# Potential of Palm Blend in the Formulation of Mozzarella Analogue

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## INTRODUCTION

Natural mozzarella cheese is produced from buffalos' or cows' milk and the most prominent fat present is milkfat. Mozzarella cheese originated from Italy but the United States has become its principal producer. This cheese had remained an ethnic product with a limited market until around World War II, when Italian cuisine in general and pizza pie in particular, began its meteoric rise in popularity that continues to the present. Mozzarella cheese constitutes one of the most expensive ingredients of a pizza pie. It is normally used as a topping and its major function is to cling on to all the other ingredients as it melts.

The role of fat in cheese is to contribute to its physical characteristics by giving opacity and it has a large influence on the rheology of the cheese. Fat is also a precursor of many flavour compounds and it modifies their perception and volatility, especially in the mouth. According to Eric (1993), fat globules normally act as a filler between protein fibres, thus, reducing the interactions among proteins within the cheese matrix.

Consumption of mozzarella cheese in Malaysia has shown a tremendous growth due to the introduction and popularity of pizza pie. Local statistics indicate that the import of cheese and curd from January-May 2000 was valued at RM 17.75 million (US$ 4.67 million) while that for January - May 2001 was RM 20.37 million (US$5.36 million).

In the manufacture of mozzarella cheese, milk is soured by the addition of thermophilic starters followed by the addition of rennet to coagulate the curd. As rennet is obtained from the stomach of young calves, its usage has become a sensitive religious issue to a majority of the population in Malaysia. Substitute products would, therefore, be well accepted in the market. Substitution by palm blends could also be an advantage due to the absence of cholesterol in vegetable fat, less subjected to seasonal variation and cheaper price. Furthermore, Malaysia, the world's major exporter of palm oil is not a major producer of dairy products. Therefore, these factors have given an impetus to the development of mozzarella analogues. This study was undertaken with the following objectives:

- to study the physical, chemical and functional properties of commercial mozzarella cheese to be used as the control;
- to identify a suitable palm blend with a similar solid fat profile as milkfat; and
- to compare the properties of palm-based mozzarella analogues with the control.

## MATERIALS AND METHODS

### Control

Commercial mozzarella cheeses were obtained from local supermarkets and used as the control. Only four brands, three imported from Denmark and one from Australia were available (coded: C1, C2, C3 and C4). All the samples were packed in block form, each weighing about 250 g. The control samples used throughout this experimental study were not subjected to any storage test because they were already more than a month old when purchased. Popular pizza outlets in Malaysia such as Pizza Hut, Domino's and Shakey's, however, import mozzarella cheese mainly from New Zealand and Australia. Here, the samples were packed in 10 kg rectangular forms and kept at freezing temperature.

### Experimental Samples

Casein (90 mesh size), was obtained from New Zealand Milk Products. National Starch, Malaysia supplied modified starch that was used as a replacement for casein. Refined, bleached and deodorized (RBD) palm-based

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products such as palm oil (PO), palm kernel oil (PKO), palm stearin (POs), palm olein (POo) and palm kernel olein (PKOo) were obtained from local refineries.

**Processing**

Two formulations and processing techniques were used in the production of the mozzarella analogues. Samples were cooked using a steam injection kettle (model UM/SK5: Stephan, Germany). Analogue A (without starch) was manufactured by mixing 26% fat with 43% water at low speed followed by the addition of about 28% casein. Emulsifying salts (2.5%) were then added and further mixed at low speed until a homogeneous mixture was acquired. Then 0.6% acid was added and agitated at low speed. The casein: fat (C/F) ratio of analogue A was 1.07.

Analogue B (with starch) was produced by dissolving 3% emulsifiers in 47% water at low speed. Eighteen percent casein was incorporated at medium speed followed by the addition of 24% fat. Six percent starch was then added and steam injected for a few minutes. Finally, colour and acid were added and mixed at low speed until a homogeneous mass was obtained. The C/F ratio for analogue B was 0.75. The analogues were packed in 12 cm x 12 cm plastic containers and incubated at 5·C. After stabilizing for 24 hr, samples were wrapped in aluminium foil. Evaluation of analogues A and B were conducted on day 1, 8, 15, 21 and 30. Each analogue sample was manufactured in two batches and the mean calculated.

