FOOD INGREDIENTS AND THE ASIAN FROZEN DESSERT MARKET

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ABSTRACT

The frozen dessert market in Asia is reviewed. The sizes and values of markets, consumption data, and a discussion of the particular attributes of Asian frozen desserts, compared and contrasted to other markets, are included.

The typical composition of ice cream is presented, along with information on how the main components (fat, protein, lactose and salts) affect dessert quality. The chemistry and sensory aspects are discussed. The available fat, milk solids and sweetener sources for Asia are reviewed. The traditional sources are canvassed. These are contrasted with the newer chemistries, which include: specific protein fractions for skim milk replacers, hydrolysis of lactose to alter sweetness and freezing point depression, blending of fat fractions and choice of emulsifier combinations to control surface chemistry of the fat globules and to alter agglomeration characteristics, and the use of protein fractions, enzymes and alternative heat treatments for water control. The future for emerging processing technologies and dairy ingredients is discussed.

1. INTRODUCTION

This paper is divided into 3 parts: the first part is an overview of the Asian frozen dessert market, the second part is an outline of dairy ingredients used in frozen desserts, their function, common sources and alternatives to dairy ingredients and the third part concludes with a discussion of future opportunities seen for dairy ingredients in the frozen dessert market.

2. THE FROZEN DESSERT MARKETPLACE IN ASIA

The frozen dessert market worldwide is worth about $US 36.4 billion per annum. Asia makes up about 20 % of this value and slightly less of the volume (Figure 1). The reason for the difference between the percentage volume and the percentage value contributed to Asia, is due to the fact that as markets start to mature their value per volume starts to increase. North America and Europe are very affluent and mature markets, and for this reason they make up a significantly larger amount of percentage volume.

