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*Full Length Research Paper*

# Physico-chemical and sensory qualities of soy and milk solids fortified low fat yoghurt

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**The study evaluated the physical and sensory qualities of low fat yoghurt made by fortifying milk base with soy milk powder (SMP) instead of non-fat dried milk (NFDM) powder. Two batches of yoghurt were produced using 2% fat milk fortified with 1.0, 2.0, 3.0 and 4.0% of SMP or NFDM. One batch contained Maizena as stabilizer (MS). Yoghurts were produced from the fortified milk and a control without fortificant. Total soluble solids (TSS), pH, titratable acidity, viscosity, susceptibility to syneresis (STS), water holding capacity (WHC), color, whiteness index (WI) and consumer acceptability of the yoghurts were analysed. STS in SMP-fortified yoghurts without stabilizer was greater ($p<0.05$) than for NFDM-fortified and stabilized yoghurt. TSS, viscosity, WHC, STS and WI were higher for NFDM-fortified and stabilized yoghurts than yoghurt without stabilizer, at all the concentrations tried out. NFDM-fortified and stabilized yoghurt had higher sensory scores than that without stabilizer. SMP-fortified low fat yoghurts displayed poor physical quality compared to NFDM-fortified yoghurts. Yoghurt made using soymilk solids fortification exhibited weaker physico-chemical properties as compared to NFDM-fortified yoghurts. The fortification of yoghurt with soy solids using stabilizer is, however, recommended considering the isoflavones and mineral content in soymilk.**

**Key words:** Yoghurt, fortification, soya solids, milk solids, syneresis, stabilizer.

## INTRODUCTION

The use of soy ingredients in foods is receiving significant attention from the food industry and consumers because of their role as a functional food (Walsh et al., 2010). Yoghurt is an ideal food matrices for delivery of beneficial functional ingredients (Baroke, 2008). The functionality of food can be addressed from the perspective of food components (Tapsell, 2009). Despite the rich health benefits of soy ingredients (Mian, 2006; Velasquez and Bathena, 2007; Xiao, 2008) and affordability, their use in widely consumed dairy products needs further study.

In order to improve the organoleptic properties and nutritional profile of any product, fortification with soy milk is very much relied upon by yoghurt manufacturers (Tamime and Robinson, 2004, Sodini et al., 2005). The use of Non-fat dried milk (NFDM) to fortify yoghurt may result in excess proteins which may impair the taste of yoghurt (Deeth and Tamime 1980).Alternative ingredients like soy milk that offer an opportunity to lower the lactose content of the yoghurt.

Soy milk has good water holding capacity (Mian, 2006). Such a property can enable it to be used as a stabilizer in food systems. Multifunctional ingredients would offer a cost effective approach to yoghurt manufacture. Keeping the foregoing in mind, the objectives of this study were to produce low fat yoghurt fortified using soy milk powder (SMP) and NFDM and finally compare their physic-chemical and sensory properties.

## MATERIALS AND METHODS

Powdered soymilk, a product of Nature's Choice, South Africa (RSA) was obtained from a Pharmacy store. Non-fat dried milk, a product of sun spray food ingredients, RSA, low fat ultra high

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temperature processed milk, a product of Clover RSA were obtained from Spar supermarket. Sucrose, a product of Tongaat Hulett Ltd, RSA, Maizena stabilizer (refined corn flour), and Nutriday plain yoghurt with live culture, a product of Parmalat, RSA were used.

**Experimental design**

Two batches of low fat (2%) milk were fortified with either soy milk powder (SMP) or non-fat dried milk (NFDM) at concentrations of 1.0, 2.0, 3.0 and 4.0% of the milk. Within each batch, to one set (4 samples) a Maizena stabilizer (MS) was added. Two controls without fortification, one with, and the other without MS were used. The experimental unit was 300 ml of yoghurt per sample in a plastic bottle, and Nutriday plain yoghurt were used as the inoculums, at a concentration of 0.85% v/v of the milk. Incubation was at 40°C for 20 h. Physico-chemical quality of the yoghurt samples was analysed in triplicates per production. Consumer acceptability tests, using a 9-point hedonic scale, were conducted on the color, consistency, flavor and overall acceptability of the yoghurts.

**Yoghurt preparation**

After standardizing the milk base, the mixture was subjected to a heat treatment at 80°C for 30 min. Sucrose (5% w/v) was added to the milk while heating. Within each batch (2 sets of 4 x 300 ml milk samples), to one set the Maizena stabilizer (0.6% w/v) was added. After heating, the mixture was cooled to a temperature of 42°C before inoculation with 2.5% v/v of *Nutriday* plain yoghurt. The mixture was incubated at 40°C (Sodini et al., 2005) for 20 h.

