Croatian Journal of Food Science and Technology

journal homepage: www.ptfos.unios.hr/cjfst/

Original scientific paper

DOI: 10.17508/CJFST.2018.10.2.13

Physicochemical properties, colour characteristics, and sensory evaluation of full-cream cow-coconut milk yoghurts

SARAFA ADEYEMI AKEEM*, OLUWAFEMI YERUMOH, OLUWADAMILOLA LEIGH, KEHINDE BAMGBALA, GABRIEL OKEKE, FADEYINMI SOKUNBI, IBRAHIM OLAYIWOLA

University of Ibadan, Faculty of Technology, Department of Food Technology, Ibadan, Nigeria.

ARTICLE INFO

Article history:
Received: November 20, 2017
Accepted: June 26, 2018

Keywords:
Acceptability,
coconut milk,
full-cream powdered cow milk,
quality attributes,
yoghurts

ABSTRACT

Yoghurt is a popular fermented milk product, and milk, like other animal protein sources, is scarce and expensive. This study was therefore designed to explore the potentials of coconut milk and cow milk prepared from full cream powdered milk in the production of yoghurts and to determine the physicochemical, colour, and sensory properties of the yoghurts. Yoghurts were produced from milk blends obtained by mixing full-cream cow milk prepared from powdered milk and coconut milk in five different ratios (90:10, 80:20, 70:30, 60:40, and 50:50), based on a completely randomized design, with 100% full-cream cow milk yoghurt as the control. The physicochemical, colour, and sensory properties of the yoghurts were evaluated. Significant differences ($p<0.05$) existed among the physicochemical properties and colour characteristics of the yoghurts. However, all the evaluated sensory parameters of the yoghurts were not significantly different from one another. Acceptable yoghurts that were highly comparable to the control (100% full-cream milk yoghurt) were produced from full-cream cow milk and coconut milk at the ratios of 90:10 and 70:30. This study demonstrated that delicious and acceptable yoghurts could be prepared from full-cream powdered milk and coconut milk, which could be particularly advantageous to people that are moderately lactose intolerant and those in resource poor settings.

Introduction

Yoghurt is a fermented dairy product obtained through an anaerobic fermentation of lactose in milk by relevant micro-organisms (Tull, 1996). The microbial fermentation process resulted in the production of acetaldehyde, diacetyl, lactic, and acetic acids, which are responsible for the characteristic flavour of yoghurts (Reed, 1982). Yoghurt, apart from being a probiotic carrier, is a rich and known source of quality protein, calcium, milk fat, potassium, magnesium, and vitamins B_2, B_6, and B_{12} (Staffolo et al., 2004). The fact that most of the lactose in milk precursor is being converted to lactic acid by the bacterial culture during fermentation makes yoghurt suitable for people who are moderately lactose intolerant (Heyman, 2000). Apart from being nutritionally rich in protein, vitamins, and minerals, yoghurts offer several health benefits, some of which include the prevention of antibiotic associated diarrhoea and helping with a variety of gastro-intestinal conditions (Mazahreh and Ershidat, 2009). Other notable roles attributable to probiotic bacteria in dairy fermentations include the production of flavour compounds such as acetaldehyde in yoghurt and cheese, and other metabolites such as extracellular polysaccharides that will provide a product with the organoleptic properties desired by the consumer, the preservation of the milk by the generation of lactic acid and probably other antimicrobial compounds, the provision of special therapeutic or prophylactic properties against cancer, and the improvement of the nutritional value of food, this for example includes the synthesis of vitamins or the release of free amino acids (Fernandes et al., 1987; Gilliland, 1990; O' Sullivan et al., 1992), and control of serum cholesterol levels (Lin et al., 1989).

*Corresponding author E-mail: akeemsarafa@yahoo.com

Coconut (*Cocos nucifera*), a versatile fruit of the family *Arecaceae*, is found in most regions of the world and forms part of the daily diets of many people, particularly in Northern South America, the Caribbean, and Southeast Asia (Kayode et al., 2017). The aqueous emulsion of the coconut kernel prepared by pressing fresh coconut kernel by hand or in a machine is known as coconut milk. Unlike cow milk, which has almost equal amounts of oil and proteins, coconut milk has about ten times more oil than proteins (Hagenmaier et al., 1974). Coconut milk is nutritionally rich in dietary protein, energy, calcium, and fat such as myristic acid, oleic acid, lauric acid, linoleic acid, palmitic acid, and capric acid (Belewu and Belewu, 2007). It is also a rich source of vitamins and minerals (Nieuwentus and Nieuwelink, 2002). The use of coconut milk in various food industries, such as confectionaries, bakeries, biscuits and ice cream, to enhance flavour and taste of food products is being practiced worldwide (Persley, 1992).

