PRODUCTION OF PROBIOTIC LOW-CALORIE FROZEN YOGHURT

By

MERANDA ABD EL-MEGALY TAWFEK

B. Sc. Agric. Co-operative Sc., Higher Institute of Agriculture Co-operation, 1996

M. Sc. Agric. Sc. (Dairy Science and Technology), Ain Shams University, 2005

A thesis submitted in partial fulfillment
of
the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Agricultural Science
(Dairy Science and Technology)

Department of Food Science
Faculty of Agriculture
Ain Shams University

2012

Approval Sheet

PRODUCTION OF PROBIOTIC LOW-CALORIE FROZEN YOGHURT

By

MERANDA ABD EL-MEGALY TAWFEK

B. Sc. Agric. Co-operative Sc., Higher Institute of Agriculture Co-operation, 1996

M. Sc. Agric. Sc. (Dairy Science and Technology), Ain Shams University, 2005

This thesis for Ph.D. degree has been approved by:

Dr. Baher Abd El-Khalik Effat ……………….…..

Research Prof. of Dairy Microbiology and Technology, National Research Center

Dr. Youssef Morsey Youssef El-Kenany ………………..

Prof. of Dairy Microbiology and Technology, Faculty of Agriculture, Ain Shams University

Dr. Ahmed Ismail Metwally ..………………..

Prof. of Dairy Science and Technology, Faculty of Agriculture, Ain Shams University

Dr. Atef El-Sayed Fayed ………………..

Prof. of Dairy Science and Technology, Faculty of Agriculture, Ain Shams University

Date of Examination: 2 / 2 / 2012

PRODUCTION OF PROBIOTIC LOW-CALORIE FROZEN YOGHURT

By

MERANDA ABD EL-MEGALY TAWFEK

B. Sc. Agric. Co-operative Sc., Higher Institute of Agriculture Co-operation, 1996

M. Sc. Agric. Sc. (Dairy Science and Technology), Ain Shams University, 2005

Under the supervision of:

Dr. Atef El-Sayed Fayed

Prof. of Dairy Science and Technology, Food Science Department
Faculty of Agriculture, Ain Shams University (Principal Supervisor)

Dr. Ahmed Ismail Metwally

Prof. of Dairy Science and Technology, Food Science Department
Faculty of Agriculture, Ain Shams University

Dr. Ehab Abd El-Baky Youssef

Senior Researcher of Dairy Science, Food Technology Research
Institute, Agricultural Research Center

ABSTRACT

Meranda Abd El-Megaly Tawfek: Production of Probiotic Low-Calorie Frozen Yoghurt. Unpublished Ph. D. Thesis , Department of Food Science, Faculty of Agriculture, Ain Shams University, 2012.

The aim of this research was conducted to study the manufacture possibility of reduced caloric yoghurt and hence frozen yoghurt *via* proportional fat and/or lactose and even sucrose replacement in relation to the several attributes of yoghurt and frozen yoghurt made using milk inoculated whether with ordinary or probiotic bacterial starter culture (BSC).

Ultrafiltration (UF) skimmed cow's milk retentate (18% total solids, TS) was diluted to 12% TS either by UF permeate (6% TS) for T_1, sorbitol solution (6%) for T_3 or by their mixture (1:1) for T_2 to reduce the lactose content by nil, 50 or 25% respectively. Fat content was adjusted in each treatment to nil, 1.5 or 3% using fresh cream (30% fat). Conversely, simplesse 100® was added to mimic fat at the level of 3, 1.5 or nil %, respectively. Those were expressed on the base of "each part of fat would be replaced with one part of simplesse 100®". Potassium sorbate was added for all treatment at the level of 0.015%. Then milk preparations were heat treated to 85°C for 5 min followed by temperature adjustment to 42°C. Milk preparations were converted into yoghurt by the inoculation with 2% of freshly activated YC-X11 or ABT-2, and incubation at the same temperature degree (42°C) until complete coagulation (through about 3 h.). Thereafter, the containers were transferred to the refrigerator (5±1°C).

Frozen-yoghurt base mix (the control) was prepared to contain 3% fat, 12% milk solids not fat (MSNF), 15% sucrose, and 0.25% sodium carboxy methyl cellulose (CMC). The previous three milk preparations, namely T_1, T_2 and T_3 were supplied with 3% of simplesse 100® for full fat mimicking. Every milk preparation was divided into four portions. The 1st

and 2nd portions were exposed, in order, for ordinary- and bio-yoghurts as before mentioned. Then yoghurts were kept for the 2nd day at the frig temperature. On the parallel time, the 3rd and 4th portions were used to make the complementary mixes, whereas, the milk preparation T_1 was sweetened as the control to 30% sucrose (to be finally 15% sucrose when mixed with the equal portion of analogues ordinary- or bio-yoghurt), while, T_2 was sweetened with 22.5% sucrose, 0.1% aspartame and 7.5% sorbitol solids. Whilst, T_3 was sweetened with 15% sucrose, 0.2% aspartame and 15% sorbitol solids. All complementary mixes were stabilized with 0.5% CMC, heat treated at 85°C for 5 min. then cold to 5°±1° C and aged at this temperature for the 2nd day. Thereafter, each aged complementary mix was mixed with an equal part of the analogous one-day cold ordinary- or bio-yoghurt. All frozen yoghurt mixes were flavoured with suitable amounts of Vanilla and frozen in an experimental ice cream batch freezer at -18°C. The resultant frozen product was hardened in a deep freezer at -20°C.