**Physicochemical properties of yoghurt**

The pH was determined using a pH meter [Mettler – Tolegdo AG, E120 Model, Switzerland] (Vargas et al., 2008). A Brookfield viscometer [Brookfield Model RVD E230, USA] with spindle number 6 was used to measure the apparent viscosity at 50 rpm at 25°C. The method of Isanga and Zhang (2009) was used to determine susceptibility to syneresis (STS). The yoghurt sample (20 ml) was placed on a filter paper on top of a funnel and allowed to drain for 3 h. The index of syneresis was calculated from the formula:

STS (%) = $V_1/V_2$ x 100.

[$V_1$ = Volume of whey collected after drainage; $V_2$ = Volume of yoghurt sample].

The method of Harte et al. (2003), with slight modification, was used to determine the water holding capacity (WHC) of stirred yoghurt samples after subjecting them to 15 min centrifugation at 6000 rpm at 5°C in a centrifuge [Hettickh Zentrifugen, D 78532 Tuttligen, E120 Model, Germany]. WHC was calculated using the formula: WHC (%) = {1 – [$W_1/W_2$]} x 100 [$W_1$ = weight of whey after centrifugation and $W_2$ = weight of the yoghurt used]. Titratable acidity (TA) was determined using the AOAC (1990) method. A refractometer [Atago automatic, Smart 1, Model 1620, Attago Co Ltd, Japan] was used to measure the total soluble solids (TSS) of the yoghurts 25°C. For colour, a Hunter lab [Colorflex, VA, Model 45/0, USA] was used to measure the L, a, and b colour parameters at 25°C.

**Sensory evaluation of yoghurt**

A panel of judges (Osundahunsi et al., 2007) drawn from the University community assessed the sensory quality of yoghurts. They were chosen based on their willingness, availability and motivation (Meilgaard et al., 1999). A nine-point hedonic scale was used to point out the differences amongst the yoghurt samples. The judges rated the yoghurt samples for colour, consistency, flavor and overall acceptability. The sample presentation order was randomized among and within assessors (Hashim et al., 2009).

**Statistical analysis**

Triplicate analysis of yoghurt per production was done. The data generated was analysed using analysis of variance (ANOVA) in order to evaluate the influence of powdered soy milk (PSM) as a replacement to non-fat dried milk (CPM). SPSS 17.0 statistical software was used (Salovuo et al., 2005). Separation of means was done using the Tukey HSD (Bower, 1995) and Duncan's multiple range tests (Domagala, 2008). T-tests were used to detect significant differences (de Ancos et al., 2000) on the sensory evaluation results.

## RESULTS AND DISCUSSION

### Physical quality of yoghurt samples

After pasteurization, the milk became relatively thicker. This could be due to the modification of the milk's protein structure brought about by heat treatment (Jayeola et al., 2010). Yoghurt samples fortified at 0.0 and 1.0% SMP were somewhat less thick and pourable. A low amount of total solids could explain this observation (Tamime and Robinson, 2004). Small amounts of whey were seen on the surface of the yoghurts fortified with SMP or NFDM at 0.0 (controls), 1.0 and 2.0% levels. This could suggest that, at concentration below 2.0%, both NFDM and SMP imparted limited water binding capacity. A yoghurt gel, characteristic of commercial yoghurts was observed in the 3.0 and 4.0% fortified samples, regardless of the type of solids fortified.

The data obtained for the total soluble solids (TSS) ranged from 10.73 to 13.12 °Brix (Figure 1). In general, the TSS increased with increase in concentration of both NFDM and SMP yoghurts. The TSS within each fortificant concentration did not significantly ($p<0.05$) differ from each other, regardless of MS addition or fortificant type (Figure 1).

Since, NFDM and SMP have got an almost similar chemical composition (Mian, 2006); their addition did not change the TSS of yoghurt milk base significantly. However, comparisons of TSS values between different levels of fortificant concentration gave significantly ($p<0.05$) different results for both fortificants. This was expected due to difference in concentration of the fortificant used (Pomeranz and Meloan 1995). Khan et al. (2008) reported the TS content (from gravimetric weighing) in 4 brands of commercial yoghurt ranged between 9.10 to 17% which conforms to the 10.73 to 13.12 °Brix range of the present study.