Yoghurt is traditionally made from animal milk, especially cow milk. Milk is commonly available in powdered form because of the high moisture content and consequently short shelf-life of raw milk. However, over the years, milk from plant sources is being explored as animal milk substitute in the production of dairy products including yoghurt. This development was necessitated by a wide range of reasons which include allergies and affordability by the consumers (Masamba and Ali, 2013). A preliminary study has reported the production of delicious and nutritious yoghurts with the incorporation of coconut milk (Imele and Atemnkeng, 2001). Belewu et al. (2005) and Kolapo and Olubamiwa (2012) have also documented the combination of soymilk and coconut milk in the preparation of soy-coconut yoghurts. Likewise, yoghurts produced from tigernut (50%) and coconut (50%) milk have been shown to be acceptable based on the evaluated sensory parameters (Belewu et al., 2010). An acceptable symbiotic functional yoghurt with both probiotic and prebiotic properties has been produced from powdered full-cream milk and coconut cake (Ndife et al., 2014). Sanful (2009) has also shown that an acceptable yoghurt based on sensory attributes could be produced from skimmed cow-coconut milk. These showed that while limited data is available on skimmed powdered-coconut milk yoghurt, no substantial data has been reported on full-cream powdered-coconut milk yoghurt. Therefore, the present study was designed to determine the physicochemical properties, colour characteristics and sensory attributes of full-cream powdered cow-coconut milk yoghurts at different levels of coconut milk substitution, in comparison to 100% full-cream powdered cow milk yoghurt.

Materials and methods

Raw materials procurement

The coconut fruit and commercial full-cream powdered (Peak) milk were purchased from 'Bodija' market, Ibadan in Nigeria. Yogourmet freeze-dried starter culture (KetoNaija, Plot 352, Durbar Road, Anuwo Odofin, Lagos, Nigeria) containing *Streptococcus thermophillus* and *Lactobacillus delbrueckii subsp. bulgaricus* (1:1) was also purchased from a chemical supermarket in Ibadan. The materials were brought to the Department of Food Technology, University of Ibadan in Nigeria for storage, processing, and analyses. Distilled water was strictly used throughout the experiment.

Preparation of cow milk

Cow milk was prepared by weighing approximately 225 g of full cream milk powder (Peak) into a measuring cylinder containing 1500 mL of distilled water and then stirred thoroughly to ensure homogeneity.

Extraction and preparation of coconut milk

The coconut milk was prepared as described by Kolapo and Olubamiwa (2012) with little modifications. Coconut seed was cracked manually and the coconut meat removed with a sharp knife. The brown part of the coconut meat was gently scraped off. The meat was cut into smaller pieces to facilitate blending. Three hundred grams (300 g) of white coconut meat were blended with 600 mL of distilled water. The slurry obtained was then sieved with double layers of cheese cloth. The filtrate obtained is termed coconut milk.

Preparation of full-cream cow-coconut milk blends

Milk blends were produced by mixing cow milk and coconut milk together in different proportions, as shown in Table 1.

Preparation of full-cream cow-coconut milk yoghurts

About 8% (24 g) of sugar was added to each of the milk blends. The milk blends were heated separately to a temperature of 80 °C for 30 minutes.

Table 1. Milk blends and their proportions

Sample Codes	Full-cream cow milk (mL)	Coconut milk (mL)	Proportions (cow milk:coconut milk)
A	300	0	100:0
B	270	30	90:10
C	240	60	80:20
D	210	90	70:30
E	180	120	60:40
F	150	150	50:50

The blends were subsequently placed in a water bath to cool down to 40 °C, after which each of the blends was inoculated with 3% (1.50 g) of the starter culture (*Streptococcus thermophillus* and *Lactobacillus bulgaricus* at a ratio of 1:1). All the inoculated milk blends were poured into different plastic cups and then incubated at 40 °C for 12 hours to induce fermentation and curd formation. The yoghurts were placed in a refrigerator at 4 °C and subjected to analyses within 12 hours after production.

