UNIVERSITI PUTRA MALAYSIA

EFFECTS OF INLUIN AND OLIGOFRUCTOSE FORTIFICATION ON THE PHYSICO-CHEMICAL, SENSORY AND FUNCTIONAL PROPERTIES OF CLARFIFIED BANANA JUICE

MUHAMMAD SOHAIL YOUSAF

FSTM 2007 4

EFFECTS OF INLUIN AND OLIGOFRUCTOSE FORTIFICATION ON THE PHYSICO-CHEMICAL, SENSORY AND FUNCTIONAL PROPERTIES OF CLARFIFIED BANANA JUICE

MUHAMMAD SOHAIL YOUSAF

DOCTOR OF PHILOSPHY
UNIVERSITY PUTRA MALAYSIA

2007

EFFECTS OF INLUIN AND OLIGOFRUCTOSE FORTIFICATION ON THE PHYSICO-CHEMICAL, SENSORY AND FUNCTIONAL PROPERTIES OF CLARFIFIED BANANA JUICE

By

MUHAMMAD SOHAIL YOUSAF

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

May 2007

DEDICATION

This Dissertation is dedicated to my late beloved mother

Safia Yousaf

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy.

EFFECTS OF INLUIN AND OLIGOFRUCTOSE FORTIFICATION ON THE PHYSICO-CHEMICAL, SENSORY AND FUNCTIONAL PROPERTIES OF CLARFIFIED BANANA JUICE

By

MUHAMMAD SOHAIL YOUSAF

May 2007

Chairman: Professor Salmah Yusof, PhD

Faculty: Food Science and Technology

A comparative study conducted between Berangan and Mas banana cultivars at the same maturity index 6 (fully yellow-good eating stage) revealed that Berangan was more suitable for value added processing because of its lower soluble protein concentration, peroxidases and polyphenoloxidase activity. The two enzymes are responsible for developing browning in fruit tissues and also ultimately in the juice. Berangan has better sensory attributes in terms of taste, colour and over-all acceptability. Inulin and oligofructose are non-digestible oligosaccharides found in banana at 0.3-0.7%, respectively. These are considered too low to have any significant prebiotic effect for host health. Therefore clarified banana juice was prepared and fortified with inulin and oligofructose in order to increase its nutritional and functional properties. The fortification levels of inulin and oligofructose optimized at 2% and 10%, respectively yield banana juice with acceptable sensory and physical characteristics without effecting the original taste and flavour of banana. Storage study was conducted for 8 weeks at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C to determine the storage stability of clarified banana juice fortified

with inulin and oligofructose. The juice quality remained stable in terms of its physicochemical, microbiological and sensory characteristics for 8 weeks at different storage temperatures except for turbidity, whose continuous increase during storage in all the samples was found a critical quality problem especially for samples stored at 35 ^{0}C. However juice samples stored at 4 ^{0}C had less turbidity problem and were rated highest and most acceptable for different sensory parameters. The results of the *in vivo* study revealed that administration of fortified banana juice significantly increase the growth of health promoting bacteria i.e. *Bifidobacterium* and *Lactobacillu*s, short chain fatty acids especially butyrate in the gut of the treated rats compared to rats fed distill water and with plain clarified banana juice. There was also an increase in mucosal thickness in cecum and proximal colon of rats fed with fortified juice, hence reduces the chances of many large bowel diseases. Rats of this same group also observed significant reduction in total cholesterol and LDL (Low density lipoprotein) concentration in the serum lipid thus contributing to hypochlesterolemic effect for patients with high serum cholesterol level.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagi memenuhi keperluan untuk ijazah Doctor Falsafah