There were no differences ($p<0.05$) in the pH readings of the fortified yoghurts, regardless of the fortificant type or their rate of addition (Table 1). This indicates that the

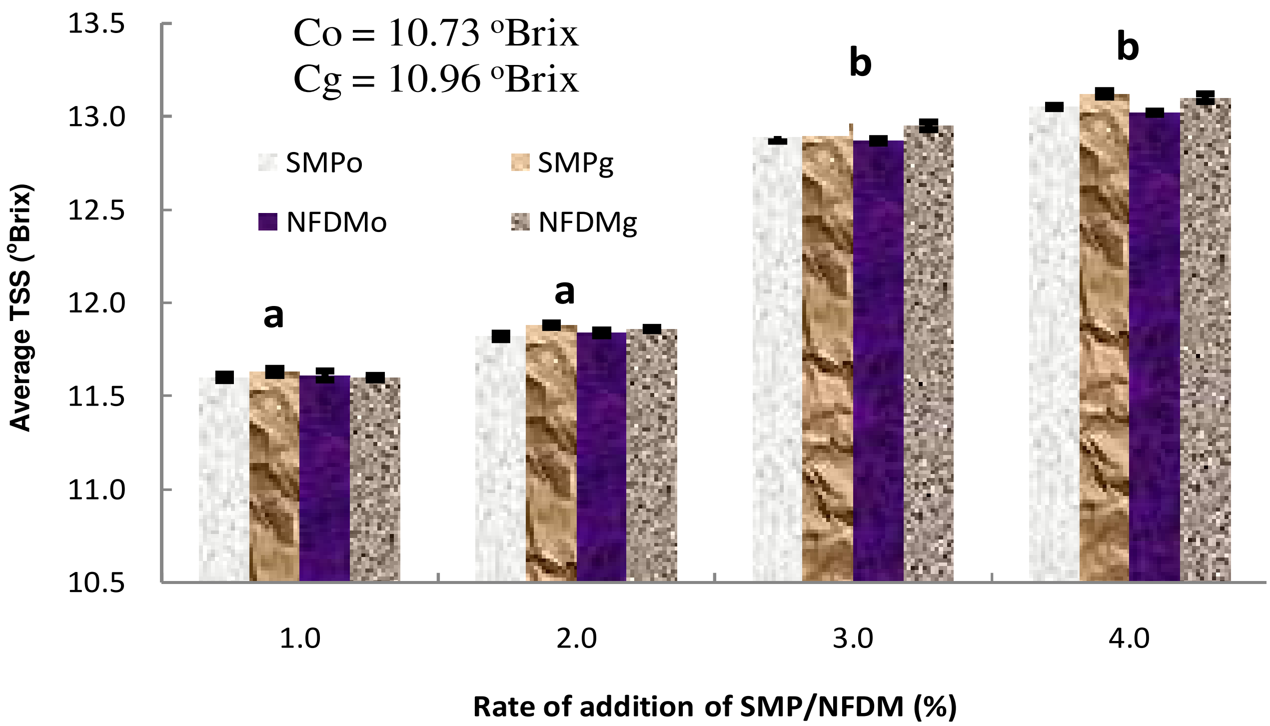


**Figure 1.** Total soluble solids (°Brix) of the yoghurt samples. Co = Control, Cg = Control with stabilizer, SMPo = Soy milk powder, SMPg = Soy milk powder and stabilizer, NFDMo = non-fat dried milk, NFDMg = non-fat dried milk and stabilizer. TSS values written on top inside the plot area are for the controls, that is, Cg and Co. Different alphabets at the top of each usage level indicate significant difference ($p < 0.05$).