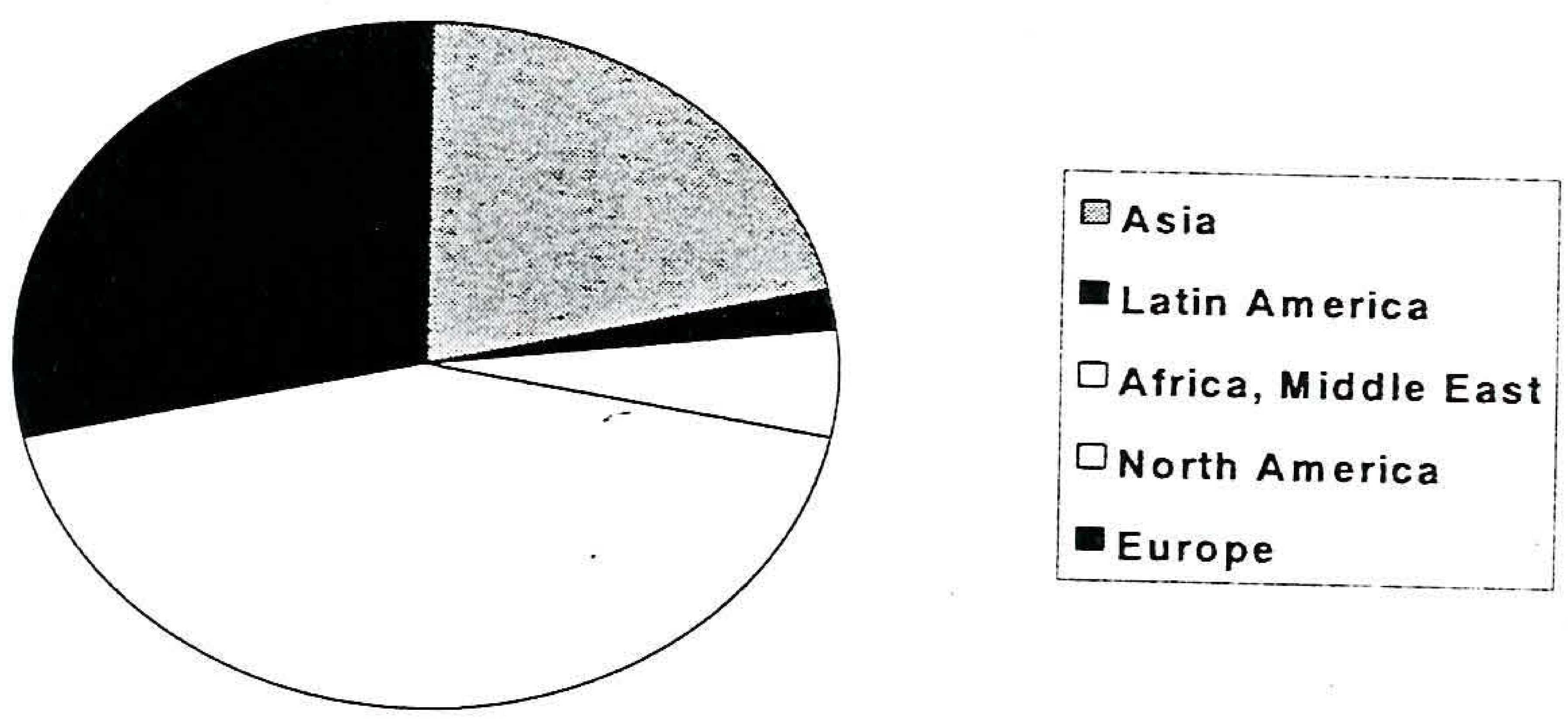

Figure 1: *Global volumes in the frozen dessert market*

If one now looks at the frozen dessert marketplace in Asia by country (Figure 2) it can be seen that the single biggest market for frozen desserts is that of China with 1.3 billion litres of frozen desserts consumed annually. Obviously, the market volume of each country is made up of 2 factors: firstly the population, and secondly, the per capita consumption of desserts.

