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CHANGES IN PHYSICO-CHEMICAL CHARACTERISTICS AND VOLATILE FLAVOUR COMPONENTS OF DIFFERENT YOGHURT PRODUCTS MADE FROM SOY, PEANUTS AND COW MILK

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ABSTRACT

Milk blends from legumes are potential nutritional substitutes in cultures where cow milk is used for yoghurt production. Peanut and soy based products have been considered to have poor sensory characteristics due to the beany and off-flavours they generate in food products that contain them. The high polyunsaturated fatty acid content of legumes makes these products susceptible to lipid oxidation leading to rancidity and development of off-flavours. Acceptability ratings of these products have been significantly lower than the traditional dairy products. Nonetheless, food scientists are still faced with the challenge of formulating foods that are appealing and acceptable to consumers, but still contain significant amounts of these oilseed proteins for their health benefits. The development of a storage stable yoghurt product from these vegetable seeds has the potential to increase utilization and market for peanut and soy beans. The study investigated the keeping quality of Soy-peanut-cow milk yoghurt (SPCY), Defatted peanut-soy milk yoghurt (DPSY) and Cow milk yoghurt (CMY) refrigerated at 5°C over a period of 21 days during storage. Volatile flavor compounds in the different yoghurt samples were determined by static head space technique using Gas Chromatography-Mass Spectrometer (GC-MS). Titratable acidity increased in all samples after one week of storage but was highest in CMY (1.2% - 2.60%) followed by DPSY (0.57% - 0.89%). SPCY had the least titratable acidity value (0.23% - 0.44%). CMY and DPSY were more susceptible to syneresis. Free fatty acid (FFA) and peroxide value (PV) were high in the full fat product compared to defatted product and cow milk yoghurt. Flavour analysis using GC-MS identified aldehydes, alcohols, organic acids and furans as the volatile flavour components in the yoghurts studied. The defatted vegetable milk yoghurt (DPSY) had better storage keeping qualities than the whole fat vegetable milk yoghurt (SPCY) and the control (CMY). Defatting of oilseeds prior to use in food formulations can enhance the storage stability of the products. Utilization of less expensive and available indigenous crops such as soy beans and peanut in yoghurt production will help reduce the cost of the product in some developing countries.

Key words: Vegetable milk yoghurt, storage characteristics, volatile flavour compounds

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INTRODUCTION

Fat is important in foods for sensory qualities such as flavour, colour, texture and mouth-feel [1]. Peanuts contain approximately 45% to 56% oil, and the oil is composed of about 80% unsaturated fatty acids containing 45% oleic (18:1) and 35% linoleic (18:2) acids [2]. There has been a considerable interest in oil seeds due to their high protein value, high polyunsaturated /saturated fatty acids ratio and mineral content [3]. Since oilseeds contain high levels of polyunsaturated fatty acids they are susceptible to lipid oxidation, leading indirectly to the formation of numerous aldehydes, acids, ketones and alcohols responsible for rancid and off-flavors in peanut products [4]. To produce oilseed products with enhanced storage stability and also devoid of undesirable flavours, solvents can be used to reduce the oil content of these seeds. Aqueous ethanol, 2-propanol, and azeotropic mixtures of hexane and alcohols have been used as extraction solvents. Apart from the storage quality of high fat products, health concerns have also led consumers worldwide to reduce consumption of food perceived as high in fat, which has opened the way for a growing market of foods with low fat. However, these foods are incorporated with other products to provide the expected mouth-feel associated with high fat foods [1]. Yoghurt producers are motivated to market low-fat products with natural ingredients but removal of fat may modify rheological behaviour such as firmness and texture [5]. Full-fat cow milk yoghurt has been noted to have a greater number of fat globules which act as structure promoters of the protein network. Fat reduction in cow milk yoghurt can cause deficiencies such as decreased flavour quality and/or intensity, weak body and poor texture [6].

Syneresis is a quality defect frequently faced in yoghurt manufacture. It refers to expulsion of liquid from a gel, and is the opposite of swelling [7]. Yoghurts developed from a mixture of skim milk and soy milk have been noted to produce relatively smaller syneresis than skim milk based yoghurt [8, 9]. The microstructure of yoghurt consists of chains and cluster of casein molecules and the susceptibility to syneresis is closely related to the space between casein clusters [10]. Incorporation of soy milk in the manufacture of yoghurt filled in the spaces between casein clusters of skim milk gel and reinforced the gel network [8]. Vegetable milk yoghurt produced by adding whole fat peanut milk or defatted peanut milk into a soy-cow milk blend may influence the storage and rheological qualities of the products.

More than 100 volatile flavour compounds have been detected in yoghurt and these include carbonyl compounds, alcohols, acids, esters, hydrocarbons, aromatic compounds, sulfur-containing compounds, and heterocyclic compounds [11 – 14]. Lactic acid, acetaldehyde, diacetyl, acetoin, acetone, and 2-butanone have been noted to contribute to the typical flavour of yoghurt [13]. The major volatile compounds that are responsible for imparting desirable flavour to yoghurt are the carbonyl compounds: acetaldehyde, diacetyl, acetone, acetoin, and 2-butanone [13, 15, 16]. The analysis of flavour components of different types of vegetable milk yoghurts is critical in determining consumer acceptability of a particular yoghurt from a legume milk source. Considerable knowledge has been accumulated on volatile flavour compounds in cow milk yoghurt. However, there is limited research on volatile flavour compounds in vegetable milk yoghurt. Further research is, therefore, required to elucidate vegetable

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milk yoghurt aroma and flavour. There is the need to also correlate the composition of these volatile flavour compounds with sensory aroma attributes. The objective of this study was to investigate changes in physico-chemical qualities of soy-peanut-cow milk yoghurt, defatted peanut-soy milk yoghurt and cow milk yoghurt during storage and also characterize their volatile flavour components in the yoghurt samples using GC-MS.