Physicochemical analyses of full-cream cow-coconut milk yoghurts

Determination of moisture content and total solids

The moisture content and total solids (TS) of the yoghurts were determined according to AOAC (2000). Initially, an empty crucible was weighed, and 2.0 g of each sample was transferred into it and reweighed. The content of the crucible was subjected to continuous drying in a hot air drying oven at 105 °C until a constant weight was obtained. Each crucible containing the sample was cooled in a desiccator and then weighed. The percentage of moisture and the total solids were calculated using equations 1 and 2, respectively.

$$\text{Moisture content (\%)} = \frac{Initial\ weight - final\ weight \times 100}{Initial\ weight\ of\ sample} \quad (1)$$

$$\text{Total solids} = 100 - \text{moisture content} \quad (2)$$

Determination of pH

A Hanna HI-2211 Bench Top pH and mV (Hanna Instruments Ltd, Eden Way Pages Industrial Park, Leighton Buzzard, Bedfordshire LU 4AD, UK) meter was used to determine the pH of the yoghurts produced. The pH meter was switched on and allowed to warm up for about 15 min. The pH meter was calibrated with standard buffers (pH 4.0 and 7.0) at room temperature (25±2 °C). The electrode of the meter was cleaned, dried, and dipped into each yoghurt sample in a 50 mL beaker and the reading was recorded.

Determination of total titratable acidity

Titratable acidity in terms of the % of lactic acid was measured according to Hamad et al. (2017). Approximately 2.0 g of the sample was dissolved in a beaker containing 10 mL of distilled water and about three drops of 0.5% phenolphthalein were added. The mixture was titrated against 0.1 N NaOH until the solution turned pink. The amount of NaOH used was recorded and the total titratable acidity was calculated as shown in equation 3.

$$\text{Titratable acidity (\% lactic acid)} = \frac{titre\ value \times 0.009 \times 100}{weight\ of\ sample} \quad (3)$$

Colour determination

The colour of yoghurt samples was determined by the Minolta Colour meter CR-410 model (Minolta Co., Osaka, Japan). The calibration of the meter was achieved using a white standard calibration plate (L*= 92.95, a*= -4.86, b* = 6.65). The CIE L*, a*, b* and ΔE values of the yoghurts were obtained directly from the meter. Colour L* denotes the degree of lightness on a scale of 0–100. The parameter a* could be positive (redness) or negative (greenness) and the chromaticity coordinate b* could also be positive (yellow) or negative (blue) (Soysal, 2004), while the ΔE measures the total colour difference with respect to the standard. The hue angle (h*), chroma (C*), and the whiteness index (WI) were calculated based on equations 4, 5, and 6, respectively (Rhim et al., 1999; Pathare et al., 2013).

$$\text{Hue angle, } h^* = \tan^{-1}\left(\frac{b*}{a*}\right) \quad (4)$$

$$\text{Chroma, } C^* = \sqrt{a*^2 + b*^2} \quad (5)$$

$$\text{Whiteness index, WI} = \sqrt{(100 - L*)^2 + a*^2 + b*^2} \quad (6)$$

Sensory evaluation of full-cream cow-coconut milk yoghurts

The sensory quality parameters, such as sourness, appearance, mouthfeel, taste, and overall acceptability, of the six (6) yoghurt samples were evaluated by 20 member panellists comprising of both students and staff members of the Faculty of Technology, University of Ibadan who regularly consume yoghurts. The panellists were presented with the coded yoghurt samples and drinkable water to rinse their mouths after tasting each sample. The panellists were instructed to score the coded samples based on a 9-point hedonic scale with 1 as dislike extremely and 9 as like extremely.

Statistical analysis

All analyses were conducted in triplicates. All the data obtained was subjected to one way analysis of variance (ANOVA) and the difference among the means was determined using the Duncan multiple range test ($p<0.05$). Data analyses were carried out using the Statistical Package for Social Sciences (SPSS) Version 20.0 (SPSS Inc., Chicago, IL USA) and the results were presented as mean with standard deviation.

Results and discussion

Physicochemical properties of full-cream cow-coconut yoghurts

The physicochemical properties of full-cream cow-coconut milk yoghurts are presented in Table 2. The substitution of coconut milk for cow milk at various levels resulted in irregular changes in the moisture content, total solids, pH, and titratable acidity of the yoghurts. The moisture content of the yoghurts ranged from 84.24% for sample E (60:40) to 87.65% for sample B (90:10). This was slightly higher than the range of values (80.10-85.23%) reported by Ndife et al. (2014) for milk-based yoghurts enriched with coconut cake. The higher moisture content obtained for yoghurt samples in this study could be attributed to the higher moisture content and lower dry matter content of coconut milk compared to coconut cake. The addition of coconut milk up to the 30% level increased the moisture content of the yoghurts, which decreased with the further increase in the level of coconut milk substitution. The decrease in moisture contents of coconut milk substituted yoghurts agreed with the assertion of Sanful (2009) that skimmed cow milk contained more water than pure coconut milk yoghurt. However, the moisture contents of the yoghurts were significantly different ($p<0.05$) from one another.