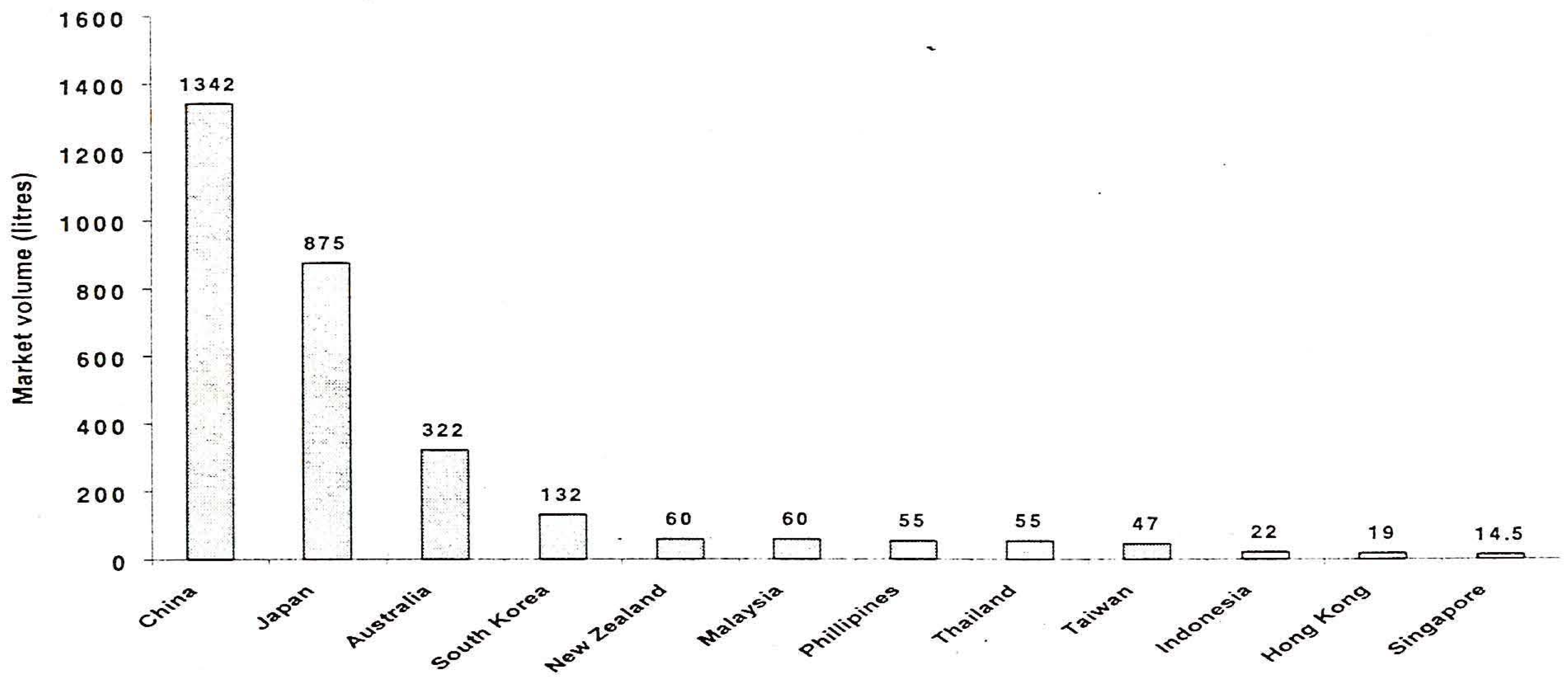

Figure 2: *Asian market volumes for frozen desserts.*

Inspection of the data in Figure 3 indicates that the per capita consumption varies greatly within the Asian region. Australia and New Zealand have quite high per capita consumption up at about 18 litres per capita per annum. These two countries are second and third respectively behind the US which has a per capita consumption of frozen desserts somewhere in the region of 20-22 litres per capita per annum. The other Asian countries have per capita consumption within the range of about 7 to less than 1 litre per capita.