**Table 1.** pH, Titratable acidity and viscosity of the yoghurt samples[1].

| Fortificant rate (%) | | Experimental yoghurts | | | | | |
|---|---|---|---|---|---|---|---|
| | | Co | Cg | SMPo | SMPg | NFDMo | NFDMg |
| 0.0 | pH | 4.10 ± 0.01 | 4.12 ± 0.01 | - | - | - | - |
| | TA (%) | 1.31 ± 0.02 | 1.32 ± 0.03 | - | - | - | - |
| | Viscosity (cP) | | | - | - | - | - |
| 1.0 | pH | | | 4.10 ± 0.01 | 4.11 ± 0.01 | 4.11 ± 0.01 | 4.10 ± 0.01 |
| | TA (%) | | | 1.31 ± 0.05 | 1.32 ± 0.08 | 1.32 ± 0.08 | 1.32 ± 0.05 |
| | Viscosity (cP) | | | 1467 ± 9.4 | 1480 ± 16.3 | 1433 ± 9.4 | 1467 ± 9.4 |
| 2.0 | pH | | | 4.12 ± 0.01 | 4.13 ± 0.01 | 4.14 ± 0.01 | 4.12 ± 0.01 |
| | TA (%) | | | 1.32 ± 0.05 | 1.32 ± 0.08 | 1.32 ± 0.05 | 1.33 ± 0.05 |
| | Viscosity (cP) | | | 1480 ± 16.3 | 1500 ± 16.3 | 1493 ± 9.4 | 1553 ± 9.4 |
| 3.0 | pH | | | 4.13 ± 0.01 | 4.15 ± 0.01 | 4.15 ± 0.01 | 4.13 ± 0.01 |
| | TA (%) | | | 1.32 ± 0.09 | 1.32 ± 0.09 | 1.32 ± 0.05 | 1.33 ± 0.05 |
| | Viscosity (cP) | | | 1547 ± 9.4 | 1567 ± 9.4 | 1560 ± 16.3 | 1573 ± 9.4 |
| 4.0 | pH | | | 4.16 ± 0.01 | 4.16 ± 0.01 | 4.15 ± 0.01 | 4.16 ± 0.01 |
| | TA (%) | | | 1.32 ± 0.06 | 1.32 ± 0.05 | 1.33 ± 0.05 | 1.33 ± 0.05 |
| | Viscosity (cP) | | | 1640 ± 16.3 | 1733 ± 9.4 | 1673 ± 9.4 | 1813 ± 16.3 |

[1]Co = control, Cg = control with stabilizer, SMPo = soy milk powder, SMPg = soy milk powder with stabilizer, NFDMo = Non-fat dried milk, and NFDMg = Non-fat dried milk and stabilizer.

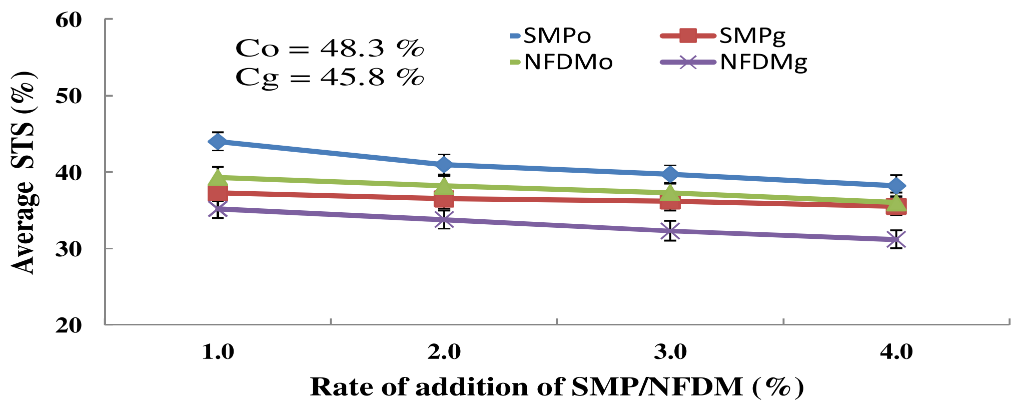


**Figure 2.** Susceptibility to syneresis (%) of the yoghurt samples. Co = control, Cg = control with stabilizer, SMPo = soy milk powder, SMPg = soy milk powder and stabilizer, NFDMo = Non-fat dried milk, NFDMg = Non-fat dried milk and stabilizer. STS values for the control sample are written inside the plot area at the top.

type of fortificant did not alter the rate of acid production by the starter culture. The pH in yoghurt depends on lactic acid starter culture, since each has its own distinctive lactose consumption features and acidification capacities (daCruz et al., 2009).

The pH of control yoghurt was lower than those of SMP and NFDM yoghurts with 4% fortificant. Use of fortificant solids at 4% level might have led to buffering of yoghurt matrix, retarding the pH lowering of the samples in both SMP and NFDM. It is well known that proteins present in the fortificant can act as buffers in food systems by their ability to release or accept free hydrogen atoms (Belitz et al., 2009).

There was no significant difference ($p<0.05$) in the titratable acidity (TA) for most of the yoghurts prepared (Table 1). However, TA in yoghurts without any fortificant (controls – Co, Cg) and 1.0% fortificant (both SMP and NFDM) differed significantly ($p<0.05$) from those fortified at 4.0% using either of the fortificants. NFDM and SMP being rich protein sources, they exert some buffering action stabilizing the acidity of yoghurt systems (Belitz et al., 2009). The TA in 4 brands of commercial yoghurt of the Lahore Market in Pakistan ranged from 1.0 to 1.5% lactic acid (Khan et al., 2008).