MATERIAL AND METHODS

Materials

Red-skinned peanut seeds (Chinese variety) and soya bean seeds (Jenguma variety) were purchased from a registered seed grower in the Northern part of Ghana. Care was taken to ensure that good quality and mold-free seeds were selected. The starter culture (*Lactobacillus bulgaricus, Streptococcus thermophilus*) and cow milk used for the study were obtained from Amrahia Dairy Farms, Amrahia, Ghana.

Milk Preparation

Peanut milk, defatted peanut milk and soy milk were prepared by a method reported by Kpodo *et al*. [17] (Figure 1). Cow milk was added to the prepared soy milk and peanut milk/ defatted peanut milk to obtain the soy-peanut-cow milk/ defatted peanut-soy-cow milk for the study (Table 1). Proportions (%) of ingredients used in yoghurt formulation were obtained from a validated optimum region in a sensory consumer analysis conducted on ten different yoghurt formulations generated using a three-component constraint mixture design [18].

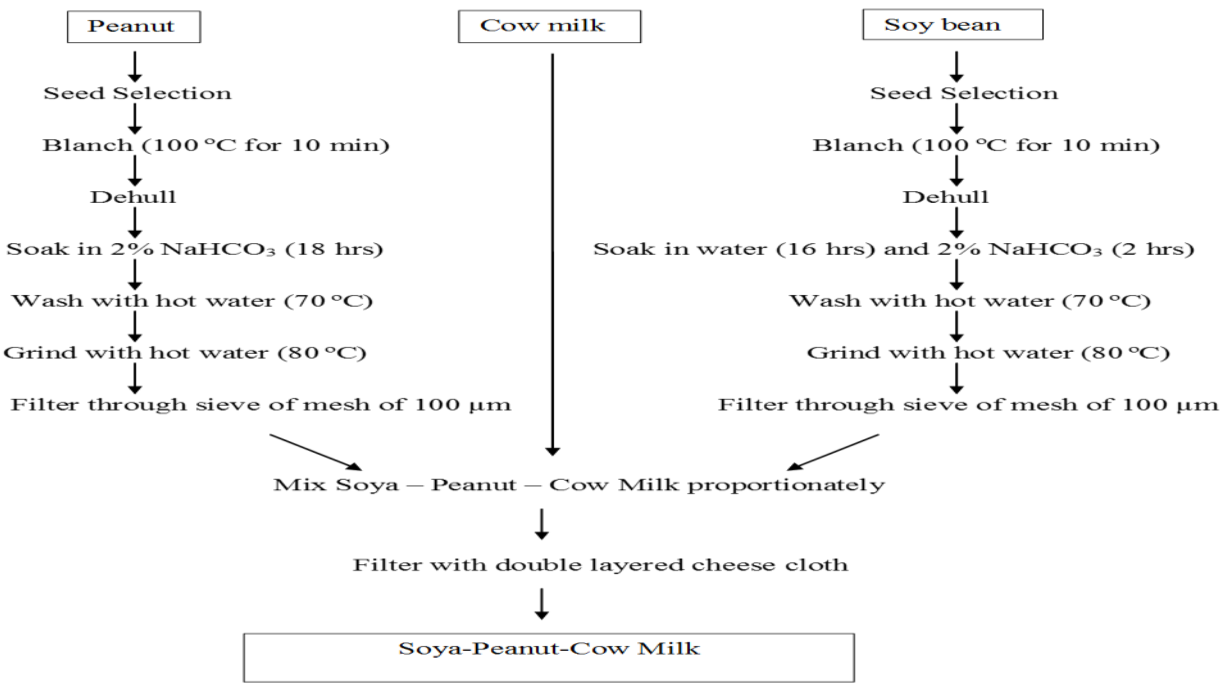

Figure 1: Process flow chart of soy-peanut-cow milk

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Yoghurt Preparation

Starter Culture Preparation

Freeze-dried yoghurt starter cultures of *S. thermophilus* and *L. bulgaricus* were obtained and revived separately in 12 g/100 g sterilized milk broth [19] and then transferred to soya-peanut-cow milk/ defatted peanut-soy milk/ cow milk broth for yoghurt production [18].

Preparation of Yoghurt

Soy-peanut-cow milk yoghurt (SPCY), Defatted peanut-soy milk yoghurt (DPSY) and the control - cow milk yoghurt (CMY) were prepared by a method reported earlier by Kpodo *et al*. [18] (Figure 2).

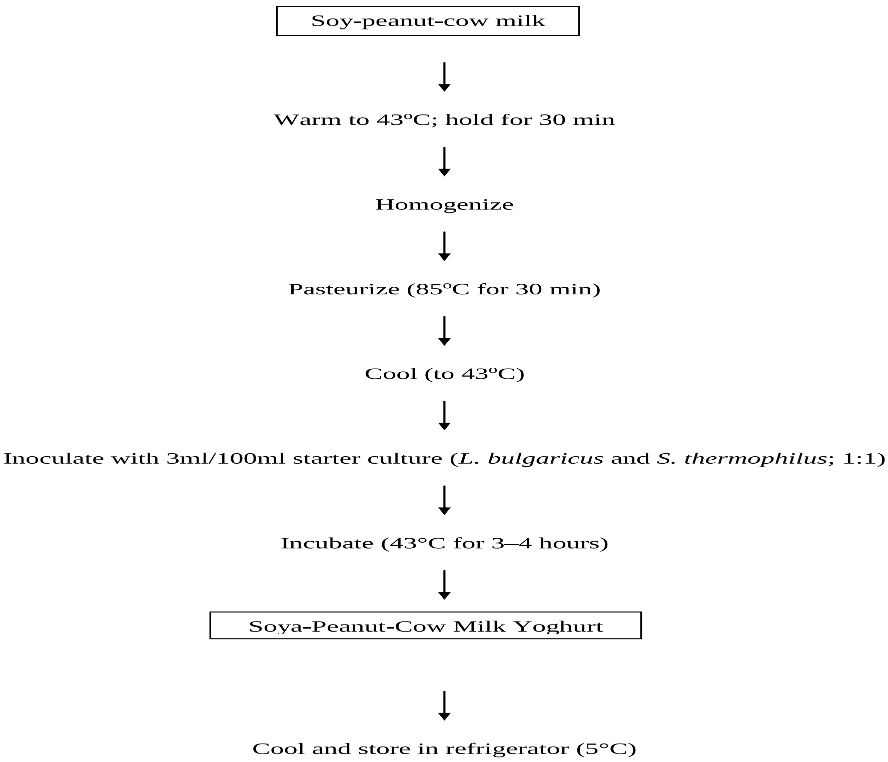

Figure 2: Process flow chart for soy-peanut-cow milk yoghurt

Analytical Methods

Yoghurt samples were stored in triplicate at 5 °C. The stored samples were analysed after day 1, 3, 5, 7, 14 and 21 for titratable acidity, susceptibility to syneresis, free fatty acids and peroxide value. The Werner-Schmid process [20] was used to extract fat for the determination of peroxide value and free fatty acid [20].