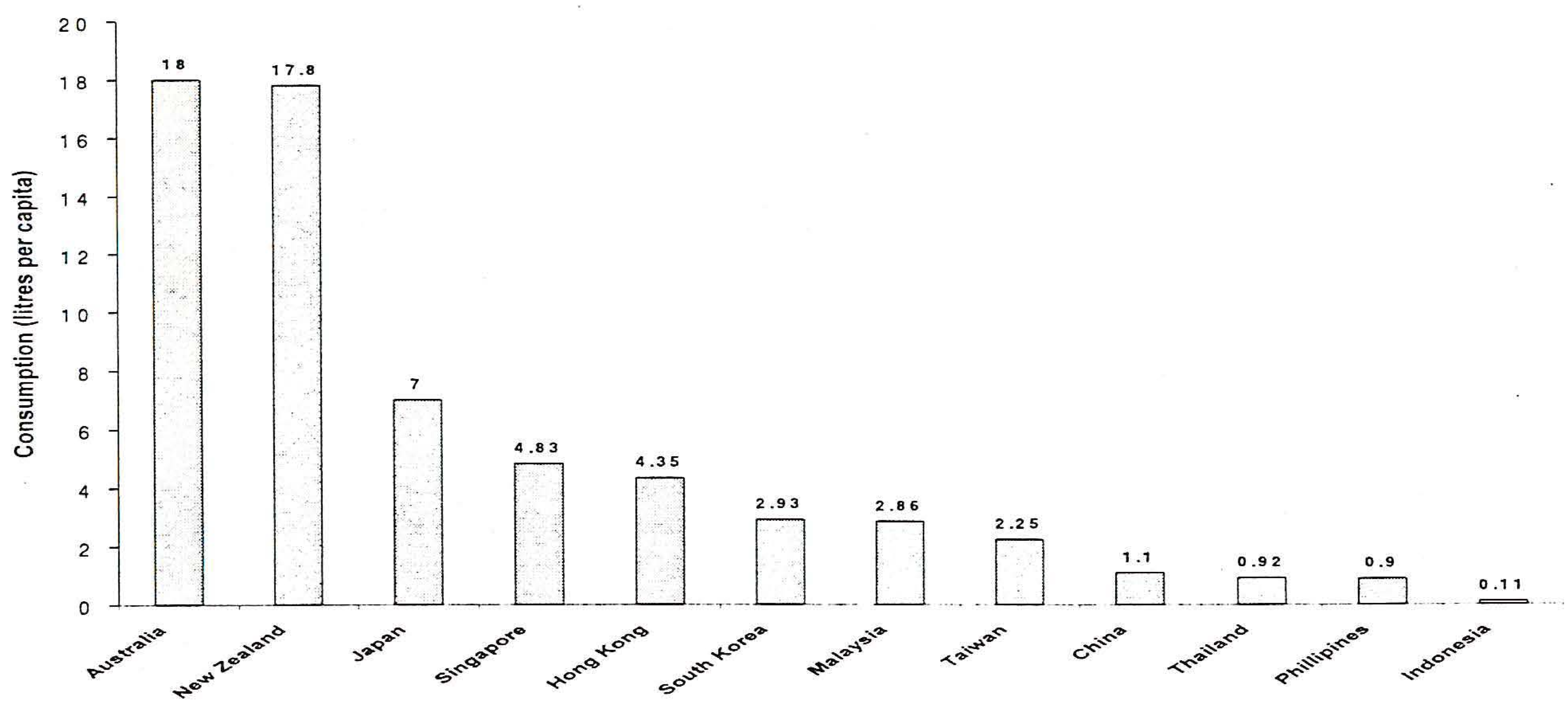

Figure 3: *Per capita consumption of frozen desserts in the Asian market.*

The consumption of frozen dessert is a western trend and therefore the western markets have the highest per capita consumption with most European countries being in the region of about 10-15 litres consumed per capita per annum.

As the Asian dollar starts to be influenced more by western style diets, then one would expect to see the per capita consumption also start to increase to levels approaching the western style countries. In addition, as the disposable income of the general population of some of the developing countries in Asia begins to become higher, the consumption of frozen desserts will start to increase, as such desserts seem to more of a luxury item than that of a staple food item.

There is a general trend that as the per capita consumption increases in a country, so too does the value per litre of the frozen dessert. There are exceptions to that trend, for example South Korea, which has an exceptionally high percentage of novelties in scooping parlours in their frozen dessert market, both of which are very high value items. Therefore, even though their per capita consumption is quite low, their actual value per litre is much higher.

Asia is a particularly strong growth region for frozen desserts. All of China is the single biggest market in Asia and the second biggest single market for frozen desserts in the world behind USA. It is expected that within the next 2 to 4 years China will become the single biggest market for frozen desserts in the world.

In conclusion, it can be seen that the Asian frozen dessert market makes up a considerable portion of the world's frozen dessert market. In addition it is one of the highest growth areas for frozen desserts in the world. However, it is far from being a homogeneous market. There are many diverging features within the Asian market, including legal differences (for instance the different food standards and trade barriers in each market) or practical differences (for instance history, technology levels available within the country or economic situation).

3. COMPOSITION OF FROZEN DAIRY DESSERTS AND THE USE OF DAIRY INGREDIENTS

Figure 4 shows the typical composition of frozen desserts. It lists product types from low or no fat through to high fat products.

Component	**Percentage**
Fat	0 2 4 6 8 10 12 14 16 18
MSNF/Whey solids	←— 14-12 —→←— 12-6 —→
Total sweetness	14-18
Sucrose	10-18
Glucose	0-4(+?)
Glucose syrup solids	←— 10-6 ←— 6-0 —→
High fructose solids	0-4(+?)
High intensity sweeteners	Depends on the type added
Stabiliser	←— 1(+/-)-0.4 —→ ←— 0.4-0 —→
Emulsifier	←— 0.5(+/-)-0 —→
Water (ice)	Balance
Air	20-150 % overrun

Figure 4: *Typical formulations for hardened frozen desserts (ice cream, ice milk and milk ice)*

The general formulation of frozen desserts varies considerably depending on the application in which they are being used and the ingredients that are available. Typically, they contain both milk fat and milk solids non-fat with added sugars and other sweeteners to contribute body, texture and sweetness. Stabilisers and emulsifiers are also added due to their particularly high functionality and the desirable properties and benefits they can give to the frozen dessert. Air (also know as overrun) is also added, as this provides a softer eating quality with some creaminess to the mix and is also cost effective.