The viscosity of experimental yoghurts ranged from 1.47 to 1.81 x $10^3$ cP (Table 1) at 25°C. A consistent trend of increase in viscosity with increase in the rate of addition of SMP and NFDM was observed. Except for the control (0.0) and 1.0% fortified yoghurts, the viscosity differed ($p<0.05$) significantly with varying rate of addition and type of the fortificant used. This relates to the observation in Figure 1 where the TSS increased with increase in the rate of usage of the fortificant. In general, the higher the levels of solids in the yoghurt mix the greater the viscosity/consistency of the end product (Domagala, 2008; Tamime and Robinson, 2004; Cais-Sokolińska et al., 2002).

Usage rate of fortificant at 2.0 and 3.0% levels gave similar viscosities within each subset of fortificant rate of addition, regardless of type of fortificant or the presence of stabilizer type. Presence of stabilizer and the type of fortificant used led to significantly different ($p<0.05$) results for yoghurts fortified at 4.0% level that is, SMP with MS (SMPg-1733 cP) and NFDM with MS (NFDMg-1813 cP) (Table 1). Yoghurt viscosity is directly related to the protein content (Sodini et al., 2005). After exceeding a critical protein level in yoghurt system, the enhancement in the viscosity is probably evident.

The susceptibility to syneresis (STS) of the yoghurts decreased with increase in the rate of addition of the fortificant, irrespective of the fortificant used (Figure 2). This could imply that, free water molecules within the yoghurt matrix were better absorbed with increasing fortificant level (Cais-Sokolińska et al., 2002). Stabilized and NFDM fortified yoghurts (NFDMg) gave significantly different ($p<0.05$) results compared to the STS of stabilized and SMP treated (SMPg) yoghurts, especially when used at 2.0, 3.0 and 4.0% levels. This could be supported by the differences in the TSS composition of such yoghurts (Figure 1). Since the composition and physical properties of proteins in soy milk and skimmed milk are different (Belitz et al., 2009), a corresponding difference in STS is expected when the type of fortificant is varied. STS of whole milk yoghurts drained for a period of 6 h ranged from 43 to 47% (Isanga and Zhang, 2009). The lower values obtained in the current experiment is attributed to the use of low fat milk (Osundahunsi et al., 2007).

The water holding capacity (WHC) of the fortified yoghurts differed significantly ($p < 0.05$) from each other at each level of fortificant used. Generally, stabilized and NFDM fortified yoghurts (NFDMg) gave higher WHCs than their corresponding yoghurts fortified with SMP (SMPg) at all concentration levels (Figure 3). A similar trend was observed in SMP and NFDM fortified yoghurts without MS. These results could be attributed to the difference in the physical properties of the proteins present in SMP and NFDM (Belitz et al., 2009).

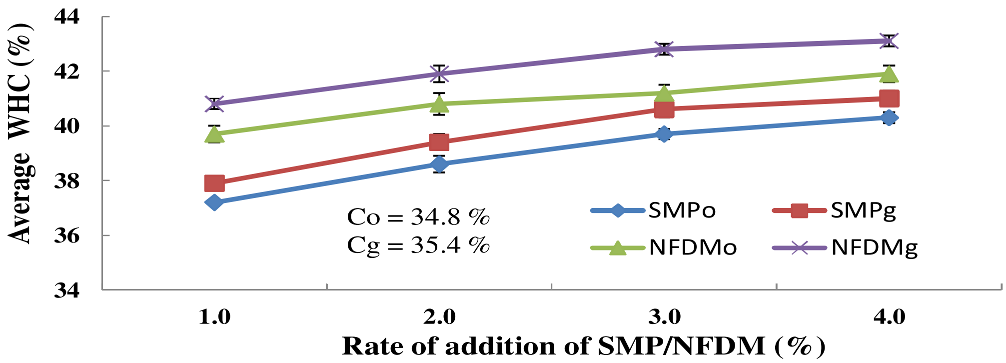


**Figure 3.** Water holding capacity (%) of the yoghurt samples. Co = control, Cg = control with stabilizer, SMPo = soy milk powder, SMPg = soy milk powder and stabilizer, NFDMo = Non-fat dried milk, NFDMg = Non-fat dried milk and stabilizer. WHC values of the control samples are written inside the plot area.