**Physico-chemical and Functional Analysis**

The titratable acidity (TA) and pH were evaluated according to the AOAC Official Methods of Analysis (1990). Moisture was determined using a Halogen moisture analyser-model HR 37 - Mettler Toledo. About 3 g of grated sample was evenly spread on an aluminium pan. A two-step drying temperature was used, at 80°C for 7 min followed by 150°C for another 7 min. Cheese moisture was calculated in quadruplicate as the loss in weight of the sample. Colour was determined using a Minolta-Chroma meter, model CR-300. Each analysis was conducted in triplicate. Readings were interpreted as L-, a- and b-values. Meltability was evaluated according to the method of Arnott *et al.* (1957). A stretchability test was carried out according to the method described by Kosikowski (1982). The browning properties of cheese was determined using the procedure by McMahon *et al*. (1993). The colour difference was analysed as the E-value. The texture test was performed using a TA-XT2 texture analyser (Texture Technologies Corp. Scarsdale, NY/Stable Microsystems, Godalming, UK). The cone probe (part No. P/45C) was used to measure the maximum force. The setting conditions were: pre-test speed 2.0 mm $s^{-1}$, test speed 1.0 mm $s^{-1}$, post-test speed 1.0 mm $s^{-1}$ and a data acquisition rate of 200 pps. Shreddability was conducted manually using a grater.

**Milkfat Substitute**

The solid fat content (SFC), slip melting point (SMP) and fatty acid composition (FAC) of selected palm-based products were compared with milkfat. SFC was the criterion used for comparison purposes. Palm products that exhibited a close SFC profile as milkfat were subjected to a simple and cheap modification technique, *i.e.* blending. Binary blends were then prepared to further simulate the SFC profile of milkfat. The most suitable blend was then used in the formulation of mozzarella analogues.

**Fat Analysis**

The SMP was measured using the open capillary method according to PORIM Test Methods (1985). The SFC was analysed using Pulse Nuclear Magnetic Resonance (pNMR). Tempering was done at 70°C for 30 min, followed by chilling at 0°C for 90 min and then held at each measuring temperature for 30 min prior to measurement. FAC was determined according to official AOCS methods Cd 14c-94 (1992). Fat was esterified into fatty acid methyl ester (FAME). One microlitre of the FAME was injected into a gas chromatograph (model: HP 6890S) fitted with polar capillary column. The detector and injector port temperatures were 240°C. The carrier gas was helium at 0.8 ml $min^{-1}$. The column temperature was isothermal at 190°C.

## RESULTS AND DISCUSSION

**Control**

The physical, chemical and functional properties of the control samples (C1, C2, C3 and C4) are shown in *Table 1*. A fairly wide range was observed for parameters such as TA (0.14-0.50%), moisture content (43.28% - 47.16%) and texture (653. 22 - 1142.3 g). According to the American Federal Standards (*Table 2*), low moisture part-skimmed (LMPS) mozzarella, *i.e.* the type commonly used for pizza toppings, should have a moisture content of more than 45% but less than 52%. However, the control samples evaluated did not comply with the above standard due to their origins (Denmark and Australia). The difference in moisture content among the control samples was about 4.0%. A large variation in texture values was observed. This indicated that the moisture content was not the sole factor contributing to texture. All the samples exhibited very good shreddability. According to Yun *et al*. (1993), mozzarella

TABLE 1. PHYSICO-CHEMICAL CHARACTERISTICS OF COMMERCIAL SAMPLES

| Commercial samples | A | B | C | D |
|---|---|---|---|---|
| Shreddability | Good | good | good | good |
| pH | 5.76 | 6.07 | 6.07 | 5.94 |
| TA % | 0.50 | 0.35 | 0.29 | 0.14 |
| Moisture % | 44.0 | 43.28 | 45.39 | 47.16 |
| Texture (g) | 879.25 | 946.04 | 1 142.3 | 653.22 |
| Meltability (mm) | 82.35 | 82.35 | 82.35 | 85.29 |
| Colour | | | | |
| L | 76.68 | 76.28 | 77.53 | 80.36 |
| a | -3.94 | -3.39 | -3.22 | -2.20 |
| b | 25.46 | 15.97 | 12.70 | 20.24 |
| Browning | | | | |
| Before | | | | |
| L | 71.93 | 72.12 | 75.77 | 73.64 |
| a | -4.37 | -3.90 | -3.14 | -3.52 |
| b | 20.31 | 14.34 | 9.26 | 14.86 |
| After | | | | |
| L | 56.58 | 57.23 | 64.46 | 58.43 |
| a | 6.48 | 6.07 | 3.34 | 6.31 |
| b | 24.59 | 22.24 | 20.61 | 23.91 |
| E-value | 19.32 | 19.71 | 17.33 | 21.91 |