Frozen dessert formulations are among the most complex physically and chemically of any food product that is available. Frozen desserts comprise gaseous, liquid and solid phases and they are both a foam and an emulsion. For this reason, every component in the frozen dessert has a large impact on the final taste and texture of the frozen dessert.

The fat contributes a subtle distinctive dairy flavour to frozen desserts. It also acts as a carrier, which has a synergistic effect for some other added flavourings in the frozen desserts and it can subtly modify the profile of the flavours and colours that are added to frozen desserts. However the main effect of the fat is on the texture of the frozen dessert. Fat gives a particularly creamy, smooth, rich character. Creaminess is affected by a number of different factors, for example, the level of homogenisation of the fat particle (in other words, the size of the fat particle in the frozen desserts) and the percentage of fat present. Generally, the higher the level of fat, the more creamy and smooth that the frozen dessert becomes and also the higher the level of emulsification required.

Fat contributes texture by firstly forming large semi-continuous agglomerates in the frozen dessert made up of individual fat globules. Agglomerates give the frozen dessert considerable structure and also have good capacity to hold water. Secondly, they contribute strength to the cell air walls (or lamella) in the frozen dessert. Agglomerates assist in allowing more, smaller air cells to be created, in which case, the richness and creaminess of the ice cream is enhanced.

Agglomerated fat structures in the frozen dessert can be thought to be similar to those in whipped cream. The individual fat particles are processed in such a way that the semi-continuous agglomerates begin to form. There are a number of factors that affect the formation of the fat agglomerates.

3.1 Emulsifiers

An emulsifier has an unusual function in frozen desserts. Its function is not so much to stabilise the emulsion, as to destabilise it in a controlled fashion. Dairy systems contain natural emulsifiers in the form of phospholipids and also secondary emulsifiers in the form of caseins and whey proteins. These milk proteins will coat the surface of the fat globules present in the system and, therefore, it is not necessary to add additional emulsifier to stabilise this emulsion.

The protein coating around the fat globules is not conducive to the formation of fat agglomerates. Fat agglomeration will be greatly increased by the addition of emulsifiers such as mono- and di-glycerides or polysorbate 80. They have the effect of stripping away some of the proteinaceous material around the fat globule leaving comparatively exposed fat surfaces, which are then more prone to the formation of agglomerates.

3.2 Fat concentration and homogenisation

To form these agglomerates, it is necessary to create a number of high impact collisions between the individual fat globules. There are a number of ways to increase the number of collisions. Firstly, the higher the level of fat in the frozen dessert, the more collisions there will be between the individual fat particles in the frozen dessert. Secondly, by homogenising the mix there will be a massive increase in the number of fat particles in the frozen dessert.

In an ice cream freezer barrel, high levels of shear are applied to the ice cream mix; this provides the necessary energy to agglomerate the fat particles. In addition, some of the water present in the mix is being converted to ice; this has the effect of freeze concentration, and since the fat is left in the aqueous phase, the relative percentage of fat is increased.

Considering now the negative effects of fat in frozen dairy desserts, the most obvious negative impact is off flavour if poor quality fat is used. Particularly strong rancid odours are created when short chain fatty acids are hydrolysed. This is normally caused by poor quality fats being added initially, because once the frozen dessert has been frozen, the temperature is quite low and the product is relatively stable. Although the shelf life of a frozen dessert can be up to two years long, in that time period off flavours can certainly develop.

The second negative effect is over agglomeration. This relates to the fat destabilisation effect discussed earlier. If the agglomeration has been taken too far, the fat globules can form agglomerates which become too large; this causes greasiness and buttering in the ice cream. Products with this defect can typically have small lumps of butter that are visible to the naked eye and can also be felt with the tongue during consumption.

Another defect seen with over agglomeration is a poor reduced capacity of the frozen dessert to incorporate and hold its overrun which can lead to other defects such as low overrun being achieved and also to shrinkage in the final product.