The total solids content is an index of the dry matter content of the yoghurt samples (Belewu et al., 2010; Khalifa et al., 2011). The total solids recorded for the yoghurts ranged from 12.35 to 15.76% for sample B (90:10) and E (60:40), respectively. These values were within the range of values (10.30-18.50%) reported by Belewu et al. (2010) for cow, coconut, tigernut, and soybean milk mixture yoghurts. Comparable values of 14.62-16.13% had also been reported for bio-yoghurts made using the ABT (*L. acidophilus, B. bifidum*, and *S. thermophiles*) culture, cow milk, and coconut milk (El-Kadi et al., 2017). Unlike the moisture content, the total solids of the yoghurts initially decreased with the inclusion of coconut milk. However, the total solids of the full-cream cow-coconut milk yoghurts increased with the increase in the level of coconut milk substitution, except for sample F (50:50). The total solids of the yoghurts were also significantly different ($p<0.05$) from one another.

The pH of the yoghurts ranged from 3.90 to 4.15, while the titratable acidity ranged from 0.74 to 1.38%. The range of values obtained for the pH of the yoghurts was similar to 3.90-4.30 reported for coconut-tigernut milk yoghurts and comparable to 4.20-4.40 reported for skimmed cow milk powder-coconut milk yoghurts by Akoma et al. (2000) and Sanful (2009), respectively. The pH values of the yoghurts in this study were within the acceptable limit (<4.50) recommended by the Food Standard Code for safe yoghurt (Donkor et al., 2006). Coconut milk substitution generally decreased the pH but increased the titratable acidity of the full-cream cow-coconut milk yoghurts significantly ($p<0.05$). This inverse relationship between pH and titratable acidity had been observed by earlier researchers (Kayode et al., 2017). The total titratable acidities of the yoghurts were significantly different ($p<0.05$) from one another. The values obtained for pH and titratable acidity indicated that the yoghurts were acidic, and this could be beneficial in the inhibition of pathogenic and spoilage micro-organisms, as well as responsible for the sourness of the yoghurts. Akoma et al. (2006) attributed such acidity in *kunun zaki* to the production of lactic acid by some species of lactic acid bacteria during the fermentation process.

Colour attributes of full-cream cow-coconut milk yoghurts

Colour is an important quality parameter in food industries, owing to its direct relationship with the consumer's choice and preferences. Colour is the first contact perceived as a measure of quality and could greatly influence the consumer's acceptability of food products. Colour of a food material is influenced by microbiological, biochemical, chemical, and physical changes that occur during physiological processes, postharvest handling, and processing (Pathare et al., 2013).

Table 2. Physicochemical properties of full-cream cow-coconut milk yoghurts

Sample	Moisture (%)	Total solids (%)	pH	TTA (%)
A (100:0)	86.75±0.02^{d}	13.26±0.02^{c}	4.15±0.04^{a}	0.74±0.03^{f}
B (90:10)	87.65±0.01^{a}	12.35±0.01^{f}	3.92±0.01^{d}	0.93±0.16^{e}
C (80:20)	87.56±0.03^{b}	12.44±0.03^{e}	3.90±0.02^{d}	1.15±0.03^{c}
D (70:30)	86.94±0.04^{c}	13.06±0.04^{d}	3.94±0.02^{d}	1.06±0.03^{d}
E (60:40)	84.24±0.01^{f}	15.76±0.01^{a}	4.04±0.01^{b}	1.38±0.04^{a}
F (50:50)	86.48±0.03^{e}	13.52±0.03^{b}	3.98±0.04^{c}	1.19±0.03^{b}

Mean values with different superscript in each column are significantly (p<0.05) different from one another. TTA = Total titratable acidity, A = 100% full cream cow milk yoghurt, B = 90% full-cream cow milk + 10% coconut milk yoghurt, C = 80% full-cream cow milk + 20% coconut milk yoghurt, D = 70% full-cream cow milk + 30% coconut milk yoghurt, E = 60% full-cream cow milk + 40% coconut milk yoghurt, F = 50% full-cream cow milk + 50% coconut milk yoghurt