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Titratable Acidity
Tritratable acidity was determined using Association of Official Analytical Chemists (AOAC) method 947.05 [21] by titration with 0.1N NaOH (Sodium hydroxide) solution and expressed as percent lactic acid.

Susceptibility to Syneresis
The yoghurt susceptibility to syneresis (STS) was measured by placing 100 ml of yoghurt sample on a filter paper placed on top of a funnel. After 6 hours of drainage, the volume of the whey collected in a beaker was measured and used as an index of syneresis [19]. The following formula was used to calculate STS:

$$\text{STS (\%)} = V_1/V_2 \times 100$$

Where: V_1 = Volume of whey collected after drainage; V_2 = Volume of yoghurt sample.

Free Fatty acids
Free fatty acid was analysed by weighing 5g of a well-mixed melted fat sample and adding (25ml) of 95% Ethanol/Ether (1:1). The mixture was titrated with 0.1N NaOH using phenolphthalein as indicator until a pink colour persisted for 30 seconds [20].

Peroxide Value
Peroxide values were determined by weighing 5g of fat into a dry 250ml stoppered conical flask. Chloroform (10ml) was added to dissolve the oil. Fifteen (15) ml glacial acetic acid and one (1) ml freshly prepared saturated aqueous solution of KI (potassium iodide) was added to the flask. The flask was stoppered, shaken and placed in the dark for one minute. Water (75ml) was added and the mixture titrated with 0.01M sodium thiosulphate solution using soluble starch solution (1%) as indicator [20].

Volatile Compound Analysis
The flavour components of soy-peanut cow milk yoghurt (SPCY), defatted peanut-soy milk yoghurt (DPSY) and cow milk yoghurt (CMY) were determined using Gas Chromatography-Mass Spectrometer. Volatile compound analysis was determined by static head space technique according to Guler [22]. The compounds were identified by a computer-matching of their mass spectral data with those of known compounds (Mass Spectral Database).

Statistical Analysis
Data obtained from the analysis was analysed using Statgraphics (Graphics Software System, STCC, Inc. U.S.A). Comparisons between quality variable during storage period were done using analysis of variance (ANOVA) with a probability, $p < 0.05$.

RESULTS

Soy-peanut-cow milk yoghurt (SPCY), Defatted peanut-soy milk yoghurt (DPSY) and the control - cow milk yoghurt (CMY) were analysed after day 1, 3, 7, 14, 17 and 21 for titratable acidity, susceptibility to syneresis, peroxide value, and free fatty acids (Table 2).

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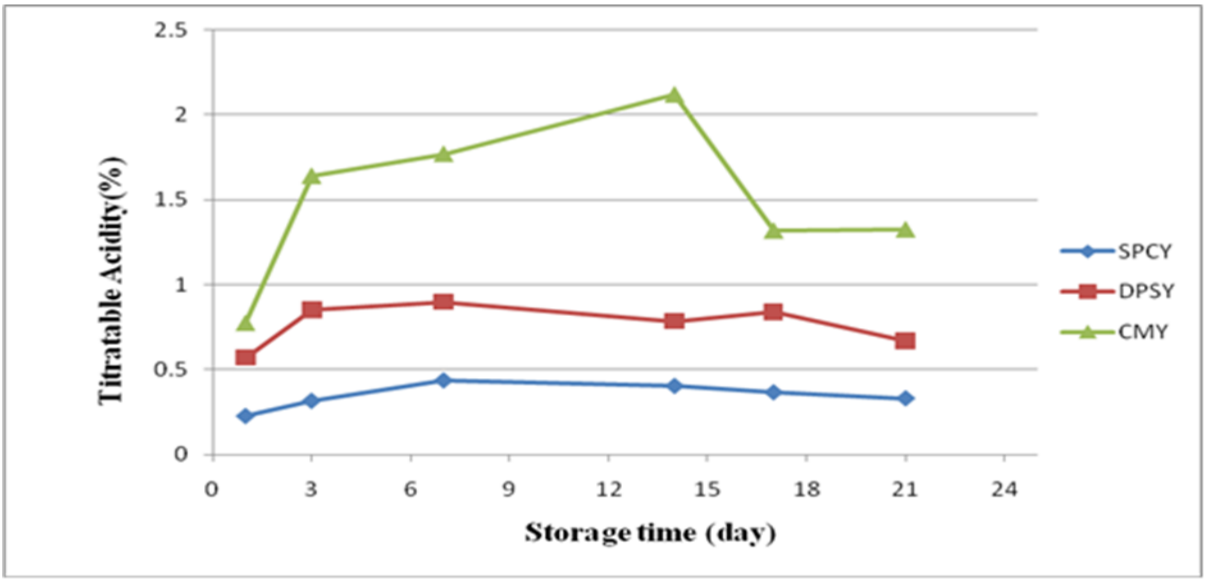

Figure 3: Changes in titratable acidity of SPCY, DPSY and CMY during storage ((SPCY- Soy-peanut-cow milk yoghurt; DPSY- Defatted peanut-soy milk yoghurt; CMY- Cow milk yoghurt)

Titratable acidity increased in all samples during one week of storage (Figure 3). However, while the acidity of DPSY and SPCY decreased after one week storage, that of CMY continued to increase to day 14 before decreasing (Figure 3). Storage period significantly affected the titratable acidity of soy-peanut-cow milk yoghurt (0.23% to 0.44%) (Table 2), defatted peanut-soy milk yoghurt (0.57% to 0.89%) (Table 2) and cow milk yoghurt (1.2% to 2.60%) (Table 2).