The results of yoghurt indicated that, the contents of protein, titritable acidity (TA), acetaldehyde (AC) and diacetyl (DA) in addition to the certain lactic acid bacteria (LAB) counts, the values of consistency coefficient (CC), yield stress (YS), dynamic viscosity (DV) and the sensory scores of consistency (body and texture) flavour as well as overall quality of yoghurt were increased, while the calorie, pH and penetration values were decreased as the fat was replaced with simplesse. The count of LAB strains, TA, AC, DA, CC, YS and DV contents of yoghurt were increased, while the values of calorie, pH and penetration were decreased as the lactose was replaced with Sorbitol. Yoghurt became containing 27-32% or 44-50% less of calories than the reference product when the fat was replaced by 50 or 100% respectively, regardless the kind of BSC used. The smaller range figures are for the higher levels of lactose replacement and *vice versa*. Ordinary yoghurt contained *Streptococcus thermophilus* count, TA, AC, DA, CC, YS and DV contents higher and pH as well as penetration values lower than those of bioyoghurt. The cold storage period for 3 weeks led to decrease all LAB counts, penetration value, flavour, and total scores of yoghurt. While, TA%, CC, YS and DV values of yoghurt were raised.

The results of frozen yoghurt revealed that, the conversion of yoghurt into frozen mix caused a reduction in the TA % and increments in pH and DV values. Moreover, the ash, TA, AC and DA contents as well as the count of LAB strains and DV value of frozen yoghurt mix were higher, while the calorie value, specific gravity (sp. gr.) and freezing point were lower as the disaccharides were replaced. Frozen yoghurt mix became containing 24, 29 or 34% less of calories than the reference product, when the fat was totally replaced and the disaccharides were replaced by nil, 25 or 50% respectively, regardless the kind of BSC used. The frozen mix made from ordinary yoghurt possessed ash, TA, AC and DA contents as well as *Streptococcus thermophilus* count higher and pH value as well as sp. gr. Lower than that made using bioyoghurt. The freezing and hardening processes of yoghurt mixes yielded in increases in the AC content and decrease in sp. gr. and the count of all LAB strains to about the tithe but stilled conforming the figures provided, which approved an international standard as established a minimum of 10^7 /g for the starter cultures of fermented milks and a minimum of 10^6 /g for specific starter bacteria for which a claim is made for specific microorganism that has been added as supplement. The final frozen yoghurt was characterized with higher overrun % and stronger melting resentence as the disaccharides were replaced and when it was made using ordinary yoghurt *versus* the bioyoghurt. The quality of all sensory criteria of the disaccharides-replaced frozen yoghurt was evidently better than that of the control, which was made with neither fat nor disaccharides replacement.

The results led satisfactory to conclude that, yoghurt and hence frozen yoghurt beyond their ability to be probiotic food *via* its culturing with the gut strains, it could further carry more healthy benefits when it was made in the reduced calorie form *via* proportional fat and/or lactose

and rather sucrose replacement by certain advanced ingredients such as simplesse and aspartame in combination with sorbitol, which known for its action as prebiotic converts the product to be synbiotic. Besides, the product would become quite suitable for diabetes and lactose intolerance people. i.e., this study introduces a product, which could contribute positively to overall health and help to maintain a healthy digestive system.

Keywords: Simplesse, Aspartame, Sorbitol, Yoghurt, Synbiotic, Diabetes, Lactose intolerance.

ACKNOWLEDGMENT

I wish to extend my deepest appreciation and sincere gratitude to **Prof. Dr. Atef E. Fayed,** Professor of Dairy Science and Technology, Food Science Department, Faculty of Agriculture, Ain Shams University for the suggestion as well as initiation of this study, kind attention and greater help provided for the accomplishment of this work and for his efforts, supervising and helping me to achieve this manuscript.

I wish to find the words that can help to express my great thanks to **Prof. Dr. Ahmed A. Metwally,** Professor of Dairy Science and Technology, Food Science Department, Faculty of Agriculture, Ain Shams University, for his true guidance, encouragement during study.

Appreciation should be extended to **Dr. E.A. Essawy,** Senior Researcher, Food Technology Research Institute, Agricultural Research Center, for his fruitful efforts during study.

My special thanks would be expressed for **Dr. H.S. Hassan,** Senior Researcher, Food Technology Research Institute, Agricultural Research Center, Giza, for the facilities of Ultrafiltration retentate and permeate needed for the study.

I would like to thank all stuff members of Food Science Department, Faculty of Agriculture, Ain Shams University as well as Food Technology Research Institute, Agricultural Research Center, Giza.

Thanks also to every one who provided help or advised me to achieve this manuscript.

My deepest thanks to my parents, father, mother, brothers and sisters, for helping me to achieve this manuscript.

CONTENTS

LIST OF TABLES

LIST OF FIGURES