UNIVERSITI PUTRA MALAYSIA

EFFECT OF AGEING ON PHYSICO-CHEMICAL PROPERTIES OF NON-DAIRY ICE CREAM MIX

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

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Dedication

To my husband Kamal Azidy for his support throughout this study
and also to my son Muhamad Faiz, my daughter
Aina Nabilah and Ain Nadhirah.

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

EFFECT OF AGEING ON PHYSICO-CHEMICAL PROPERTIES OF NON-DAIRY ICE CREAM MIX

By

WAN ROSNANI AWG ISA

April 2004

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Faculty : Food Science and Biotechnology

The rheological characteristics of ice cream mix prepared from palm oil (PO), palm kernel oils (PKO) and their blends with anhydrous milk fat (AMF) at 30:70, 50:50 and 70:30 ratios during ageing were studied. The experimental ice cream mixes were compared with a control sample prepared from AMF. Ice cream mix containing 33.44% total solids including 10% fat, 11.09% milk solid–non fat (MSNF), 12% sugar, 0.35% commercial blend of emulsifier/stabiliser and water. The rheological properties such as the flow behaviour, Newtonian viscosity (η_o) and compliance (J_o) were measured after ageing at 4°C for 0, 0.5, 1, 1.5, 2 and 24 hr and determined using a controlled stress rheometer (Haake RS 100). The Power Law and Casson equation was employed to estimate the yield stress (τ_o) of an ice cream mixes. The correlation coefficients (r) for the regression analyses of the square root of the shear stress-shear rate data were represented well by the

Casson model ($r > 0.99$) for all the samples, indicating goodness of fitted. The shapes of the curves of consistency coefficients (K_c) were quite similar for all the experimental samples. The flow behaviour index (n) of the ice cream mixes prepared with palm fraction (PO and PKO) and their blends were less than 1.0 (range 0.04-0.08) indicating that the mixes were pseudoplastic fluid. The η_o at shear rate 20^{-1} indicated that the degree of viscosity in the control sample was higher.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN PENUAAN KEATAS SIFAT- SIFAT FIZIKAL-KIMIA CAMPURAN AIS KRIM BUKAN TENUSU

Oleh

WAN ROSNANI AWG ISA

April 2004

Pengerusi : Profesor Madya Mohd Yazid Abdul Manap, Ph.D.

Fakulti : Sains Makanan dan Bioteknologi

Sifat-sifat reologi campuran ais krim daripada minyak kelapa sawit (PO), minyak isirong sawit (PKO) dan campurannya dengan lemak susu anhidrous (AMF) pada nisbah 30:70, 50:50 dan 70:30 semasa penuaan dikaji. Campuran ais krim mengandungi 33.44% jumlah pepejal termasuk 10% lemak, 11.09% pepejal susu tanpa lemak (MSNF), 12% gula, 0.35% pengemulsi/penstabil dan air. Sifat-sifat reologi seperti pelakuan aliran, kelikatan Newtonian (η_o) dan komplian (J_o) diukur selepas penuaan pada 4°C untuk 0, 0.5, 1, 1.5, 2 dan 24 jam dan dikenalpasti menggunakan rheometer kawalan tekanan (Haake RS 100). Persamaan Power Law dan Casson digunapakai untuk menganggarkan hasil tekanan (τ_o) campuran ais krim. Korelasi koofisi (r) untuk analisa regrasi data punca ganda dua tekanan shea- kadar shea adalah diwakili dengan baik oleh model Casson ($r > 0.99$) untuk semua sampel, menunjukkan padanan yang

terbaik. Bentuk graf konsistensi koofisi (K_c) adalah hampir sama untuk semua sampel kajian. Indek pelakuan aliran (n) campuran ais krim yang disediakan dari pecahan minyak kelapa sawit (PO dan PKO) dan campurannya adalah kurang daripada 1.0 (range 0.04-0.08) menunjukkan mereka adalah cecair pseudoplastik. η_o pada kadar shea 20^{-1} menunjukkan darjah kelikatan yang tinggi pada sampel kawalan.