The colour of food products could be indirectly used to measure other quality attributes such as flavour, sensory, nutritional, and pigments, due to its simplicity and good correlation with other physicochemical properties (Pathare et al., 2013). The L* values of the yoghurts ranged between 68.78 for sample B (90:10) and 82.59 for sample E (60:40). It was observed that no significant difference existed between the L* values of sample D (70:30) and the control yoghurt sample (100:0). L* is an index of luminosity (Granato and Masson, 2010) and hence, the higher the L* value the lighter the sample on a scale between black and white.
The colour a* ranged from -8.36 (sample E) to -7.25 (sample B), while colour b* ranged from 9.41 (sample A) to 13.91 (sample E). The negative values obtained for the parameter a* indicated a green colouration of the yoghurts, while the positive values recorded for parameter b* indicated a yellow colouration of the yoghurts. The observed greenish-yellow colour of full-cream cow milk yoghurt could be attributed to the presence of coloured nutrients such as riboflavin (vitamin B_2) in milk, while the yellow colour could also be the result of the presence of carotenoid pigments such as beta-carotene in the fat globules of the milk (McGill University Office for Science and Society, 2017). No significant differences existed among the a* values of samples A (control), C (80:20), and F (50:50). The full-cream cow-coconut milk yoghurts had significantly (p<0.05) higher b* values (yellow colour) than the control (full-cream milk yoghurt). This high yellowness index may be attributed to the presence of pigments such as carotenoids in the oil films formed on the surface of full-cream cow-coconut milk yoghurts. This is plausible, since coconut had been reported to be very rich in oil (Hagenmaier et al., 1974), which composed predominately of medium-chain fatty acids (MCFA) that could help in lowering the risk of both atherosclerosis and heart diseases (Imele and Atemnkeng, 2001; Belewu et al., 2010).
The hue angle (h*) of the yoghurts ranged between -59.44 and -49.84, with sample A (control) having significantly (p<0.05) higher value than the full-cream cow-coconut milk yoghurts. The hue angle is used to differentiate between a particular colour with reference to grey colour with the same lightness and a higher hue angle denotes a lesser yellow character in the sample (Pathare et al., 2013). Hence, the yellowness of the control yoghurt was lower than those of the full-cream cow-coconut milk yoghurts. The chroma (C*), which measures the degree of colourfulness of the yoghurts, ranged from 12.32 for sample A (control) to 16.23 for sample E (60:40). A higher chroma value indicates a higher colour intensity that will be perceived by humans (Pathare et al., 2013). The total colour difference (ΔE) is an indication of the colour difference between the sample and the standard plate (Rhim et al., 1999). The total colour difference of the yoghurts ranged from 13.14 to 24.55. Based on the Adekunte et al. (2010) method of classifying differences in perceivable colour [very distinct ($\Delta E > 3$), distinct ($1.5 < \Delta E < 3$), and small difference ($1.5 < \Delta E$)], samples B (90:10), E (60:40), and F (50:50) were very distinct, sample C (80:20) was distinct, while sample D (70:30) was slightly different from the control yoghurt (sample A). The whiteness index (WI), which measures the overall whiteness of the food product or its deviation from the white colour, ranged from 66.36 to 76.19 for samples B (90:10) and E (60:40), respectively. It was observed that while 10% coconut milk substitution significantly decreased the whiteness index, 40% and 50% coconut milk substitutions significantly increased the whiteness index of the yoghurts.

Sensory properties of full-cream cow-coconut milk yoghurts

Table 4 shows the sourness, appearance, mouthfeel, taste, and overall acceptability of the full-cream cow-coconut milk yoghurts in comparison with the control (full-cream cow yoghurt) as scored by the panellists. Interestingly, no significant difference existed among all the sensory parameters evaluated. This was similar to the findings of Sanful (2009) that the yoghurt produced from skimmed cow milk did not differ from those produced from coconut and cow milk composites in all sensory quality attributes.

Table 3. Colour characteristics of full-cream cow-coconut milk yoghurts

Sample	L*	a*	b*	h*	C*	ΔE	WI
A (100:0)	73.06±0.50^{bc}	-7.94±0.07^{c}	9.41±0.07^{f}	-49.84±0.04^{a}	12.32±0.09^{e}	20.32±0.47^{bc}	70.37±0.42^{b}
B (90:10)	68.78±3.00^{d}	-7.25±0.36^{a}	10.14±0.49^{e}	-55.19±1.22^{b}	12.47±0.61^{e}	24.55±2.87^{a}	66.36±2.59^{c}
C (80:20)	75.35±0.56^{b}	-7.82±0.07^{bc}	11.86±0.11^{c}	-56.59±0.02^{c}	14.21±0.13^{c}	18.60±0.49^{c}	71.55±0.42^{b}
D (70:30)	72.29±1.13^{c}	-7.56±0.13^{b}	10.57±0.18^{d}	-54.43±0.01^{b}	12.99±0.22^{d}	21.21±1.06^{b}	69.39±0.94^{b}
E (60:40)	82.59±0.96^{a}	-8.36±0.09^{d}	13.91±0.17^{a}	-59.01±0.04^{d}	16.23±0.19^{a}	13.14±0.62^{d}	76.19±0.56^{a}
F (50:50)	81.22±0.16^{a}	-7.94±0.03^{c}	13.45±0.04^{b}	-59.44±0.01^{d}	15.62±0.05^{b}	13.90±0.12^{d}	75.57±0.10^{a}