TABLE 2. COMPOSITION STANDARDS FOR MOZZARELLA CHEESE

| Type | Moisture (%) | FDM |
|---|---|---|
| Mozzarella | >52 but <60 | >45 |
| Low moisture | >45 but <52 | >45 |
| Low moisture, part skim | >45 but <52 | >30 but <45 |
| Part-skim | >52 but <60 | >30 but <45 |

Source: Fox (1993).

cheese should have acceptable shredding properties because it is usually diced or shredded to facilitate uniform distribution on the product and uniform melting. The pH of the control samples ranged from 5.76 - 6.07, meltability 82.35% - 85.29%, L-value 76.28 - 80.36 and browning properties expressed as E-value 19.32-21.91. The values for all these attributes will be used as a guideline in the formulation of mozzarella analogues.

**Mozzarella Analogues**

Analogue A (no starch) had a mean TA value ranging from 0.11% - 0.16% while analogue B (with starch), had a mean TA value of 0.18% - 0.41%. *Figure 1* shows the mean TA values of the control samples compared to the analogue samples. The TA for both analogues A and B were maximum on day-15 (0.16% and 0.14% respectively). However, after a storage period of 30 days, the TA of both analogues A and B experienced a drop in TA value (0.11% and 0.19% respectively). Analogue A had a close TA profile as C4 while analogue B imitated that of C3.

The mean pH values of both analogues A (6.44-6.59) and B (6.63-6.72) were slightly higher than the control. According to Ramkumar *et al.* (1998), during cheese manufacture, the activity of microorganisms result in a continuous decrease in the pH, which is controlled mainly by the amount of starter culture added, the temperature of cooking and the rate of salting. However, in the production of mozzarella analogues, the cultures were not incorporated and thus, the reduction in pH was rather slow. According to Kindstedt (1991), the differences in pH can affect the cheese texture. Cheese pH is important because it influences

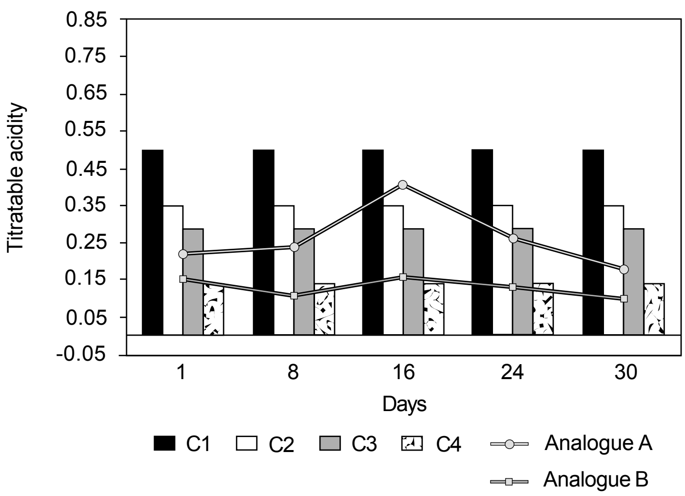


Figure 1. Titratable acidity of commercial and mozzarella analouges.

proteolysis during refrigerated storage which in turn, affects the texture as well as functional properties of the cheese (Lawrence *et al.,* 1987).

The moisture profile of both analogues A and B were fairly uniform throughout the storage period, *i.e.* 53.11%-54.74% and 51.58%-53.14% respectively (*Figure 2*). These results comply very closely with the American Federal Standards for LMPS mozzarella. However, the moisture contents of the analogue samples were 7%-8% higher than the control samples.