Excessive overrun can also be incorporated which gives a light fluffy texture to the ice cream. Finally, excessive structure and body in the texture of the frozen dessert is undesirable as it can be manifested as a reduction in the refreshing nature of the frozen dessert.

3.3 Common dairy fat sources in Asia for frozen desserts

The following fat sources are available for frozen desserts. They include fresh cream, frozen cream, butter, cream powder and other fat powders, AMF/butter oil, fractionated AMF, and fat blends (for example, AMF/vegetable fat blends)

The main alternative to dairy fat used in the Asian region is vegetable fat. Vegetable fat can be used to provide the same structure that is provided by the dairy fat; however, it does not give the same dairy flavour. This is not so important since many flavours, for example vanilla and fruit, are added to frozen desserts. The main advantage of the vegetable fats is price (vegetable fat may typically cost less than a quarter than the equivalent dairy fat). Vegetable fat can be used in some markets in the Asian region as a 100 % substitute of all dairy fat and the frozen dessert can still be legally labelled as ice cream, however this depends very much on the local legislation in each country.

The second alternative to dairy fat is the use of more milk solids non-fat. There is a general rule that as the level of fat in a frozen dessert decreases, this can be compensated for by increasing the milk solids non-fat. Approximately 1 % of whole milk protein can replace 2.2 - 2.5 % of fat in the frozen dessert.

Other dairy fat substitutes are stabilisers, starches and fructo-oligosaccharides which can be made to either emulate the perception of fat in the dessert and also to extend the fat. This would make a comparatively low fat frozen dessert appear as though it has a high level of fat.

3.4 Effect of milk solids non-fat

Firstly, the quality of the milk solids non-fat, especially the quality and source of the milk protein will have a large impact on the final texture and flavour of the frozen dessert. Milk protein provides a mild skim milk flavour; however, it has a much larger impact on the structure and texture of the frozen dessert. Milk protein starts to gel when it is concentrated during the freeze concentration process and begins to denature. This denaturation has both a positive and negative effect.

The denatured protein starts to increase its water holding capacity and also adds additional strength to air cells, both of which have positive effects on the texture of the product by slowing meltdown and giving more mouthfeel. The negative side of protein denaturation is the fact that if it is not controlled or if the quality of the milk protein is low, then a curd-like meltdown can be seen, in other words the ice cream mix starts to separate into curds and whey. Serum separation may also be seen in the mix prior to freezing. There may be excessive air retention in the mix and, depending on the type of the protein, it can modify the behaviour of the fat, especially in the agglomeration process.

3.5 Other constituents

Lactose imparts a slightly sweet flavour to the frozen dessert, as it has approximately one-sixth of the sweetness of sucrose. Lactose can have the effect of enhancing other added flavours. The direct effect of lactose on ice cream texture is two fold. Firstly, lactose is comparatively insoluble when compared to sucrose, so when the freeze concentration takes place in the freezer and is further extended during the hardening process, the lactose can start to form small crystals in the ice cream. If these crystals grow to a size above the limit which can be detected by the tongue, a defect called sandiness is produced, where the ice cream tastes like it contains sand. The lactose crystals will start to form as an ice cream starts to age and the lactose crystals will increase when the ice cream is subjected to heat shock. If the size of the lactose crystals is kept below the detection threshold of the tongue there is no negative impact on eating quality.

Salt is also present in the milk solids non-fat. Salt imparts an obviously salty flavour, which also enhances other added flavours. The salt will influence the milk protein stability. During the freeze concentration process, the relative salt content of the aqueous phase is increased by more than five times, resulting this component being a major contributor to milk stability.

Both lactose and salt have a major impact on the freezing profiles of frozen desserts. The freezing profile of the ice cream mix indicates the percentage of water that will be present in an ice cream mix at any particular temperature the freezing process occurs. This is effected by the addition of solids. The more soluble componen' t' ıt are added to the frozen dessert (for instance salt, lactose or other added sugars), the further the ,re.‿zing point will be depressed, and at any temperature one would expect to see less water present as ice and more water present as a liquid.