Mean values with different superscript in each column are significantly ($p<0.05$) different from one another. L* = Colour lightness, a* = Red (+)/ green (−), b* = Yellow (+)/ blue (−), h* = Hue angle, C* = Chroma, ΔE = Total colour difference, WI = Whiteness index, A = 100% full-cream cow milk yoghurt, B = 90% full-cream cow milk + 10% coconut milk yoghurt, C = 80% full-cream cow milk + 20% coconut milk yoghurt, D = 70% full-cream cow milk + 30% coconut milk yoghurt, E = 60% full-cream cow milk + 40% coconut milk yoghurt, F = 50% full-cream cow milk + 50% coconut milk yoghurt.

Table 4. Mean sensory scores of full-cream cow-coconut milk yoghurts

Sample	Sourness	Appearance	Mouthfeel	Taste	Overall Acceptability
A (100:0)	6.35±1.60^{a}	6.50±1.73^{a}	6.65±1.46^{a}	6.45±1.23^{a}	6.65±1.31^{a}
B (90:10)	6.10±1.55^{a}	6.55±1.73^{a}	6.55±1.36^{a}	6.45±1.61^{a}	6.55±1.54^{a}
C (80:20)	5.85±1.63^{a}	5.80±2.40^{a}	6.05±1.73^{a}	6.20±1.96^{a}	6.20±1.94^{a}
D (70:30)	6.50±1.19^{a}	7.00±1.41^{a}	6.45±1.47^{a}	6.45±1.64^{a}	6.55±1.54^{a}
E (60:40)	5.40±1.79^{a}	6.25±2.00^{a}	5.90±1.86^{a}	5.85±1.81^{a}	6.00±1.75^{a}
F (50:50)	5.60±1.60^{a}	6.55±1.91^{a}	5.90±1.62^{a}	5.75±1.62^{a}	5.90±1.68^{a}

Mean values with different superscript in each column are significantly ($p<0.05$) different from one another. A = 100% full-cream cow milk yoghurt, B = 90% full-cream cow milk + 10% coconut milk yoghurt, C = 80% full-cream cow milk + 20% coconut milk yoghurt, D = 70% full-cream cow milk + 30% coconut milk yoghurt, E = 60% full-cream cow milk + 40% coconut milk yoghurt, F = 50% full-cream cow milk + 50% coconut milk yoghurt.

The sourness mean scores of the yoghurts ranged from 5.40 to 6.35 for sample E (60:40) and the control sample (100:0), respectively. Sourness is a desirable property which had been attributed to the production of lactic acids, acetaldehyde, acetic acid, and diacetyl from lactose by the fermenting organisms (Reed, 1982). The appearance of a food material which entails many other attributes, including shape, size, mass, texture, colour, and gloss, is one of the major factors used by consumers to evaluate quality (Pathare et al., 2013). In terms of the appearance, sample C (80:20) had the lowest mean score (5.80) while sample D (70:30) had the highest mean score (7.00). The highest mean score (6.65) for mouthfeel was recorded for the control sample (A), though the value was closely followed by those of samples B (6.55) and D (6.45), while the mean taste scores (6.45) of the three yoghurt samples were the same. The mouthfeel of yoghurt is directly related to texture (viscosity) and consistency, and Staffolo et al. (2004) have reported the mouthfeel of yoghurts to be affected by enrichment with fibre. The lower score ratings obtained for mouthfeel of full-cream cow-coconut milk yoghurts in the present study may be due to their poor consistency (flowing nature), which could be attributable to the coconut milk substitution. Similar observation has been reported for yoghurts produced from full-cream powdered milk and coconut cake (Ndife et al., 2014). The overall acceptability measures the consumers' degree of preference in relation to the control sample or samples of the same category. Like the mouthfeel, the highest overall acceptability mean score (6.65) recorded for the control sample (A) was closely followed by those for samples B (6.55) and D (6.55). The sensory evaluation of the yoghurts indicated that highly acceptable yoghurts could be produced from milk blends containing full-cream cow milk prepared from powdered milk and coconut milk at the ratios of 90:10 and 70:30.