The texture of analogue A (414.44-512.54 g) was better than analogue B (219.28-369.20 g). Analogue A resembled the texture profile of the control more closely. Marshall (1990) reported that the differences found in the texture of cheese and analogues could be related to the way the fat and protein are distributed. Higher protein densities in cheese have been associated with high values of hardness and firmness (Bryant *et al.,* 1995).

The degrees of lightness (L-value) of both analogues A (89.12-92.40) and B (86.65-89.49) were close to the control and no specific increase or decrease in L-value was observed in storage. The melting range of analogues A and B were (39.21-75.49) and (78.44-89.71) respectively. A drastic change in meltability during storage was observed in analogue A while that of analogue B showed very little improvement (*Figure 3*). The salt (NaCl) content strongly influences the melting properties. Analogue A consisted of about 2% salt while analogue B did not have any salt in the formulation. Olson (1982), reported that mozzarella containing 1.78% salt was less meltable and less stringy initially after manufacture than another cheese of equal age containing 1.06% salt. According to Rizvi *et al*. (1999), mozzarella cheese needs to be aged for two to four weeks at a storage temperature of

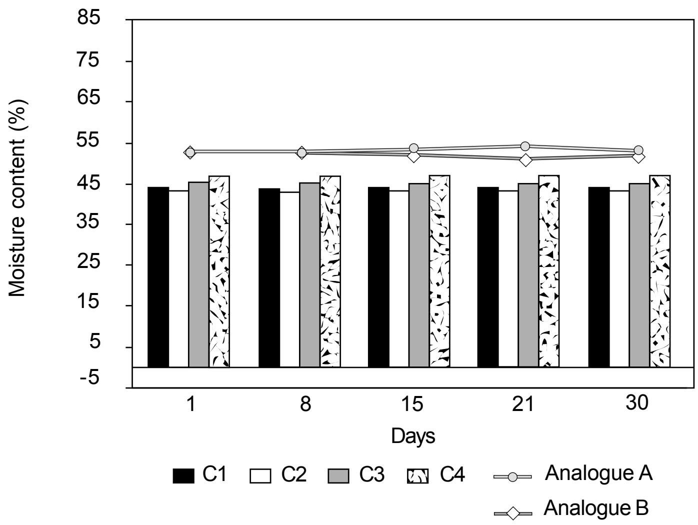


Figure 2. Moisture contents of commercial and mozzarella analogues.

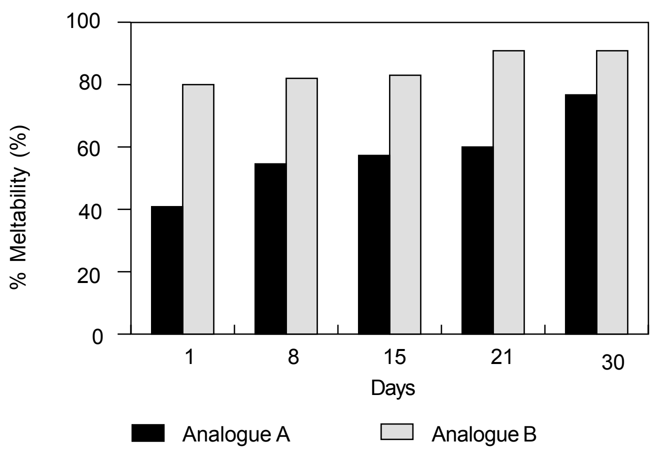


Figure 3. Meltability of mozzarella analogues during storage.

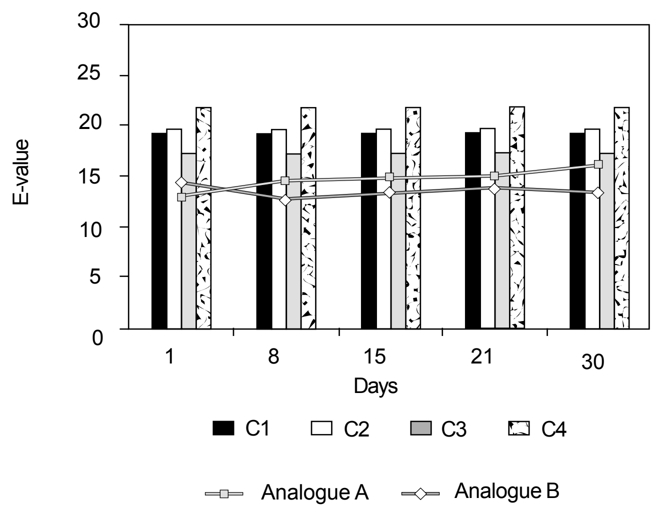


Figure 4. Browning properties of mozzarella analouges and the controls.