KESAN PENAMBAHAN INLUIN DAN OLIGOFRUCTOSA KETAS CIRI FISIKO-KIMIA, SENSORI DAN FUNGSIAN JUS JERNIH PISANG

Oleh

MUHAMMAD SOHAIL YOUSAF

Mei 2007

Pengerusi: **Profesor Salmah Yusof, PhD**

Fakulti: **Fakulti Sains Dan Teknologi Makanan**

Satu kajian perbandingan yang telah dijalankan di antara kultivar pisang Berangan dan Mas pada indeks kematangan yang sama iaitu 6 (kuning sepenuhnya-peringkat yang sesuai untuk dimakan) menunjukkan bahawa pisang Berangan lebih sesuai bagi pemprosesan selanjutnya untuk menambahkan nilainya berikutan kerana tahap aktiviti peroksida dan polifenoloksidanya yang rendah. Kedua-dua enzim tersebut merupakan enzim utama di dalam pembentukan kesan pemerangan ke atas tisu buah dan juga di dalam jus. Kandungan protein terlarut berangan juga rendah dan mempunyai ciri-ciri penilaian deria yang lebih baik dari segi rasa/aroma yang tinggi, warna dan tahap penerimaan keseluruhan yang tinggi. Inulin dan oligofruktosa merupakan oligosakarida yang tidak boleh dihadam yang terdapat di dalam pisang pada kepekatan 0.3-0.7% masing-masing, di mana ia dianggap sebagai sangat rendah untuk memberikan kesan prebiotik yang nyata kepada kesihatan badan. Oleh itu jus jernih pisang disediakan dan diperkayakan dengan inulin dan oligofruktosa bagi meningkatkan tahap nutrisi dan ciri-ciri kefungsiannya. Kandungan inulin dan oligofruktosa telah dioptimakan pada 2% dan

10% masing-masing, bagi menghasilkan jus jernih pisang yang boleh diterima dari segi penilaian deria dan ciri-ciri fizikalnya tanpa merencatkan rasa dan aroma pisang yang asli. Kajian penyimpanan selama 8 minggu pada 4°C, 25° dan 35°C telah dijalankan bagi menentukan tahap kestabilan jus jernih pisang yang telah diperkayakan dengan inulin dan oligofruktosa. Kualiti jus kekal stabil dari segi fizikokimia, mikrobiologi dan ciri-ciri penilaian deria selama 8 minggu pada suhu penyimpanan yang berbeza kecuali kekeruhan, di mana ia terus meningkat sepanjang penyimpanan di dalam kesemua sampel, menunjukkan bahawa ia merupakan masalah kualiti yang kritikal terutamanya sampel yang disimpan pada suhu 35°C. Bagaimanapun, sampel jus yang disimpan pada suhu 4°C menunjukkan kurang bermasalah dan daripada penilaian deria, ia dipilih sebagai yang paling tinggi dan paling diterima dari segi kepelbagaian ciri penilaian deria. Keputusan dari kajian *in vivo* menunjukkan bahawa penggunaan jus jernih pisang yang telah diperkayakan ini terbukti secara nyata dapat meningkatkan pertumbuhan bakteria yang baik bagi kesihatan, contohnya *Bifidobacterium* dan *Lactobacillus*, asid-asid lemak berantai pendek terutamanya butirat di dalam usus tikus jika dibandingkan dengan tikus-tikus yang diberikan dengan air suling dan jus jernih pisang biasa. Terdapat juga peningkatan ketebalan mukuosa di dalam sekum dan kolon proksimal bagi tikus-tikus yang diberikan dengan jus jernih pisang yang diperkayakan, dan ini akan membantu dalam pengurangan risiko penyakit-penyakit berkaitan usus besar. Tikus-tikus ini juga mengalami pengurangan yang nyata dalam kandungan kolesterol keseluruhan dan LDL (lipoprotein berketumpatan rendah) di dalam serum lemak, dengan itu ia menyumbangkan kesan hipokolesterolemik bagi pesakit hiperkolesterolemia.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my deepest and sincere thanks and appreciation, to my advisor Prof Dr. Salmah Yusof for providing me the opportunity to work in her lab, her constructive guidance throughout my study period, her motivation in difficult times of my research and above all her confidence in me to complete this project.

Thanks are due to her also for her interesting research project, from which I gain valuable research experience and scientific knowledge. I would like also to thank Prof Dr. Mohd Yazid Manap, Prof Dr. Suhaila Mohamed and Dr. Suraini Aziz, who were gracious to serve on my Dissertation Committee, for their guidance, comments, by adding value to my research project by giving value suggestions and for reviewing dissertation manuscripts. Also sincere thanks to Dr. Nordin from Faculty of Veterinary Sciences helping me to conduct histology studies in the histology lab.

Thanks also to all those lab assistants who helped me to carry our experimental work in their lab.

I am also grateful to Mr Steven Ong from Orafti Malaysia for providing me free samples of inulin and oligofructose and also to all those peoples who were outside

suppliers for providing me equipments, chemicals and enzymes in my research project.

Furthermore, I would like to thank my friends and colleagues during my study for their help and for their insight. The friendship that I have had with them will always be cherished.

Acknowledgement is also due to Government of Malaysia and Universiti Putra Malaysia for granting me Graduate Research Assistantship, to carry out the PhD program.