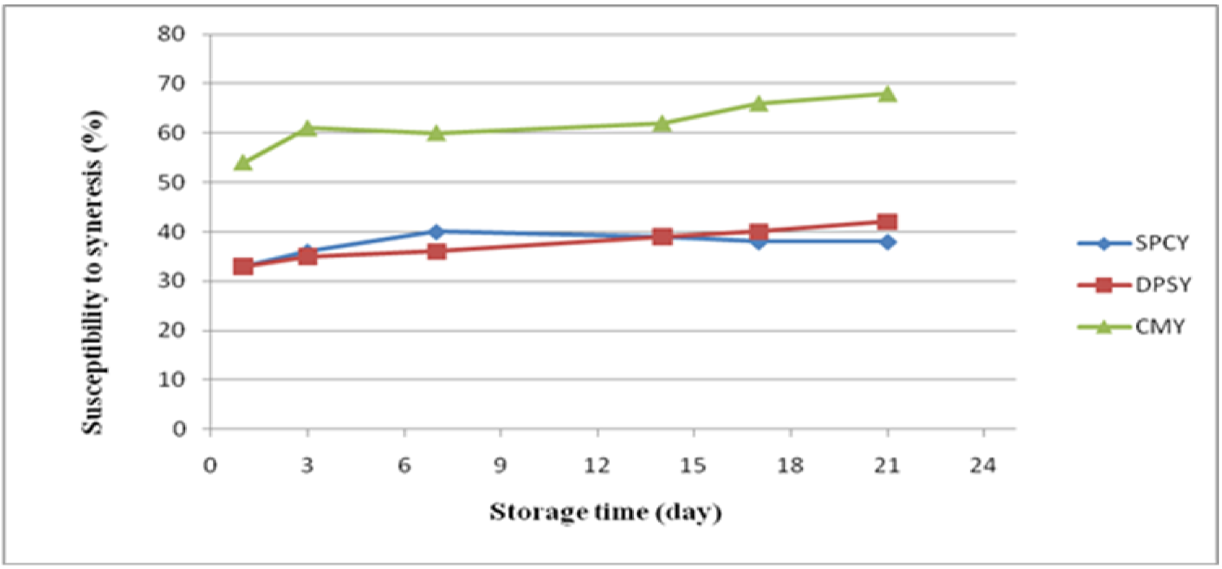

Figure 4: Changes in susceptibility to syneresis of SPCY, DPSY and CMY during storage (SPCY- Soy-peanut-cow milk yoghurt; DPSY- Defatted peanut-soy milk yoghurt; CMY- Cow milk yoghurt)

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Susceptibility of vegetable milk yoghurts to syneresis showed only marginal increases during storage compared to the control (CMY). Susceptibility of cow milk yoghurt to syneresis was the highest with values ranging from 54 to 68 %. The vegetable yoghurt products however had relatively low syneresis values- and DPSY (33 – 42 %) and SPCY (33 – 38 %).

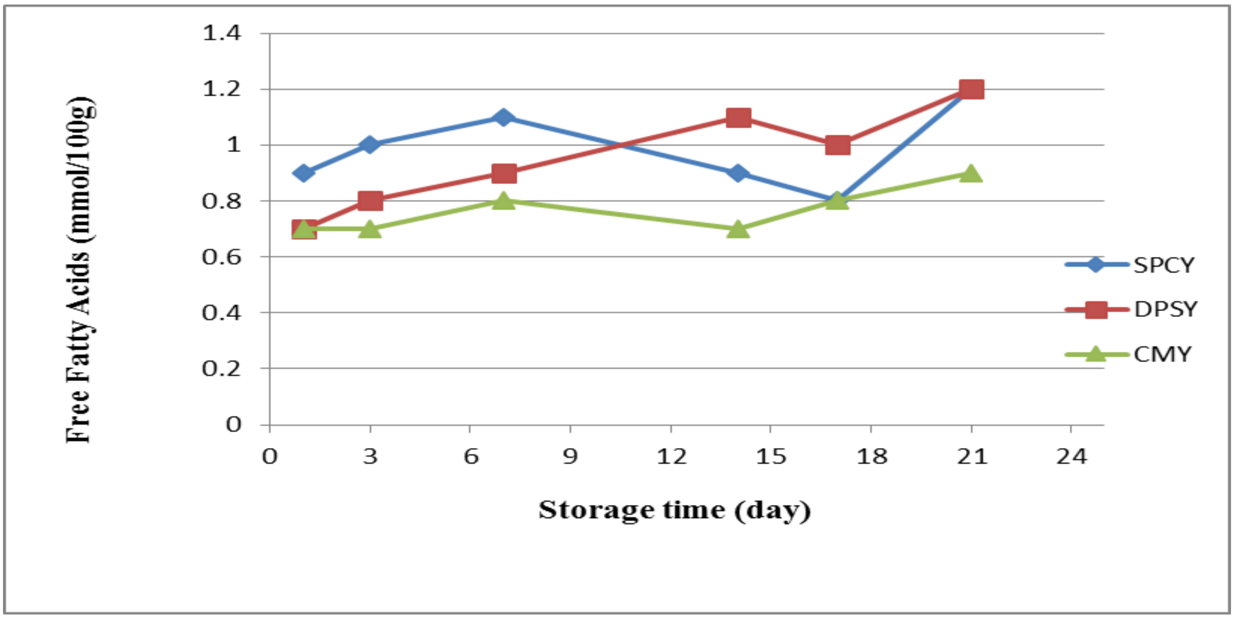

Figure 5: Changes in free fatty acid of SPCY, DPSY and CMY during storage
(SPCY- Soy-peanut-cow milk yoghurt; DPSY- Defatted peanut-soy milk yoghurt; CMY- Cow milk yoghurt)