5°C to allow the breakdown of protein through proteolysis in order to develop desirable melting characteristics. Mozzarella in fact undergoes a rather dramatic and characteristic change in melted functionality when it is stored under condition of refrigeration storage (Kindstedt, 1993). Harvey *et al.* (1982), reported that fat and water contents were not always found to influence significantly the melting quality.

The browning properties of analogue B was more comparable to the control than analogue A as shown in *Figure 4*. The browning of mozzarella is a heat-induced reaction between sugars and proteins similar to the Maillard reaction during baking. Johnson and Olson (1985), demonstrated that accumulation of galactose, resulting from the incomplete fermentation of lactose by the starter culture is a major determinant of browning. Processing variables, such as type of culture (Oberg *et al*., 1991) and coagulant (Oberg *et al*., 1992) influence the functional properties of mozzarella cheese.

It was clearly observed that analogue A had better shreddability than analogue B. This could be due to the C/F ratio of analogue A (1.07) which was higher than analogue B (0.75). Mozzarella cheese should have acceptable shredding properties. Undesirable shredding characteristics occur when the cheese is too soft or gummy, causing the shredded cheese to adhere to each other. Too hard or dry cheese will result in large losses of fines during shredding (Yun *et al*., 1993).

**TABLE 3. FAC OF MILKFAT AND A FEW PALM-BASED PRODUCTS**

| Carbon No. | Milkfat | Palm oil | Palm kernel olein | Palm blend |
|---|---|---|---|---|
| C4 | 0.7 | - | - | - |
| C6 | 1.9 | - | 0.3 | 0.2 |
| C8 | 1.4 | - | 4.9 | 3.0 |
| C10 | 3.3 | - | 3.7 | 2.5 |
| C11 | 0.3 | - | - | - |
| C12 | 3.6 | 0.1 | 42.9 | 32.4 |
| C13 | 0.1 | - | - | - |
| C14 | 12.4 | 1.0 | 10.7 | 10.7 |
| C14:1 | 1.6 | - | - | - |
| C15 | 1.4 | - | - | - |
| C15:1 | 0.2 | - | - | - |
| C16 | 32.4 | 43.5 | 8.3 | 18.5 |
| C16:1 | 2.5 | - | - | - |
| C17 | 0.8 | - | - | - |
| C17:1 | 0.5 | - | - | - |
| C18 | 10.8 | 4.3 | 2.4 | 3.0 |
| C18:1 | 19.2 | 41.8 | 21.3 | 24.4 |
| C18:2 | 2.8 | 9.3 | 3.0 | 4.9 |
| C18:3 | 1.4 | 0.2 | - | 0.2 |
| C20 | 0.9 | 0.4 | - | 0.2 |
| SMP(°C) | 33.8 | 36.4 | 24.4 | 25.2 |

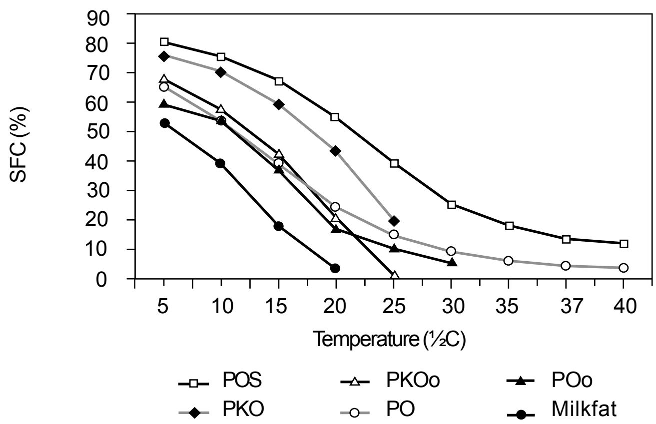


Figure 5. SFC profile of selected palm-based products and milkfat.