Conclusion

Yoghurts were successfully produced from full-cream powdered cow milk and coconut milk. Partial substitution of cow milk with coconut milk resulted in the production of yoghurts with varying physicochemical and colour attributes. Though there was no significant difference among the sensory parameters of the yoghurts according to the panellists' evaluation, samples B (90:10) and D (70:30) were highly accepted based on the mean sensory scores of the parameters. Conclusively, while none of the yoghurts had a mean score below 5.40 (neither like nor dislike), highly acceptable yoghurts comparable to control (full-cream cow milk yoghurt) were produced from milk blends containing full-cream cow milk prepared from powdered milk and coconut milk at the ratios of 90:10 and 70:30. This study showed that delicious and acceptable yoghurts could be produced from full-cream powdered milk and coconut milk, which could be advantageous, especially to people who are moderately lactose intolerant and those in resource poor settings.

References

Adekunte, A., Tiwari, B., Cullen, P., Scannell, A., O'Donnell, C. (2010): Effect of sonication on colour, ascorbic acid and yeast inactivation in tomato juice. *Food Chem.* 122 (3), 500–507. https://dx.doi.org/10.1016/j.foodchem.2010.01.026.

Akoma, O., Elekwa, U.O., Afodunrinbi, A.T., Onyeukwu, G.C. (2000): Yoghurt from coconut and tigernuts. *J. Food Technol. Afr.* 5, 132-134.

AOAC (2000): Official Methods of Analysis, (17th ed.) Washington, DC, USA: Association of Official Analytical Chemists International.

Belewu, M.A., Belewu, K.Y. (2007): Comparative physico-evaluation of tiger-nut, soybean and coconut milk sources. *Int. J. Agric. Biol*. 9, 785-787.

Belewu, M.A., Belewu, K.Y., Bamidele, R.A. (2010): Cyper-coconut yoghurt: preparation, compositional and organoleptic qualities. *Afr. J. Food Sci. Technol.* 1(1), 010-012.

Belewu, M.A., Belewu, K.Y., Olatunji, S.A. (2005): Soy-coconut yoghurt: Preparation, composition and organoleptic properties. *Bio. Sci. Res. Bull*. 21, 129-37.

Donkor, N.O., Henriksson, A., Vasiljevic, T., Shah, N. (2006): Effect of acidification on the activity of probiotics in yoghurt during cold storage. *Int. Dairy J.* 16, 1181–1189. https://dx.doi.org/10.1016/j.idairyj.2005.10.008.

El-Kadi, S.L., Ismail, M.M., Hamad, M.F., Zidan, M.S. (2017): Chemical and microbial characterizations of bio-yoghurt made using ABT culture, cow milk and coconut milk. *EC Microbiol.* 5 (3), 109-124.

Fernandes, C.F., Shahani, K.M., Amer, M.A. (1987): Therapeutic role of dietary lactobacilli and lactobacillic fermented dairy products. *FEMS Microbiol. Rev.* 46 (3), 343-356. https://dx.doi.org/10.1111/j.1574-6968.19877.tb02471.x.

Gilliland, S. E. (1990): Health and nutritional benefits from lactic acid bacteria. *FEMS Microbiol. Lett.* 87 (1-2), 175-188. https://dx.doi.org/10.1016/0378-1097(90)90705-u.

Granato, D., Masson, M.L. (2010): Instrumental color and sensory acceptance of soy-based emulsions: a response surface approach. *Ciência e Tecnologia de Alimentos* 30 (4), 1090–1096. https://dx.doi.org/10.1590/S0101-20612010000400039.

Hagenmaier, R., Mattil, K.F., Cater, C.M. (1974): Dehydrated coconut skim milk as a food product: Composition and functionality. *J. Food Sci.* 39 (1), 196-199. https://dx.doi.org/10.1111/j.1365-2621.1974.tb01021.x.

Hamad, M.F., Ismail, M.M., Elraghy, E.M. (2017): Impact of addition tamr and honey on chemical composition, starter activity and rheological characteristics of goat's milk. *World J. Food Sci. Technol.* 1 (1), 1-6. https://dx.doi.org/10.11648/j.wjfst.20170101.11.

Heyman, M. (2000): Effect of lactic acid bacteria on diarrheal diseases. *J. Am. Coll. Nutr*. 19 (2), 137-146.