Free fatty acid (FFA) analysis is employed as a means of predicting the quality of oil because rancidity is accompanied by the formation of FFA. Free fatty acid (FFA) values obtained during 21-days storage analysis of yoghurts ranged from 0.9 mmol/100g to 1.2 mmol/100g for SPCY, 0.7 mmol/100g to 1.2 mmol/100g (DPSY) and 0.7 mmol/100g to 0.9 mmol/100g in CMY. Analysis of the whole fat vegetable milk yoghurt (SPCY), defatted vegetable milk yoghurt (DPSY) and yoghurt from cow milk revealed a general increase in FFA value as storage days increased (Figure 5). Free fatty acid content was higher in the vegetable milk products relative to the yoghurt from cow milk. Amongst the two vegetable products, FFA content was generally higher in the whole fat vegetable milk yoghurt (in the first 12 days) than the defatted yoghurt.

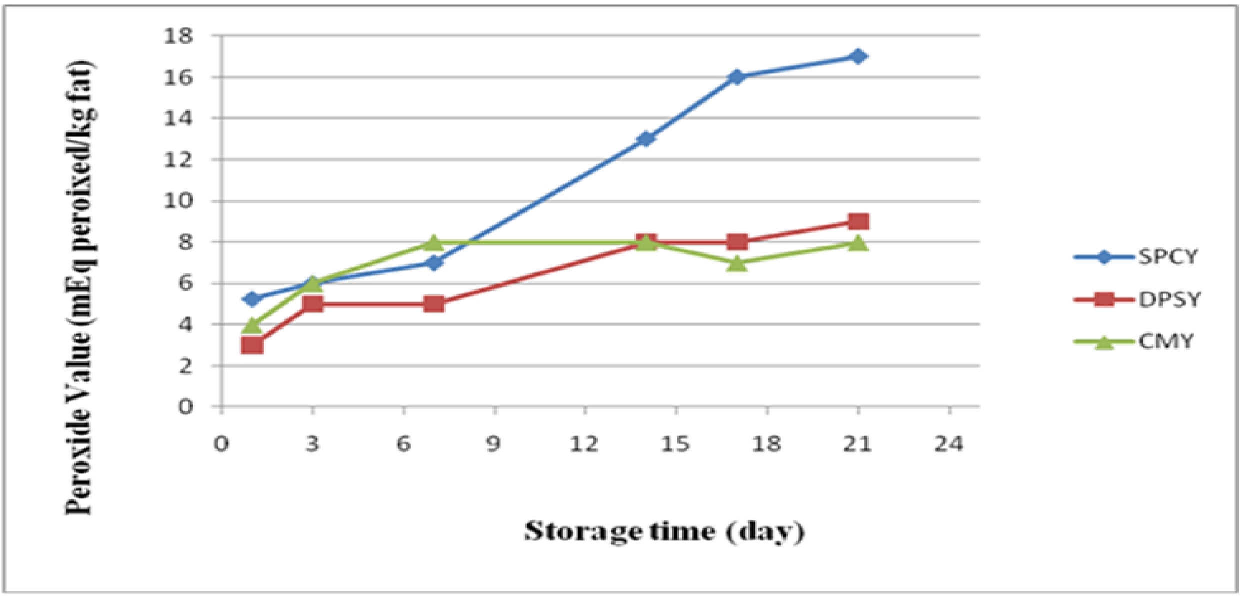

Figure 6: Changes in peroxide value of SPCY, DPSY, CMY during storage
(SPCY- Soy-peanut-cow milk yoghurt; DPSY- Defatted peanut-soy milk yoghurt; CMY- Cow milk yoghurt)

Peroxide value is defined as the milliequivalents (mEq) of peroxide per kilogram of fat. It measures the amount of peroxide or hydroperoxide groups (initial products of lipid oxidation) present in oil or fat. Peroxide values for all three yoghurts increased with days of storage (Figure 6). SPCY recorded the highest values for peroxide value (17 meq/kg fat) (Table 2) during storage.

Flavour components of soy-peanut-cow milk yoghurt (SPCY), defatted peanut-soy milk yoghurt (DPSY), and cow milk yoghurt were analysed using GC-MS. Volatile flavour analysis of the different yoghurt products identified different volatile compounds mainly aldehydes, alcohols, alkanoic acids and the heterocyclic compound furan. Compounds were identified by a computer matching of their mass spectra data with those of known compounds from a mass spectra database. External standards of the major flavour components expected to be present in cow milk yoghurt (acetaldehyde, diacetyl, acetone, acetoine and 2-butanone) and vegetable milk yoghurt (Hexylaldehyde/Hexanal) will be obtained for quantification of constituents in further studies.

DISCUSSION

Effect of Storage Days on the Titratable Acid Content of SPCY, DPSY and CMY Samples

Titratable acidity (T.A) measures the total acid content of a food product. Osman and Razig's [23] studies on the quality attributes of soy yoghurt during storage showed that storage period affected the titratable acidity of soy yoghurt (1.2% - 2.50%). Titratable acid content was highest in the cow milk yoghurt (1.2% -2.60%) followed by the defatted product (0.57% - 0.89%). This can be explained by the fact that the lactose content of cow milk relative to the vegetable milk products was high. This, therefore, provided the yoghurt microoganisms enough substrate to act on and produce lactic acid, which

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increased the titratable acid content of the CMY. The whole fat vegetable milk product had the lowest titratable acidity value. The decrease in fat content coupled with the high cow milk content of the defatted vegetable yoghurt also increased the microbial activity in the product leading to a higher titratable acid content of the deffated vegetable product relative to the whole fat vegetable product (SPCY). Supavititpatana *et al*. [24] also noted a total acidity range from 1.1% to 1.3% during a 35 days shelf life study of corn milk yoghurt at five degrees celcius (5 ^{o}C).