Finally, something for my family…..Though physically thousand s of miles away, my brother and sisters have been caring and morally supportive of my work. Thank you for remembering me in your prayers and for your sacrifices. To my father, who always support and motivate me through his positive attitude and comments, encouraging me for higher education and providing me always with his moral and physical support wherever and whenever which I need in my studies. Last to my late beloved mother who unfortunately could not see me writing this acknowledgement. I think I can write a lot on her probably more than about the size of this dissertation. However, I would like to say just about her that she was a wonderful lady and mother one can ever wish to have in the form of blessing from god. May god keep her soul in peace and give her the highest place in the next world. Amin!

I certify that an examination committee met on 29 May 2007 to conduct the final examination of Muhammad Sohail Yousaf on his Doctor of Philosphy thesis entitled "Utilization of inulin and oligofructose in clarified banana juice and its *in vivo* studies." in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommended that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Azizah Abdul-Hamid, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Chairman)

Rokiah Modh. Yusof, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Sharifa Kharidah Syed Muhammad, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Nagendra Prasad Shah, PhD
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(External Examiner)

Professor Hasanah Mohd Ghazali, PhD
Professor/ Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Salmah Yusof, PhD
Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Yazid bin Manap, PhD
Professor
Faculty of Food Science and Technology
University Putra Malaysia
(Member)

Suhaila Mohamed, PhD
Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Suraini Aziz, PhD
Associate Professor
Faculty of Biotechnology and Biomolecular Science
University Putra Malaysia
(Member)

AINI IDERIS, PhD
Professor/ Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 17 JULY 2007

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

MUHAMMAD SOHAIL YOUSAF

Date: 15 JUNE 2007

TABLE OF CONTENTS

		Page
DEDICATION		ii
ABSTRACT		iii
ABSTRAK		v
ACKNOWLEDGEMENTS		vii
APPROVAL		ix
DECLARATION		xi
LIST OF TABLES		xvi
LIST OF FIGURES		xviii
LIST OF ABBREVATIONS		xxi
CHAPTER		
I	**INTRODUCTION**	1
II	**LITERATURE REVIEW**	6
	Banana	6
	Mas	8
	Berangan	10
	Source of Nutrients	10
	Banana Volatiles	10
	Clarification of Juices	11
	Enzymatic Clarification of Juices	11
	Membrane Filtration in Clarification of Juices	12
	Thermal effects on Non-Starch Polysaccharides during processing	12
	Enzymatic Effects on Non-Starch Polysaccharides during processing	14
	Response Surface Methodology	16
	Functional Foods	21
	Gastrointestinal Ecology	22
	Prebiotics	26
	Natural Occurrence	26
	Chemical Structure	26
	Functional Properties	27
	Nutritional Properties	32
	Gastrointestinal Effects of Prebiotics	35
	Inulin and Oligofructose as Dietary Fibers	37
	Health Related Aspects and Applications	40
	Protection Against Colon Cancer	41
	Effects on Pathogens	42
	Improved Calcium Absorption	43
	Systemic Effect on Blood Lipids	44
	Immunological Effects	45
	Short Chain Fatty Acids	46

III	**PHYSICO-CHEMICAL, BIOCHEMICAL AND SENSORY CHARACTERISTICS OF BERANGAN AND MAS BANANA (*MUSA SAPIENTUM*) CULTIVARS AND THEIR SUITABILITY FOR VALUE ADDED PROCESSING**	51
	Introduction	51
	Material and Methods	52
	Raw Material	52
	Physical Determination	53
	Texture	53
	Colour	53
	Physico-chemical Determinations	54
	pH	54
	Titratable Acidity	54
	Soluble Solids	54
	Chemical determination	55
	Sugars	55
	Organic Acids	55
	Vitamin C	56
	Tannins	56
	Total Carotenoids	57
	Total Fructans	58
	Biochemical Determination	65
	Polyphenol Oxidase Assay	65
	Peroxidase Assay	66
	Soluble Proteins	66
	Sensory Evaluation	67
	Criteria for Choosing the Panelist	67
	Screening, Selection and Training of Panelists	67
	Statistical Analysis	68
	Results and Discussion	70
	Morphological Characteristics	70
	Physical and Physico-chemical Characteristics	72
	Chemical and Biochemical Characteristics	75
	Sensory Characteristics	79
	Conclusion	83
IV	**OPTIMIZING THE FORTIFICATION LEVELS OF INULIN AND OLIGOFRUCTOSE IN CLARIFIED BANANA JUICE BY USING RESPONSE SURFACE METHODOLOGY**	84
	Introduction	84
	Material and Methods	86
	Preparation of Clarified Banana Juice using Berangan	86
	Determination of Total Fructans	87
	Preparation of Clarified Banana Juice fortified with Inulin and Oligofructose	87
	Determination of Total Soluble Solids (TSS)	87