**Table 2.** *L**, *a**, *b** colour parameters of the yoghurt samples[1].

| Fortificant rate (%) | | Sample codes | | | | | |
|---|---|---|---|---|---|---|---|
| | | Co | Cg | SMPo | SMPg | NFDMo | NFDMg |
| 0.0 | *L** | 32.89 ± 0.43 | 36.72 ± 0.05 | - | - | - | - |
| | *a** | -7.8 ± 0.01 | -7.37 ± 0.03 | - | - | - | - |
| | *b** | -3.3 ± 0.06 | -4.36 ± 0.18 | - | - | - | - |
| 1.0 | *L** | - | - | 23.49 ± 0.07 | 33.17 ± 0.01 | 37.98 ± 0.05 | 38.26 ± 0.33 |
| | *a** | - | - | -6.15 ± 0.01 | -7.37 ± 0.02 | -6.44 ± 0.01 | -8.13 ±0 .40 |
| | *b** | - | - | 0.08 ± 0.02 | -1.40 ± 0.06 | -4.15 ± 0.07 | -1.72 ± 0.39 |
| 2.0 | *L** | - | - | 26.98 ± 0.34 | 32.36 ± 0.28 | 37.12 ± 0.12 | 38.12 ± 0.19 |
| | *a** | - | - | -6.46 ± 0.01 | -7.62 ± 0.01 | -6.14 ± 0.05 | -7.04 ± 0.44 |
| | *b** | - | - | 0.08 ± 0.02 | -3.27 ± 0.01 | 2.14 ± 0.02 | -0.31 ± 0.37 |
| 3.0 | *L** | - | - | 28.38 ± 0.25 | 31.66 ± 0.08 | 36.84 ± 0.24 | 37.21 ± 0.19 |
| | *a** | - | - | -6.62 ± 0.16 | -7.24 ± 0.01 | -6.13 ± 0.02 | -7.00 ± 0.25 |
| | *b** | - | - | -0.58 ± 0.05 | -3.31 ± 0.01 | -0.09 ± 0.06 | -0.84 ± 0.55 |
| 4.0 | *L** | - | - | 28.92 ± 0.07 | 31.38 ± 0.30 | 34.20 ± 0.09 | 33.27 ± 0.03 |
| | *a** | - | - | -5.97 ± 0.01 | -7.46 ± 0.02 | -6.51 ± 0.11 | -5.61 ± 0.01 |
| | *b** | - | - | 0.58 ± 0.05 | -1.70 ± 0.01 | 1.26 ± 0.10 | -0.03 ± 0.01 |

[1]Co = control, Cg = control with stabilizer, SMPo = soy milk powder, SMPg = soy milk powder and stabilizer, NFDMo = Non-fat dried milk, and NFDMg = Non-fat dried milk with stabilizer.

Intrinsic factors affecting WHC of food proteins include amino acid composition, protein conformation, and surface polarity/hydrophobicity (Barbut, 1999). Soy protein seemed less effective in binding water, taking into account the extent of syneresis noted in soy yoghurt (Osundahunsi et al., 2007). The role of stabilizer in yoghurt is to bind the water and improve the texture (Thaiudom and Goff, 2003).

There was an increase in the luminosity (*L**) of SMP and NFDM fortified yoghurt with addition of stabilizer at all fortification levels (Table 2). Yoghurts fortified with SMP showed a rise in the *L** value with an increase in its level. The reason could be due to the yellowish colour of SMP compared to the white colour of NFDM. This could have affected the opacity of the resulting yoghurt gels. Changes in colour coordinates can be attributed to the different level of gel opacity which in turn can be related to the casein ratio and their aggregation level (Vargas et al., 2008) in NFDM.