Effect of Storage Days on the Susceptibility of SPCY, DPSY and CMY Samples to Syneresis

Susceptibility to syneresis (STS) in yoghurt is due to the intrinsic instability of gels which allows water to be lost after extensive storage time as a result of passive diffusion [25]. The differences in STS of the various yoghurts studied (SPCY, DPSY and CMY) (Figure 4) can be attributed to three main factors: The different proteins present in the yoghurt (which led to differences in their interactions with water); the proportions of the different proteins present in the mixture; and the fat content of the yoghurt product [6, 8, 19]. Yoghurts made from vegetable milk (SPCY and DPSY) were less susceptible to syneresis relative to yoghurt developed from cow milk. Amongst the legume based yoghurts, the defatted peanut milk yoghurt was more susceptible to syneresis. Differences in fat content in the three products might have contributed to this trend. The vegetable milk products had higher fat content than the cow milk yoghurt. Fat globules usually act as structure promoters of protein networks [6]. Low fat yoghurts tend to have higher degree of syneresis than high fat yoghurts [19]. This reason might have contributed to the increase in syneresis in the defatted vegetable milk yoghurt relative to the whole fat vegetable yoghurt during the latter days of storage. Since syneresis is also related to unstable protein networks which give rise to weak gel networks, it can probably be inferred that the protein-protein network in soy-peanut-cow milk yoghurt was more stable than that in the defatted peanut-soy milk yoghurt. Likewise, the protein networks in both vegetable milk yoghurts were more stable than that in the cow milk yoghurt.

Effect of Storage Days on Free Fatty Acid Content of SPCY, DPSY and CMY Samples

Deterioration of products containing high fat or oil content may come from the hydrolysis of triacylglycerols which yields glycerol and free fatty acids (FFA) [26]. Free fatty acids are the un-neutralized acids present in oil following hydrolysis by lipase. Lipases are enzymes that catalyse the hydrolysis of triacylgycerides, the major lipid component of milk [27]. Although lipolysis in milk can be mediated by lipases naturally present in milk, microbial lipases from contaminated psychotrophic bacteria during cold storage of fresh milk can also catalyse the breakdown of lipids in milk [26]. The study obtained relatively low values for FFA that ranged from 0.7 mmol/100g to 1.2 mmol/100g. The FFA content in milk fat as reported by Hanus *et al*. [28] is between 0.5 and 1.2 mmol/100g. Roubal *et al*. [29] reported values ranging from 0.71 – 0.97 mmol/100g during an evaluation of raw milk quality.

Effect of Storage Days on Peroxide Value of SPCY, DPSY and CMY Samples

The whole fat vegetable milk yoghurt (SPCY) recorded the highest peroxide value due to its high unsaturated fat content. Since SPCY contained high levels of polyunsaturated fatty acids, the product was more susceptible to lipid oxidation, leading indirectly to the

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formation of numerous compounds responsible for rancid and off-flavors in the product [4]. To produce oilseed products with enhanced storage stability and also devoid of undesirable flavours, solvents can be used to reduce the oil content of these seeds. Reduction of the oil content of peanut used in the production of the defatted product resulted in a drastic decrease in peroxide value relative to the whole fat product. Nielsen *et al*. [30] observed an increase in peroxide value of milk emulsions from 7.2 meq/kg fat to 46.2 meq/kg fat after four weeks of storage. Ramaprasad *et al.* [31] assessed the shelf life of spray dried milk formulations containing linseed oil and groundnut oil and observed that initial peroxide value of the products ranged from 7.88 to 11.98 meq of O_2/kg fat. They, however, noted that values increased by 86% after six months of storage.

Volatile Flavour Components in SPCY, DPSY and CMY

Aldehydes in Yoghurt

This study identified Phenanthrene-1-acetaldehyde in the control cow milk yoghurt; however, the compound was not detected in the vegetable milk yoghurts. Carbonyl compounds constitute the major aromatic substances in yoghurt [13, 14]. Acetaldehyde had been noted to be a major flavour component in yoghurt [12-15]. 2-Phenylacetaldehyde had also been noted to impart flowery flavour to yoghurt [13]. The presence of acetaldehyde might have contributed to the enhanced flavour of the yoghurt formulations with more cow milk when compared to formulations with a high peanut content [18].

Alcohols in Yoghurt

Ethanol was identified in the vegetable milk formulations analysed (SPCY and DPSY) but was however not observed in the control (cow milk yoghurt). The major alcohol that has been identified in yoghurt is ethanol and it is formed as a result of the breakdown of glucose and catabolism of amino acids present in milk used as substrate for producing yoghurt [13, 22, 32]. Although the contribution of ethanol as a flavour compound in yoghurt is not very clear, it has been suggested that the alcohol provides a complementary flavor in the fermented product [13]. All vegetable milk formulations used in the study were high in soy milk content. The main oligosaccharides in soy milk are raffinose and stachyose, while the major disaccharide is sucrose [33]. During lactic acid fermentation of soy milk, alongside reduction of the contents of stachyose, raffinose and sucrose, there is also an increase in glucose [33]. This phenomenon had been attributed to the hydrolysis of stachyose, raffinose and sucrose during fermentation, owing to the catalytic action of α- and β- galactosidase produced by lactic acid bacteria [33, 34]. Since breakdown of glucose results in ethanol production, the production of glucose as a result of lactic acid fermentation of soy-peanut-cow milk/defatted peanut soy milk would expectedly lead to the development of ethanol in the vegetable milk yoghurts produced.

Organic Acids in Yoghurt

The study identified organic acids such as dodecanoic, hexadecanoic, tetradecanoic, octadecanoic acid and acetic acid in the defatted vegetable milk product (DPSY). These compounds were, however, not detected in SPCY formulation. However, 2-Cyclohexenylacetic acid was present in SPCY. Organic acids that have been characterized in yoghurt include acetic acid (vinegary, pungent, acidic flavour), hexanoic

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acid (pungent, rancid), octanoic acid (waxy, soapy, rancid, musty flavour) and decanoic acid (rancid flavour) [13, 14]. The absence of these off-flavour compounds in the full fat yoghurt vegetable milk product (SPCY) might have contributed to its high sensorial score for flavour during consumer sensory analysis when compared with the defatted product [18].