Additional sources of milk solids non-fat for frozen desserts are skim milk, whole milk, whey and buttermilk. These can be either incorporated as liquid ingredients or as powders. If one looks at alternatives to the traditional sources of skim milk solids, dairy fat and vegetable fat can be used to some extent to substitute milk solids non-fat. In addition, stabilisers, starches, fructo-oligosaccharides and other high molecular whey products can be used to substitute some of the effects that the protein provides to the frozen dessert. More recently, dairy based skim milk replacers have become available on the market.

3.6 Dairy-based skim milk replacers

The basic concept of the dairy based skim milk replacer is to take various fractions of milk solids non-fat and blend them together to achieve a similar functionality to skim milk powder, but at a lower price. However, functionality is not always an exact match to that of skim milk powder.

Some skim milk replacers, for example, may retard meltdown in the frozen dessert, which depending on the circumstances can be seen as either a positive or negative attribute. Some may also result in excessive structure development, which may not be desirable. Problems of excessive gelation may be manifested through the usage of particular combinations of fat, skim milk replacer, stabiliser and emulsifier, where the individual components would not be normally associated with this defect.

There is a very large potential market for the skim milk replacers in Asia. They are becoming increasingly sophisticated and there are now more opportunities to move away from traditional skim milk powders due to the lower cost structure and increased functionality of some skim milk replacers.

In evaluating skim milk replacers it is necessary to conduct experiments on the skim milk replacer under conditions that approximate very closely the factory conditions in it will be used. It is not enough to look at the specification for the skim milk replacer and compare the amount of carbohydrate, salt and protein in the skim milk replacer to skim milk powder and expect it to function similarly.

There is further potential to incorporate other non-dairy ingredients into the dairy based skim milk replacer, for example specific stabilisers or emulsifiers. These can work to extend the dairy ingredients; in other words, they provide even lower cost blends. Also the functionality of the skim milk replacer could be increasingly enhanced to tailor to suit specific applications.

4. FUTURE OPPORTUNITIES FOR DAIRY INGREDIENTS IN THE FROZEN DESSERT MARKET

4.1 Alternative sweeteners

The hydrolysis of lactose to its constituent glucose and galactose molecules presents a number of advantages. Firstly, an individual with lactose intolerance may be able to consume frozen desserts without any digestive problems. Secondly, the amount of sweetener that needs to be added to the ice cream mix can be reduced, since glucose and galactose are sweeter than the lactose di-saccharide. This can also reduce the cost of the ice cream mix. However, there are a number of processing and practical issues to be overcome before this can be incorporated into a factory process.

Firstly, there is a long holding time required to completely hydrolyse the lactose in a frozen dessert. This can be eliminated by the use of prior lactase-treated dairy ingredients. Secondly, the monosaccharide constituents double the effect on freezing point depression of the frozen dessert compared to the lactose molecule. Therefore, the ice cream mix would require formulation changes so that this freezing point depression could be taken into account.

4.2 Fats

Secondly, if one looks at fractionated milk fat, by fractionating and further modifying milk fat it will be possible to produce frozen desserts with more favourable saturated and unsaturated ratios. This has an obvious health benefit that so far is only seen in vegetable fat systems.

There is also potential for additional functionality through modifying the fat behaviour to further control the agglomeration effect when formulating and producing a frozen dessert. Alternative sources of control of fat agglomeration can be explored, for instance the use of fat fractions or non traditional added emulsifiers to modify the fat globule surface. For example, non-traditional mono/di-glyceride and polysorbate combinations, high phospholipid content buttermilk powders (natural emulsifiers) or even mono/di-glycerides derived from milk fat could be explored for this functionality. In practical terms, the latter may present some difficulties as the presence of short chain fatty acids causing the strong butyric-type odours.

Sucrose esters may also find potential use in the frozen desserts, although to date, there does not appear to be any particular advantage in their use over of mono/di-glycerides. There also appears to be a negative impact on cost compared to mono/di-glycerides. Lecithin with improved flavour profiles would give greater flexibility in the use of natural emulsifiers in frozen desserts for controlled destabilisation.

