.002517	0.024576	0.00493288
0.014012	0.004041	0.002646	0.028583	0.0051316
0.017388	0.004163	0.004509	0.028868	0.00635085
0.020033	0.006557	0.004041	0.031896	0.00953939
0.024786	0.00781	0.005	0.032347	0.006245
0.027592	0.010392	0.004619	0.034699	0.00458258
0.030288	0.010017	0.005686	0.030665	0.01184624
0.034871	0.012014	0.004359	0.030348	0.00404145
0.039004	0.008327	0.003464	0.038889	0.00416333
0.044508	0.011269	0.00611	0.033501	0.00550757
0.051052	0.014	0.004359	0.034675	0.00550757
0.06137	0.012662	0.003215	0.041388	0.00650641
0.076291	0.01601	0.004163	0.028583	0.0057735
0.093602	0.006506	0.004619	0.038991	0.0011547
0.113676	0.013528	0.003786	0.030288	0.0070946
0.137689	0.007024	0.003606	0.026274	0.00737111
0.154124	0.021932	0.001155	0.030348	0.00781025
0.162428	0.032357	0.003215	0.034443	0.00057735
0.169777	0.016093	0.006	0.024331	0.0043589
0.172341	0.025325	0.005508	0.03247	0.00208167
0.172286	0.024214	0.007	0.022716	0.00152753
0.169201	0.003512	0.001732	0.021703	0.00608276
0.159475	0.008185	0.006028	0.03297	0.00057735
0.163184	0.016166	0.008185	0.025736	0.0011547
0.159863	0.002082	0.010599	0.03214	0.001
0.148334	0.005292	0.002309	0.024542	0.00057735
0.142865	0.006429	0.003512	0.028006	0.00585947
0.125933	0.004	0.008	0.027074	0.00057735
0.108427	0.003055	0.004163	0.028006	0.0052915
0.10053	0.004726	0.012288	0.024583	0.00360555

Table B86. Continued

0.098083	0.004933	0.010149	0.030039	0.00057735
0.089705	0.008185	0.006028	0.027221	0.00556776
0.081799	0.00755	0.006028	0.022679	0.00321455
0.080314	0.008505	0.004933	0.031565	0.001
0.074574	0.011533	0.004933	0.023861	0.00173205
0.068826	0.010149	0.006	0.029023	0.001
0.065156	0.009074	0.007095	0.026058	0.00057735
0.058026	0.012124	0.007371	0.025697	0.001
0.055073	0.015044	0.008021	0.025007	0.00288675
0.044859	0.016703	0.007234	0.027429	0.00264575
0.042572	0.015011	0.009452	0.034064	0.0011547
0.040067	0.015631	0.018682	0.029513	0.00057735
0.040632	0.017786	0.005686	0.030238	0.00057735
0.040841	0.016	0.017776	0.028688	0.00321455
0.041956	0.012014	0.010066	0.03177	0.0023094
0.046508	0.018903	0.009074	0.034771	0.00173205
0.045004	0.020664	0.016623	0.036019	0.00665833
0.044736	0.021362	0.006658	0.036497	0.00057735
0.048218	0.022605	0.010583	0.032005	0.00173205
0.04818	0.02558	0.009452	0.029513	0.00208167
0.048867	0.026407	0.006245	0.032332	0.0011547
0.051733	0.024	0.016703	0.030892	0.0011547
0.048758	0.018148	0.020518	0.032655	1.6997E-17
0.048218	0.020551	0.013528	0.03086	0.00208167
0.045924	0.019553	0.020502	0.032624	0.0034641
0.043684	0.019553	0.017039	0.030925	0.0023094
0.042194	0.021502	0.013077	0.027209	0.001
0.041073	0.018028	0.010214	0.027647	0.00251661
0.043555	0.023544	0.015395	0.028449	0.00208167
0.040698	0.018903	0.020429	0.028042	1.6997E-17
0.036774	0.023159	0.026102	0.03177	0.001
0.036692	0.033307	0.032909	0.028042	0.00057735
0.03691	0.035791	0.019079	0.026502	0.001
0.037207	0.047823	0.017673	0.024249	1.6997E-17
0.038188	0.044433	0.026627	0.029597	1.6997E-17