	Determination of Viscosity	88
	Sensory Evaluation	88
	Experimental Design and Statistical Analysis	89
	Results and Discussion	92
	Statistical Analysis	92
	Optimization	105
	Conclusion	110
V	**STORAGE STABILITY OF CLARIFIED BANANA JUICE FORTIFIED WITH INULIN AND OLIGOFRUCTOSE**	111
	Introduction	111
	Materials and Methods	113
	Physicochemical Determinations	114
	Microbial Count	115
	Sensory Evaluation	115
	Statistical Analysis	115
	Results and Discussion	116
	Acidity and pH	116
	Total Soluble Solids	117
	Turbidity	121
	Sugars	124
	Microbiological Analysis	131
	Sensory Analysis	131
	Taste	131
	Flavour	134
	Odour	135
	Overall acceptability	138
	Conclusion	140
VI	***IN VIVO* EFFECT OF CLARIFIED BANANA JUICE FORTIFIED WITH INULIN AND OLIGOFRUCTOSE ON THE METABOLISM OF INTESTINAL MICROFLORA OF RATS**	141
	Introduction	141
	Materials and Methodology	143
	Animals	143
	Experimental Design and Diets	143
	Flow Chart of the Experimental Design	144
	Preparation of Clarified Banana Juice Fortified with Inulin and Oligofructose	146
	Collection of Samples	146
	Blood Sampling and Analysis	146
	Total Cholesterol	147
	Triglycerides	148
	High-Density Lipoprotein (HDL)	148
	Low-Density Lipoprotein (LDL)	150
	Fecal sampling and analysis	151

Total Bile acids 151
Cecum and Colon Samples 152
Bacterial Enumeration 152
SCFA Analysis 153
Mucosal Thickness 154
Statistical Analysis 157
Results and Discussion 158
Food Intake and Body Weight 158
Total Large Bowel Weight , Wall Weight and pH 158
Bacterial Enumeration 162
Short Chain Fatty Acids 167
Mucosal Thickness 174
Serum Lipids and Fecal Bile Acids 180
Conclusion 187

VII CONCLUSION 188

BIBLIOGRAPHY 192
APPENDICES 218
BIODATA OF THE AUTHOR 224

LIST OF TABLES

Table		Page
2.1	The proximate composition of edible portion of banana	9
3.1	Quantitative Descriptive Analysis scale for Berangan and Mas banana cultivars	69
3.2	Morphological characteristics of banana fruits	71
3.3	Physical and physico-chemical characteristics of banana fruit pulp	74
3.4	Chemical and biochemical characteristics of banana fruit pulp	76
3.5	Sensory analysis of banana fruits (pulp)	81
4.1	The Quadratic experimental design (in coded level of two variables) employed for fortification of clarified banana juice with inulin and oligofructose	91
4.2	The Quadratic experimental design and effect of fortification of inulin and oligofructose on dependent variables	94
4.3	Regression Coefficients, R^2 and P of F values for Taste, Off-flavour, Odour, and Mouthfeel of clarified banana juice fortified with inulin and oligofructose	96
4.4	Regression Coefficients, R^2 and P of F values for viscosity and TSS of clarified banana juice fortified with inulin and oligofructose	99
5.1	Mean values of pH, T.A, TSS and Turbidity during storage	129
5.2	Mean values of Sucrose, Glucose and Fructose during storage	130
5.3	Mean values of taste, flavour, odour and overall acceptability during storage	132
6.1	Composition of diet (g/100 g of diet)	145
6.2	Effect of clarified banana juice and clarified banana juice fortified with inulin and oligofructose on food intake and growth in rats	159

6.3	Effect of clarified banana juice and clarified banana juice fortified with inulin and oligofructose on total weight, wall weight and pH in cecum, proximal and distal colon of rats	160
6.4	Effect of clarified banana juice and clarified banana juice fortified with inulin and oligofructose on the microbiota (log_{10} CFU/ g wet contents) in cecum, proximal and distal colon of rats	163
6.5	Effect of clarified banana juice and clarified banana juice fortified with inulin and oligofructose on the SCFA concentration (µmol/g) in cecum, proximal and distal colon of rats	168
6.6	Effect of clarified banana juice and clarified banana juice fortified with inulin and oligofructose on the molar ratio (mol/100 mol) of acetate, propionate and butyrate in cecum, proximal and distal colon of rats	169
6.7	Effect of clarified banana juice and clarified banana juice fortified with inulin and oligofructose on the mucosal thickness (µm) of cecum, proximal and distal colon in rats	176
6.8	Effect of clarified banana juice and clarified banana juice fortified with inulin and oligofructose on the lipid profile in rats blood and total bile acids in rats feces	181