Imele, H., Atemnkeng, A. (2001): Preliminary study of the utilization of coconut in yoghurt production. *J. Food Technol. Afr.* 6 (1), 11-12. https://dx.doi.org/10.4314/jfta.v6i1.19276.

Kayode, R.M., Joseph, J.K., Adegunwa, M.O., Dauda, A.O., Akeem, S.A., Kayode, B.I., Babayeju A.A., Olabanji, S.O. (2017): Effects of addition of different spices on the quality attributes of tiger-nut milk (*kunun-aya*) during storage. *J. Microbiol. Biotechnol. Food Sci.* 7 (1), 1-6. https://dx.doi.org/10.15414/jmbfs.2017.7.1.1-6.

Khalifa, M.E.A., Elgasim, A.E., Zaghloul, A.H., Maufouz, M.B. (2011): Application of inulin and mucilage as stabilizers in yoghurt production. *Am. J. Food Technol.* 6 (1), 31-39. https://dx.doi.org/10.3923/ajft.2011.31.39.

Kolapo, A.L., Olubamiwa, A.O. (2012): Effect of different concentrations of coconut milk on the chemical and sensory properties of soy-coconut milk based yoghurt. *Food Public Health* 2 (4), 85-91. https://dx.doi.org/10.5923/j.fph.20120204.01.

Lin, S.Y., Ayres, J.W., Winkler, W.Jr., Sandine, W.E. (1989): Lactobacillus effects on cholesterol: in vitro and in vivo results. *J. Dairy Res.*72 (11), 2885-2889. https://dx.doi.org/10.3168/jds.S0022-0302(89)79439-x.

Masamba, K.G., Ali, L. (2013): Sensory quality evaluation and acceptability determination of yoghurt made from cow, goat and soy milk. *Afr. J. Food Sci. Technol.* 4 (3), 44-47.

Mazahreh, A.S., Ershidat, M.O. (2009): The benefits of lactic acid bacteria in yoghurt on the gastrointestinal function and health. *Pak. J. Nutr.* 8 (9), 1404-1410. https://dx.doi.org/10.3923/pjn.2009.1404.1410.

McGill University Office for Science and Society (2017): *Why is milk white and not green like grass?* https://www.mcgill.ca/oss/article/general-science-you-asked/why-milk-white-and-not-green-grass. Accessed June 22, 2018.

Ndife, J., Idoko, F., Garba, R. (2014): Production and quality assessment of functional yoghurt enriched with coconut. *Int. J. Nutr. Food Sci.* 3 (6), 545-550. https://dx.doi.org/10.11648/j.ijnfs.20140306.19.

Nieuwentus, R., Nieuwelink, J. (2002): Agrodok Series No. 10 CTA: The Netherlands, pp. 28-30.

O'Sullivan, M.G., Thorton, G., O' Sullivan, G.C., Collins, J.K. (1992): Probiotic bacteria: myth or reality. *Trends Food Sci. Technol. J.* 3, 309-314. https://dx.doi.org/10.1016/S0924-2244(10)80018-4.

Pathare, P.B., Opara, U.L., Al-Said, F.A. (2013): Colour measurement and analysis in fresh and processed foods: A Review. *Food Bioprocess Technol.* 6, 36–60.

Persley, J.G. (1992): Replanting of the tree of life, Wallingford, Oxon: CAB International, pp. 38-40.

Reed, G. (1982): Industrial Microbiology (4th ed.). Prescot and Dunn's (Eds.), London , UK: Macmillan pub., pp. 145-173.

Rhim, J., Wu, Y., Weller, C., Schnepf, M. (1999): Physical characteristics of a composite film of soy protein isolate and propylene-glycol alginate. *J. Food Sci.* 64 (1), 149–152. https://dx.doi.org/10.1111/j.1365-2621.1999.tb09880.x.

Sanful, R.E. (2009): Promotion of coconut in the production of yoghurt. *Afr. J. Food Sci.* 3 (5), 147-149.

Soysal, Y. (2004): Microwave drying characteristics of parsley. *Biosyst. Eng.* 89 (2), 167–173. https://dx.doi.org/10.1016/j.biosystemseng.2004.07.008.

Staffolo, M.D., Bertola, N., Martino, M., Bevilacgua, Y. A. (2004): Influence of dietary fiber addition on sensory and rheological properties of yogurt. *Int. Dairy J*. 14 (3), 263-268. https://dx.doi.org/10.1016/j.idairyj.2003.08.004.

Tull, A. (1996): Food and Nutrition, Oxford University Press, pp. 109-111.