Heterocyclic Aromatic Compound-Furan
The heterocyclic flavour compound that was identified in the yoghurt formulations was furan. Furan is found in heat-treated foods and is produced through thermal degradation of natural food constituents. Achouri, *et al*. [35] also identified furan as a flavour compound in soymilk products. Furan and its derivatives have been labeled as common Maillard reaction products and had also been identified in corn milk yoghurt [24]

CONCLUSION

Titratable acidity and susceptibility of vegetable milk yoghurts to syneresis showed only marginal increases during storage compared to the control (CMY). This suggests that vegetable milk yoghurts had better storage keeping qualities than the CMY. Reduction of the oil content of peanut used in the production of the defatted product resulted in a drastic decrease in peroxide value relative to the whole fat product. Hence to produce oilseed products with enhanced storage stability and also devoid of undesirable flavours, solvents (hexane) can be used to reduce the oil content of these seeds prior to their use in food formulations. Flavour analysis using GC-MS identified aldehydes, alcohols, organic acids and furans as the volatile flavour components in the yoghurts studied.

DECLARATION OF INTEREST
The authors have no conflict of interest and are responsible for the content of the manuscript.

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Table 1: Proportions (%) of ingredients used in yoghurt formulation

Formulation	Soy-Milk (%)	Peanut Milk (%)	Cow Milk (%)
SPCY	68	25	7
DPSY	65	22	13
CMY (CONTROL)	-	-	100

SPCY- Soy-peanut-cow milk yoghurt; DPSY- Defatted peanut-soy milk yoghurt; CMY- Cow milk yoghurt

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Table 2: Storage analysis of yoghurt samples

Yoghurt	Storage time(days)	Titratable acidity (%)	Susceptibility to Syneresis (%)	Free Fatty Acids /mmol/100g	Peroxide Value/ mEq peroxide/kg fat
SPCY	Day 1	0.228±0.01[a]	33±0.01[a]	0.90±0.01[ab]	5.25±0.35[a]
	Day 3	0.316±0.01[b]	36±0.02[b]	1.00±0.01[bc]	6.00±0.01[ab]
	Day 7	0.435±0.01[e]	40±0.01[e]	1.10±0.01[cd]	7.00±0.01[b]
	Day 14	0.403±0.01[d]	39±0.01[d]	0.90±0.01[ab]	13.00±0.01[c]
	Day 17	0.366±0.02[c]	38±0.01[c]	0.80±0.01[a]	16.00±1.41[d]
	Day 21	0.331±0.01[b]	38±0.01[c]	1.20±0.02[d]	17.00±0.01[d]
DPSY	Day 1	0.570±0.01[a]	33.00±0.01[a]	0.70±0.01[a]	3.00±0.01[a]
	Day 3	0.852±0.02[d]	35.00±0.01[b]	0.80±0.01[ab]	5.00±0.01[b]
	Day 7	0.898±0.01[e]	36.00±0.02[c]	0.90±0.01[b]	5.00±0.02[b]
	Day 14	0.785±0.02[c]	39.00±0.03[d]	1.10±0.01[c]	8.00±0.01[c]
	Day 17	0.841±0.01[d]	40.00±0.01[e]	1.00±0.01[c]	8.00±0.01[c]
	Day 21	0.670±0.01[b]	42.00±0.01[f]	1.20±0.01[c]	9.00±0.04[d]
CMY	Day 1	0.775±0.01[a]	54.00±0.01[a]	0.70±0.02[a]	4.00±0.01[a]
	Day 3	1.640±0.02[c]	61.00±0.01[c]	0.70±0.01[a]	6.00±0.01[b]
	Day 7	1.769±0.01[d]	60.00±0.01[b]	0.80±0.03[ab]	8.00±0.02[d]
	Day 14	2.118±0.05[e]	62.00±0.01[d]	0.70±0.01[a]	8.00±0.02[d]
	Day 17	1.318±0.01[b]	66.00±0.01[e]	0.80±0.02[bc]	7.00±0.03[c]
	Day 21	1.325±0.03[b]	68.00±0.01[f]	0.90±0.04[c]	8.00±0.01[d]

Values are means ± standard deviations of duplicate determinations. Values in the same column having the same superscript letters are not significantly different ($p > 0.05$). SPCY- Soy-peanut-cow milk yoghurt; DPSY- Defatted peanut-soy milk yoghurt; CMY- Cow milk yoghurt

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REFERENCES

1. **Guler-Akin MB, Akin SM and A Korkmaz** Influence of different exopolysaccharide producing strains on the physicochemical, sensory and syneresis characteristics of reduced fat stirred yoghurt. *Int. J. Dairy Tech*, 2009; **62:** 422 – 430.

2. **Grosso NR and CA Guznam** Lipid, protein, and ash contents, and fatty acid and sterol composition of peanut (*Arachis hypogaea* L.) seeds from Equador. *Peanut Science*, 1993; **22**: 84-89.

3. **Khetarpaul N, Grewal RB, Goyal R and R Garg** Development of partially defatted soy flour and dhal. *Food Chem.*, 2004; **89**: 355 – 359.

4. **Nepote V, Olmedo RH, Mestrallet MG and NR Grosso** A study of the relationships among consumer acceptance, oxidation chemical indicators and sensory attributes in high-oleic and normal peanuts. *J. Food Sc.: Sensory and Food Quality*, 2008; **74**:1 – 8.

5. **Sandoval-Castilla O, Lobato-Calleros C, Aguirre-Mandujano E and EJ Vermon-Carter** Microstructure and texture of yoghurt as influenced by fat replacers. *Int. Dairy Sci.*, 2004; **14**: 151 – 159.

6. **Guggisberg D, Cuthbert-Steven J, Piccinali P, Bütikofer U and P Eberhard** Rheological, microstructural and sensory characterization of low-fat and whole milk set yoghurt as influenced by inulin addition. *Int. Dairy J.*, 2009; **19**: 107–115.

7. **Fennema OR** Food Chemistry. 3rd Ed. Marcel Dekker, Inc., New York, 1997; 391 – 394.