Milk based yoghurt showed a higher lightness *(L*)* than

**Table 3.** Sensory evaluation of yoghurt samples[1]

| Treatment rate of usage of fortificant (%) | Sample code | Acceptability scores | | | |
|---|---|---|---|---|---|
| | | Color | Consistency | Flavor | Overall |
| 0.0 | Co | 5.40 ± 0.78 | 4.40 ± 0.72 | 4.61 ± 1.18 | 3.94 ± 0.83 |
| | Cg | 5.50 ± 0.80 | 4.63 ± 0.70 | 4.69 ± 1.10 | 4.47 ± 0.85 |
| 1.0 | SMPo | 6.00 ± 1.58 | 5.20 ± 1.27 | 5.64 ± 1.27 | 4.19 ± 1.67 |
| | SMPg | 6.06 ± 1.34 | 5.38 ± 1.17 | 4.88 ± 1.41 | 5.38 ± 1.11 |
| | NFDMo | 6.30 ± 0.58 | 6.31 ± 0.98 | 6.36 ± 1.18 | 6.44 ± 0.86 |
| | NFDMg | 7.06 ± 0.90 | 6.50 ± 0.87 | 6.25 ± 0.66 | 6.44 ± 1.00 |
| 2.0 | SMPo | 5.88 ± 1.73 | 5.60 ± 1.38 | 4.63 ± 1.41 | 4.88 ± 1.58 |
| | SMPg | 5.69 ± 1.65 | 6.00 ± 1.25 | 4.56 ± 1.37 | 5.31 ± 0.98 |
| | NFDMo | 6.33 ± 1.48 | 6.38 ± 0.99 | 6.06 ± 0.97 | 6.75 ± 0.90 |
| | NFDMg | 6.75 ± 1.09 | 6.44 ± 0.70 | 6.35 ± 0.98 | 6.44 ± 1.00 |
| 3.0 | SMPo | 5.86 ± 1.05 | 5.38 ± 1.27 | 4.19 ± 1.63 | 4.75 ± 1.20 |
| | SMPg | 6.31 ± 1.36 | 6.13 ± 0.99 | 4.69 ± 1.31 | 5.56 ± 1.41 |
| | NFDMo | 7.00 ± 1.00 | 6.31 ± 0.92 | 5.88 ± 1.50 | 6.63 ± 0.93 |
| | NFDMg | 7.44 ± 0.70 | 7.19 ± 0.95 | 7.00 ± 1.06 | 7.50 ± 0.71 |
| 4.0 | SMPo | 5.00 ± 1.20 | 5.56 ± 1.06 | 3.94 ± 1.60 | 4.69 ± 1.49 |
| | SMPg | 6.25 ± 1.48 | 6.13 ± 1.32 | 4.44 ± 1.58 | 5.00 ± 1.17 |
| | NFDMo | 7.31 ± 0.68 | 7.00 ± 0.87 | 6.38 ± 1.11 | 6.81 ± 0.63 |
| | NFDMg | 7.56 ± 0.70 | 7.44 ± 1.00 | 7.38 ± 1.17 | 7.69 ± 0.85 |

[1]Co = control, Cg = control with stabilizer, SMPo = Yoghurt made with soy milk powder, SMPg = Yoghurt made with soy milk powder and stabilizer, NFDMo = Yoghurt made with Non-fat dried milk, and NFDMg = Yoghurt made with Non-fat dried milk with stabilizer.

the soymilk yogurt (Lee et al., 1990). The values for *a** and *b** parameters tended to increase in SMP fortified yoghurts while in NFDM fortified yoghurts they tend to decrease, especially with increase in the level of fortification. Soy yoghurt displayed increased redness (*a**) and yellowness (*b**) (Cheng et al., 1990). For each fortificant, treatments at 1 and 2% usage level gave significantly different (p<0.05) luminosity values while treatments using 3 and 4% levels were at par with each other.

The whiteness index (WI) of the yoghurts increased with an increase in the rate of usage of NFDM, in case of SMP fortified yoghurt the opposite were observed (Figure 4). The results obtained in this investigation are in agreement with those of Cheng et al. (1990) soy yoghurt enriched with lactose. Since the luminosity (*L**) of NFDM fortified samples increased, while *a** and *b** values decreased (Table 2), WI is expected to decrease. The higher the luminosity values, the higher the opacity and the lower the Chroma, in line with a higher whiteness index (Vargas et al., 2008).

## Sensory evaluation of yoghurt

Consumer responses on colour acceptability showed that the 4% SMPo yoghurt was least acceptable; one made using 4% NFDMg yoghurt was the most acceptable (Table 3). Consumers generally expect a clean white colour in yoghurt which is the case with non-fruit or un-flavored yoghurts (Tamime and Robinson, 2004). The highest WI (Figure 4) was in 4% NFDMg while the least was associated with sample SMPo at 4%. T-tests confirmed that there was no significant difference between the mean scores in NFDMg samples employing 1 and 2% levels. Using t-tests, the observed significant differences (p<0.05) between the mean colour scores of SMPo and NFDMo yoghurts, both at 4% usage rate, was confirmed.

The sensory score for consistency for Co (control) yoghurt was the least (4.40) while 4% NFDMg had the highest consistency score (7.44) (Table 3). This result is supported by maximum viscosity value observed for 4% NFDMg yoghurt compared to all other samples (Table 1). T-tests showed no differences (p<0.05) in the mean scores for consistency for SMPo and NFDMo at 1 and 2% usage levels. SMPg yoghurts had higher mean scores for consistency than NFDMo yoghurts, irrespective of the rate of usage. This could be as a result of presence of stabilizer in them.