### Milkfat Substitute

*Table 3* shows the FAC and SMP of selected palm-based products. It was not appropriate to simulate the FAC of palm blend similar to milkfat due to the presence of odd chain fatty acids in fats of animal origin. The SFC profiles of PKO, PKOo, POo, PO, POs and milkfat are shown in *Figure 5*. Two palm-based products namely PO and PKOo seemed to exhibit a similar SFC profile as milkfat at temperatures between 5·C-25·C. However, solids less than 10% still exist in PO at temperatures between 30·C-40·C. The SFC profiles of blend A (PO:PKOo-50:50), blend B (PO:PKOo-60:40), blend C (PO:PKOo-70:30) and milkfat are shown in *Figure 6*. A blend comprising 30% PO and 70% PKOo was almost identical to milkfat and used throughout the experiment as milkfat substitute**.**

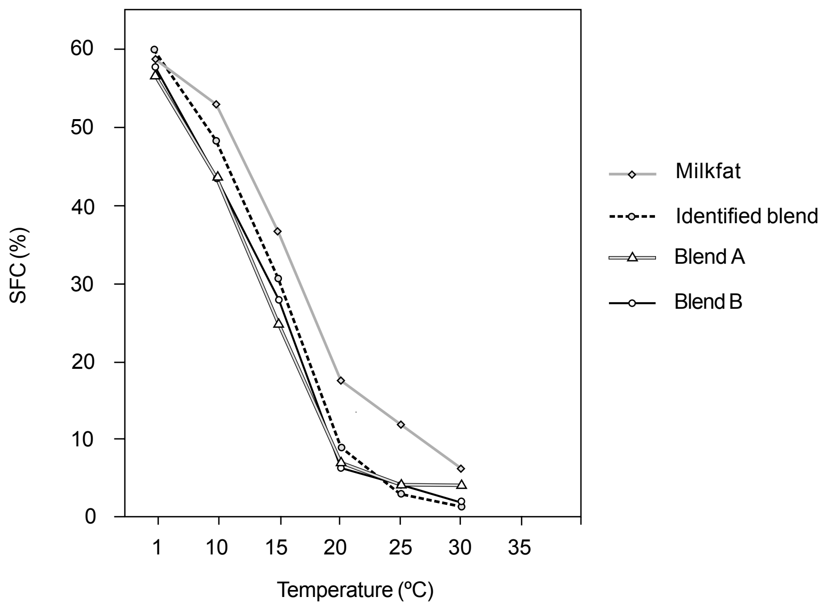


Figure 6. SFC profiles of milkfat and selected palm blends.

**CONCLUSION**

The differences in C/F ratio between the analogue samples were found to have a great influence on the textural characteristics. Analogue A with a C/F of 1.07 had a better texture profile than analogue B with a C/F of 0.75. The moisture content of analogues A and B were very close but their textural characteristics varied. The moisture content therefore, did not greatly influence the texture profiles of the analogue samples. Protein and fat were found to be the major components that contributed to the texture of the final product. The control samples had lower pH values compared to palm analogues due to the presence of starter culture which converted lactose into lactic acid and thus lowered the pH value. Besides the high cooking temperatures used during manufacture of the analogues (80°C-83°C) slowed down the chemical reactions as well. These factors contribute to the higher pH values in the mozzarella analogues. The trend of changes in meltability observed in this study was in conformity with other reports (Nilson and LaClair, 1976). Analogue A with high fat, low protein and a better texture was more meltable. The use of 6% starch in analogue B had not contributed to any improvement in the textural properties. However, it had enhanced the browning characteristic of analogue B.

A score of 1 was given to the analogue sample that had similar or fairly close results to the control. Eight parameters were evaluated and three of these were functional properties. Analogue A had a total score of 8 while analogue B had a score of only 4. Analogue A fulfilled all the criteria of mozzarella cheese including the functional properties. Therefore, the use of palm blend (PO:PKOo - 30:70) in the production of mozzarella analogue A which did not have any starch incorporation was found to be the most suitable and resembled that of natural mozzarella cheese.

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