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LIST OF ABBREVIATIONS

AMF	Anhydrous milk fat
C4:0	Butyric acid
C6:0	Caproic acid
C8:0	Caprilic acid
C10:0	Capric acid
C12:0	Lauric acid
C14:0	Myristic acid
C16:0	Palmitic acid
C18:0	Stearic acid
C18:1	Oleic acid
C18:2	Linoleic acid
C18:3	Linolenic Acid
C20:0	Arachidic acid
C22:0	Behenic acid
CNO	Coconut oil
cP	Centipoise
DAG	Diacylglyceride
DSC	Differential scanning calorimetry
E_o, E_1, E_2	Elastic moduli, N/m^2
E/S	Emulsifier /stabilizer
FA	Fatty acid
FAC	Fatty acid composition
G'	Storage modulus, Pa
G"	Loss modulus, Pa
G*	Complex modulus, Pa
GLC	Gas liquid choromatography
HMG	High melting glycerides
HTST	High temperature short time
Hz	Hertz
J, J_1, J_2	Creep compliance, Pa^{-1}

K_C	Casson model constant
LCT	Long chain triglycerides
LVR	Linear viscoelastic region
MAG	Monoacylglycerides
MCT	Medium chain triglycerides
n	Flow behaviour index
N	Newtonian
NA	Not available
NBD	Neutralized bleached deodourized
NMR	Nuclear magnetic resonance
MSNF	Milk solid non-fat
O/W	Oil- in- water
Pa	Pascal
PKO	Palm kernel oil
PO	Palm oil
POP	1,3-dipalmitoyl- 2 oleoyl glycerol
PORIM	Palm oil Research Institute of Malaysia
PSP	1,3-dipalmitoyl- 2 stearoyl glycerol
r	Correlation coefficient
SFC	Solid fat content
SMP	Slip melting point
SSS	Tristearin
TAG	Triacylglyceride
UHT	Ultra high temperature
VE	Viscoelastic
W/O	Water- in- oil
γ	Shear rate, s^{-1}
η, η_o	Viscosity, Pa s
α	Alpha
β	Beta
β'	Beta prime
t	Time

τ_o	Yield stess
μm	Micrometer
μl	Microliter
δ	Delta
≤	Less than
>	More
<	Less
%	Percentage

CHAPTER 1

INTRODUCTION

Ice cream mix is an oil-in-water emulsion. It is formulated using fat, milk solid non-fat (MSNF), sugar, emulsifier and stabiliser. The fat phase in the form of minute globules is dispersed into the aqueous phase in the ice cream mix. Each globule is coated with a layer of adsorbed milk proteins, which keep the mix stable during ageing, whipping and freezing stages of manufacturing process that contribute to the development of the ice cream structure. The quality of the mix components, together with factors such as processing condition, type of emulsifying agent and the flavour added affect the quality of the end product. The composition of the mix affects the rheological properties during ageing, the amount of air incorporated in the mix and the ice crystal formation during freezing. In a normal process of ice cream making, the accepted time for ageing the mix is about six hr. However, prolonged ageing is require to achieve the stabilisation of the mixture and this could be costly and time consuming. In a commercial production, the ageing time could be reduced or eleminated to reduce the cost without adverse effect on the stability of the mix.

Dairy fats are widely used in the production of ice cream. They are primarily derived from milk, cream, butter and anhydrous milk fat. Milk fat is the major fat component in ice cream, contains 70% saturated fatty acids and a high percentage of

cholesterol. Most countries require the use of dairy fat, but some countries like the United Kingdom and Finland allow the use of vegetable fats in ice cream. In the United States, a product made with vegetable fat must be labelled as "Mellorine". In most Asian countries which have a limited supply of milk, the price differential between animal and vegetable fats has led to the growing use of vegetable fat as a fat substitute in dairy products especially in ice cream.

Palm oil and palm kernel oil are already being used as fat ingredient in local ice cream manufacture. These oils are also being used in formulating the ice cream with incorporating of other oils by ice cream manufacturers worldwide. Besides being comparatively cheaper than milk fat, the range of palm oil and its fraction continue to increase. These oil could be tailored to meet the specific technological requirements such as the melting point, solid fat content, fatty acid, triacylglycride composition and iodine value. Moreover, palm oil and its fractions have the advantages of abundant supply and a uniform quality, longer storage time and better consistency at room temperature compared to milk fat. They have a natural colour, bland taste and are similar in their physical properties which allow them to be used as a milk fat substitute with no marked changes in flavour or consistency.

Substitution of palm-based fat in an ice cream formulations may affect the rheological properties as well as the viscosity of the mix. Changes in viscosity are related to the changes in processing condition such as the rate of freezing and the growth of ice crystals during freezing. Such changes affect the texture of the end