4.3 Proteins

Alternative water control systems can also be explored, such as milk protein systems. Complete milk protein usage can be increased due to processes such as ultrafiltration or reverse osmosis, or even fine fractionation of the protein to some of its more functional constituents. However, some of these protein systems can have flavour defects and once again, the price at the moment seems to be prohibitively expensive when compared to the existing stabilisers and emulsifiers used in frozen desserts.

4.4 Processing

The potential also exists for improved processing technology, for example, pasteurisation. The expanded and more focussed use of high temperature pasteurisation for functional purposes could alter favourably the water hydration capacity of the proteins. This would be more important with the high protein associated with increased milk solids non-fat levels or protein supplements and it is particularly relevant to low total solids associated with the low fat and no fat products.

High pressure homogenisation can also potentially be used to improve the quality of low fat products, by giving extremely small individual globules of fat particles which can lead to increased agglomeration more like a full fat frozen dessert.

NEW SPECIALISED MILK POWDERS FOR RECOMBINED AND RECONSTITUTED EVAPORATED MILK

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ABSTRACT.

In conventional evaporated milk manufacture, the milk concentrate is in-can sterilised for production of a pourable product with the desired viscosity. When milk powders are used in evaporated milk manufacture, it is essential that the milk concentrate can withstand the sterilisation process without excessive thickening or coagulation. Powders that meet this requirement when used in these applications are termed heat-stable milk powders. Traditionally skim milk powders were screened for their suitability for recombined evaporated milk manufacture on a subjective basis which was related to the time taken for a 20 % total reconstituted skim milk concentrate to coagulate or thicken at 120 °C. However, manufacturers of recombined evaporated milks faced intermittent problems when using powders that met this specification due to inadequate heat stability. A new generation of skim and full-cream milk powders, specialised heat-stable milk powders, has been developed for evaporated milk applications. Use of these powders in commercial recombining operations have shown that they have adequate heat stability in the manufacture of reconstituted or recombined full-cream evaporated milk.

1. INTRODUCTION

Substantial quantities of dairy ingredients, primarily skim milk powder, whole milk powder and anhydrous milk fat, are used in South East Asia, South America and Middle Eastern countries for the manufacture of recombined and reconstituted milk products. Recombined evaporated milk is made by recombining skim milk powder and anhydrous milkfat and subjecting the homogenised concentrate to sterilisation. It is essential that the recombined concentrate can withstand the sterilisation process without excessive thickening or coagulation. A similar resistance to heating is required for concentrates made by reconstitution of full-cream milk powder. The milk powder used has an influence on the resistance of the concentrated milk to coagulation during sterilisation and the final product viscosity.

Milk powders which yield evaporated milks with the desired viscosity after sterilisation, are termed heat-stable milk powders. However, there were intermittent technological problems with excessive thickening of concentrates when conventional high-heat milk powders, that met specifications based on the time taken for a 20 % total reconstituted skim milk concentrate to coagulate or thicken at 120 °C, were used to manufacture recombined evaporated milks.

2. HEAT STABILITY OF CONCENTRATED MILK AND MILK POWDERS

It has long been recognised that milk and milk powder used for the manufacture of evaporated milks have to be adequately heat-stable. There is seasonal variation in the inherent heat stability of milk and concentrated milks [1-3].

Heat stability has traditionally been manipulated by the addition of lecithin, buttermilk powder, or salts, adjustment of pH and heat treatment of the milk during the powder manufacturing process [4-7]. In industry, manipulation of heat stability of recombined evaporated milk and concentrated milk is usually accomplished through the addition of orthophosphates to the recombined milk concentrate at the recombination plant. A study on the effects of phosphate and pH adjustment had shown that the efficiency of these phosphates to stabilise concentrated milks was dependent on the season [8].

Due to the effects of the seasonal pattern of pasture growth and calving, the manufacture of heat-stable powders in Australia and New Zealand has conventionally been limited to between October and March. Outside of this period, milk powder manufacturers have experienced difficulties and were unable to consistently produce milk powder with adequate heat stability for recombined evaporated milks [9].