LIST OF FIGURES

Figure		Page
2.1	(a) A theoretical response surface showing the relationship yield of a chemical process variables reaction time (ξ_1) and reaction temperature (ξ_2). (b) A contour plot of the theoretical response surface	20
2.2	Inulin, naturally-occurring fructo-oligosaccharides (FOS)	30
4.1	Response surface showing the effect of inulin and oligofructose fortification on the juice taste.	97
4.2	Response surface showing the effect of inulin and oligofructose fortification on the mouthfeel of the juice.	100
4.3	Response surface showing the effect of inulin and oligofructose fortification on the preference of the juice	101
4.4	Response surface showing the effect of inulin and oligofructose fortification on the viscosity of the juice.	102
4.5	Response surface showing the effect of inulin and oligofructose fortification on the total soluble solids of the juice.	104
4.6	Contour plot showing the effect of inulin and oligofructose fortification on the taste response of the juice.	106
4.7	Contour plot showing the effect of inulin and oligofructose fortification on the mouthfeel response of the juice.	107
4.8	Contour plot showing the effect of inulin and oligofructose fortification on the preference response of the juice.	109
5.1	Changes in pH of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period.	118
5.2	Changes in titratable acidity of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	119

5.3	Changes in TSS of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	120
5.4	Changes in turbidity of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	123
5.5	GF_n Molecule of inulin and oligofructose	125
5.6	Changes in sucrose contents of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	126
5.7	Changes in glucose contents of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	127
5.8	Changes in fructose contents of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	128
5.9	Changes in taste perception of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	133
5.10	Changes in flavour of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	136
5.11	Changes in odour of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	137
5.12	Changes in overall acceptability of the clarified banana juice fortified with inulin and oligofructose stored at 4 ^{0}C, 25 ^{0}C and 35 ^{0}C for 8 weeks storage period	139
6.1	Cecal mucosa of rats fed distill water	177
6.2	Proximal colon mucosa of rats fed distill water	177
6.3	Cecal mucosa of rats fed banana juice	178
6.4	Proximal colon mucosa of rats fed banana juice	178

6.5 Cecal mucosa of rats fed fortified banana juice 179

6.6 Proximal colon mucosa of rats fed fortified banana juice 179

LIST OF ABBREVIATIONS

%	Percentage
/	per
µ	micro
µg	microgram
µL	microliter
^{0}C	degree Celsius
ANOVA	analysis of variance
ca.	approximately
CFU	colony forming units
CH_4	methane
CO_2	carbon dioxide
d	day
DMRT	Duncan's multiple range test
DNA	deoxy ribose nucleic acid
DP	degree of polymerization
E.coli	*Eschericia coli*
e.g	*example gratia* (for example)
et al	et cetera (and company)
FAMA	Food and Agriculture Marketing Authority
FAO	Food and Agriculture Organization
FOS	fructooligosaccharides

g	gram
GC	gas chromatography
GI-tract	gastrointestinal tract
GOS	galactooligosaccharides
h	hour
H^+	hydrogen ion
H_2	hydrogen
$HCLO_4$	per chloride
HCO^{+3}	bicarbonate ion
HDL	high density lipoprotein
HMF	hexamethylfurfural
HPLC	high performance liquid chromatography
i.e.	*id est* (that is)
K	potassium
Kcal	Kilocalories
Kg	kilogram
KJ	kilo joule
LDL	low density lipoprotein
log	logarithm
M	molar
mg	milligram
min	minute
ml	milliliter

mM	millimolar
mRNA	messenger ribose nucleic acid
MWCO	molecular weight cut off
n	number
Na^+	sodium ion
NaOH	sodium hydroxide
NSP	non starch polysaccharides
PVPP	polyvinylpolypyrolidone
QDA	quantitative descriptive ananlysis
R^2	regression coefficient
RSM	response surface methodology
SAS	statistical analysis system
SCFA	short chain fatty acids
TC	total cholesterol
TG	triglyceride
TPY	Trypticase-Phytone-Yeast Extract
TSS	total soluble solids
w/v	weight by volume
WHO	World Health Organization
α	alpha
β	beta