The scores for flavor acceptability in SMPo yoghurts were different (p<0.05) from those in NFDMo and NFDMg

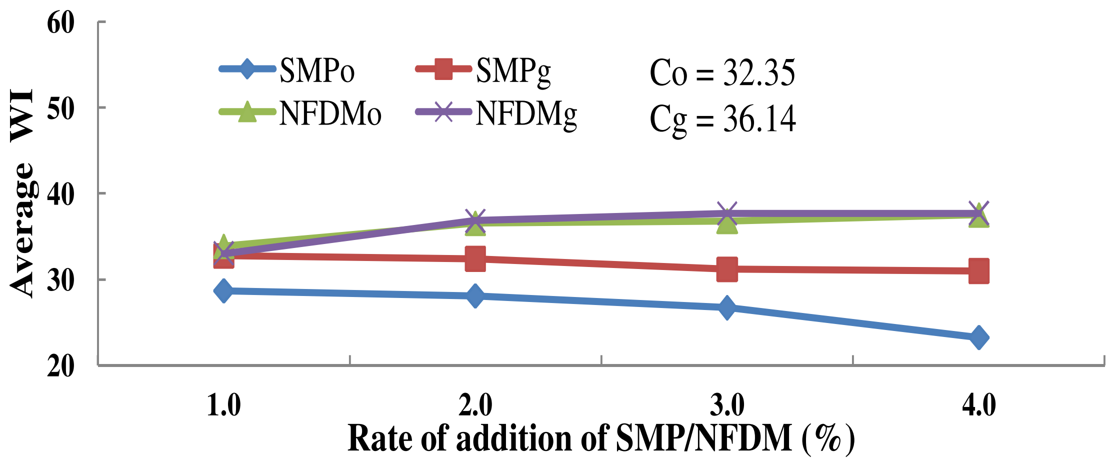


**Figure 4.** Whiteness index (WI) of the yoghurt samples. Co = control, Cg = control with stabilizer, SMPo = soy milk powder, SMPg = soy milk powder and stabilizer, NFDMo = Non-fat dried milk, NFDMg = Non-fat dried milk and stabilizer. WI values for the control samples are written inside the plot area.

treated yoghurts at 2, 3 and 4% levels. Flavor acceptability of the yoghurt samples increased in the order: SMPo<SMPg<NFDMo<NFDMg at any of the usage levels (Table 3). Flavor is a composite attribute involving taste and smell of a product (Meilgaard et al., 1999).

A beany smell and astringent taste normally associated with soy foods could possibly be the reason for lower acceptability of SMPo yoghurts by consumers. The compounds for example, phenolics which may lead to less acceptable flavor of soy milk may have to be extracted before preparing soy milk powder to be used as a fortificant in yoghurt. The stabilizer (MS) could possibly have somewhat masked the negative perceptions on flavor (Kumar and Mishra, 2004).

The incidence of astringency and beany flavor could possibly have augmented with increase in the amount of the SMP in the yoghurt. Polyphenolics for example, phytates and n-hexanal in soymilk interact with mucoprotein in mouth to contribute to astringent taste (Rehman et al., 2007).

The Co yoghurt was the least acceptable, while 4% NFDMg yoghurt was the most acceptable (Table 3). This was mainly due to the highest sensory scores of colour, consistency and flavor associated with 4% NFDMg yoghurt. The yoghurt gel network is strengthened by increasing the protein concentration. Although 4% SMPo yoghurt had higher consistency score than 1% SMPg yoghurt, it had a lower overall acceptability (Table 3).

The negative perception on flavor and color could possibly have resulted in lower overall acceptance by panelists. T-tests showed significantly difference ($p<0.05$) in overall acceptability score between 4% SMPo and 4% NFDMo yoghurt. This could be explained by the fact that, color and flavor were not as favorable in the SMPo yoghurt as was the case with NFDMo yoghurt. The degree of subjectivity in consumer acceptability tests may be very high depending on the individual panelist's preference (Meilgaard et al., 1999). Overall acceptability may or may not be a composite function of individual sensory attributes within a food product. Rehman et al. (2007) pointed out that astringency in soy milk was the main limiting factor to consumer acceptability of soy-based products.

## Conclusion

The study revealed that low fat (2% fat) milk fortified with soy milk powder (protein content 36.5%) at any rate ranging from 1.0 to 4.0% level can produce more acceptable yoghurts than the one made conventionally. However, NFDM when used at such usage levels produced yoghurts of better physical quality than did soy milk powder. The fortification of yoghurt with soy solids using stabilizer is, however, recommended considering the isoflavones and mineral content in soymilk.

Fortification of low fat yoghurt milk base with SMP does not improve the water holding capacity, viscosity, syneresis and whiteness index as much as exerted by NFDM. Although the consistency of yoghurts increased with increased rate of addition of soy solids, the flavor, color and overall acceptance of SMP fortified yoghurts were impaired; NFDM fortified yoghurts were superior to the former.

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