8. **Parker R, Noel TR, Brownsey GJ, Laos K and SG Ring** The non-equilibrium phase and glass transition behavior of betalactoglobulin. *Biophysics Journal*, 2005; **89**: 1227 – 1236.

9. **Shirai K, Guticrrez-Dura´n M, Marshall VME, Revah-Moiseev S and M Garcia-Garibay** Production of a yoghurt-like product from plant foodstuffs and whey. Sensory evaluation and physical attributes. *J. Sci Food Agric*, 1992; **59**: 205 – 210.

10. **Harwalkar VR and M Kalab** Susceptibility of yoghurt to syneresis: comparison of centrifugation and drainage methods. *Milchwissenschaft*, 1986; **38**: 517 – 522.

11. **Lubbers S, Decourcelle N, Vallet N and E Guichard** Flavor release and rheology behavior of strawberry fat free stirred yoghurt during storage. *J. Agric. Food Chem.*, 2004; **52**: 307 – 3082.

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12. **Ott A, Fay LB and A Chaintreau** Determination and origin of the aroma impact compounds of yoghurt flavor. *J. Agric. Food Chem.,* 1997; **45:** 850 – 858.

13. **Cheng H** Volatile flavour compounds in yoghurt: a review. *Crit. Rev. Food Sci. Nutr.,* 2010; **50**: 938 – 950.

14. **Routray W and HN Mishra** Scientific and technical aspects of yoghurt aroma and taste: a review. *Compr Rev Food Sci.*, 2011; **10**: 208 – 220.

15. **Ulberth F and W Kneifel** Aroma profiles and sensory properties of yoghurt and yoghurt related products. II. Classification of starter cultures by means of cluster analysis. *Milchwissenschaft*, 1992; **47:** 432 – 434.

16. **Pourahmad R and MM Assadi** Yoghurt production by Iranian native starter cultures. *Nutr. Food Sci*., 2005; **35**: 410 – 415.

17. **Kpodo FMK, Afoakwa OE, Amoa BB, Saalia KF and AS Budu** Application of multiple component constraint mixture design for studying the effect of ingredient variations on the chemical composition and physico-chemical properties of soy-peanut-cow milk, *Int. Food Res. J*., 2013; **20**:811-818.

18. **Kpodo FMK, Afoakwa OE, Amoa BB and KF Saalia** Nutritional and sensory characterization of full fat and partially defatted peanut soy milk yoghurt, *Int. J. Nur. Food Sci.*, 2014; **3**:187-193.

19. **Isanga J and G Zhang** Production and evaluation of some physicochemical parameters of peanut milk yoghurt. *Food Sci. Tech.*, 2009; **6**(**44**): 1132-2238.

20. **Pearson D** Chemical Analysis of Foods. 7th Ed. Livingstone, London: Churchill, 1976; 402 – 452.

21. **AOAC (**Association of Official Analytical Chemists) Official Methods of Analysis, Association of Official Analytical Chemists. 15th Ed. Gaithersburg, USA: AOAC Press 1990.

22. **Guler-Akin MB, Akin SM and A Korkmaz** Influence of different exopolysaccharide producing strains on the physicochemical, sensory and syneresis characteristics of reduced-fat stirred yoghurt. *Int. J. Dairy Tech*., 2009; **62**: 422 – 430.

23. **Osman MD and KA Razig** Quality attributes of soy-yoghurt during storage period. *Pakistan J Nutr.*, 2010; **9:** 1088 – 1093.

24. **Supavititpatana P, Wirjantoro TI and P Raviya** Characteristics and shelf-life of corn milk yoghurt. *CMU. J. Nat Sci*., 2010; **9**: 133 – 137.

25. **Cruz NS, Capellas M, Jaramillo DP, Trujillo AJ, Guamis B and V Ferragut** Soymilk treated by ultra-high pressure homogenization: acid coagulation properties and characteristics of a soy-yoghurt product. *Food Hydrocoll.*, 2009; **23**: 490 – 496.

26. **Serra M, Trujillo AJ, Pereda J, Guami B and V Ferragut** Quantification of lipolysis and lipid oxidation during cold storage of yoghurt produced from milk treated by ultra-high pressure homogenization. *J. Food Eng.*, 2008; **89**: 99 – 104.

27. **Deeth HC** Lipoprotein lipase and lipolysis in milk. *Int. Dairy J.*, 2006; **16**: 555 – 562.

28. **Hannus O, Vegricht J, Frelich J, Macek A, Bjellan M, Louda F and L Janu** Analysis of raw cow milk quality according to free fatty acid contents in the Czech Republic. *Czech J Anim Sci*., 2008; **53**: 17 – 30.

29. **Roubal P** Evaluation of raw milk quality in central laboratories in Czech Republic in 2005.*VUM, Praha*, 2006; 1 – 20.

30. **Nielsen SN, Klein A and A Jacobsen** Effect of ingredients on oxidative stability of oil-enriched drinking yoghurt. *Eur. J. Lipid Sci. Technology*, 2009; **111**: 337 – 345.

31. **Ramaprasad T, Baskaran V, Debnath S and B Lokeshi** Shelf life of spray-dried milk formulations supplemented with N-3 fatty acids. *J. Food Proc. Pres*., 2006; **30**: 364 – 378.

32. **Urbach G** Contribution of lactic acid bacteria to flavour compound formation of dairy products. *Int. Dairy J.*, 1995; **5**: 877 – 903.

33. **Wang YC, Yu RC, Yang HY and CC Chou** Sugar and acid content in soymilk fermented with lactic acid bacteria alone or simultaneously with bifidobacteria. *Food Microb*., 2003; **20**: 333–338.

34. **Hou JW, Yu RC and CC Chou** Changes in some components of soymilk during fermentation with bifidobacteria. *Food Res. Int.*, 2000; **33**: 393–397.

35. **Achouri A, Boye JI and Y Zamani** Changes in soymilk quality as a function of composition and storage. *J. Food Qual*., 2007; **30:** 731 – 744.