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Production and Quality Evaluation of Yogurts from Composites of Powdered Cow Milk, Soy Milk and Cornstarch

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Authors' contributions

This work was carried out in collaboration among all authors. Author ECI designed the study. Author CUO performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ECU and CUO managed the analyses of the study. Authors SNO and CSA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This research was carried out to evaluate the appropriate levels of substitution of powdered cow milk with soy milk and cornstarch needed to produce yoghurt, evaluating its quality and potential for acceptance. Powdered cow milk was substituted with soymilk and cornstarch up to 30% to produce yogurt and market sample yogurt was used as control. Each composite blend milk samples was homogenized, pasteurized at 75°C for 5 min, cooled and inoculated with a mixed freeze-dried starter culture containing strains of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* at 45°C, fermented for 6 h and cooled to 4˚C. The proximate, chemical, microbial, functional and sensory evaluation of the composite yogurt samples was determined. The yogurt samples were coded ACS-1 to ACS-13 where ACS-13 represent control. The result of the proximate analysis showed that moisture content ranged from 82.04 – 88.71%, protein ranged 2.05 – 6.48%, fat ranged from 2.14 – 3.62%, carbohydrate ranged from 4.30 – 9.91% and ash content ranged from 0.53 – 1.48%. The pH ranged from 3.73 – 4.82. For microbial evaluation, the total viable bacteria count ranged from 1.90×10^7 – 11.60×10^7, total coliform count ranged from 0.50×10^7

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– 3.90×10^7. For chemical and functional evaluation, the total solids ranged from 11.28 – 16.96%, titratable acidity ranged from 0.30 – 1.80%, syneresis ranged from 0.00 – 28.33%, water absorption capacity ranged from 0.00 – 75.53% and apparent viscosity ranged from 1337- 4863 cP. For sensory evaluation, yogurt produced with 100% powdered milk (ACS-1) was the most preferred while yogurt sample produced with 50% powdered milk, 30% cornstarch and 20% soy milk (ACS-10) was the least preferred among other yogurt samples. This study revealed the mix ratios of powdered cow milk, soy milk and cornstarch that were acceptable in accordance with yogurt standard and the extent the quality of yogurt was generally accepted with the use of processing adjuncts (soymilk and cornstarch).

Keywords: Yogurt; powdered milk; soybean, soy milk; cornstarch; starter culture.

1. INTRODUCTION

Yogurt is a cultured dairy product made from milk of cow, buffalo, goat, sheep and other mammals, usually homogenized, pasteurized and fermented [1]. Fresh animal milk has been used in yogurt production, however, in recent times especially in Nigeria, powdered cow milk is the major raw material for yogurt production due to lack of fresh liquid cow milk. Previous researchers reported that commercial powdered milk contains oxidized cholesterol in higher amounts (up to 30 µg/g) than fresh animal milk which may have both beneficial and adverse effects [2,3]. However, it was reported that the probable harmful effect of milk and dairy product consumption is dose-dependent and contamination with environmental pollutants or toxicants [4]. Therefore, harm for normal people could only occur on excessive and indiscriminate consumption rather than moderate daily intake as advised by nutritionists.

Yogurt quality requires control of raw materials during manufacturing process and on the final product. Many parameters must be carefully controlled in order to produce high quality yoghurt with the desired flavor, aroma, consistency, appearance, longer shelf-life and avoid whey separation. These parameters include inoculation and incubation temperatures; heat treatment, use of preservatives and stabilizers, composition of the milk base, type, mix and volume of starter culture among others [5,6].

Due to the scarcity and / or high cost both powdered or fresh milk, the raw material for yogurt production has been extended to include adjuncts such as soymilk and cornstarch. This high cost of animal milk and their variability in types have made most commercial producers of yogurt seeking for alternative sources so as to remain in business. Researchers reported that most yogurt producers have resorted to adjuncts such as soymilk and cornstarch in yogurt production which expectedly has affected the quality of yogurt and consumption of whole fat products (e.g., full fat yogurt) has declined due to the awareness of the probable harmful effect of fat on consumer's health [7,8].

Soybean contains about forty percent (40%) protein, twenty percent (20%) edible oil, rich in vitamins and minerals and has been used as food for centuries because of its good nutritive value [9]. Soybean derivatives such as soymilk contains virtually high amount of protein and is also lactose free and cholesterol free when compared to cow milk protein [10]. Hence, yoghurt produced with soymilk is healthy for individuals who suffer from lactose intolerance. Additionally, Vegetarians who do not consume animal products and yet desire to consume milk and milk products will have diversified products in the market that will serve their nutritive value without going against their religious belief of partial or total abstinence from animal based food and feeding on plant based food preparation, an example of which is yoghurt [11].

Adjuncts such as stabilizers can be added to milk base during yogurt production to improve its texture and prevent quality defect known as syneresis. Stabilizers as hydrophilic colloids that bind water, enhance an increase in the viscosity of yogurt and help prevent the separation of whey from the yogurt [12]. There are various types of stabilizers which can be added to the yogurt such as Gelatin, Alginates, Carbo gum, Guar gum, cornstarch and Carboxy methyl cellulose [13].

Cornstarch can be described as a high quality and affordable starch which can be used in yoghurt production for the improvement of its texture and increased viscosity [14]. Cornstarch is mostly preferred as thickening agent in yogurt production because it's readily available and affordable when compared to other hydrocolloids [15,16].

But the question remains whether yoghurt produced from composites of animal milk and/or soymilk will compare favorably in physicochemical and organoleptic qualities with yoghurt from whole cow milk? That is the major focus of this research. Hence, the objectives of this research were to evaluate the proximate, functional and sensory quality of producing yogurt with the use of cow milk and local base substitutes such as soymilk and cornstarch, while cornstarch will be used as stabilizer with a view of knowing the consumer acceptability of the product.

2. MATERIALS AND METHODS

The materials used in this study include powdered cow milk (Dano cool cow), soybean seed, cornstarch (Amel SUSAN powdered cornstarch) and commercially available yoghurt starter culture (DVS). The materials were purchased from Bakery international market, Onitsha, Anambra State.

2.1 Preparation of Soymilk

Three hundred grams (300 g) of soybean seed was sorted, washed, soaked in one liter of distilled water for twelve hours (12h) and rinsed. Soybean was boiled in 1.5 liters of water in a cooking pot for 15 minutes. The boiled soybean was hand de-hulled and the hulls removed by floatation. The soybean cotyledons were then wet-milled with 2 liters of water and sieved using muslin cloth to extract soymilk. The extracted soymilk was boiled for 20 minutes. The boiled soymilk was allowed to cool [17].

2.2 Cornstarch Gel Preparation

Cornstarch powder (50 g) was dissolved in 100 ml of ambient water temperature into a moderately thick paste. Water (500 ml) was boiled for 5 minutes until it reached boiling point (100˚C). The boiled water was added simultaneously into the cornstarch paste while stirring until it gelatinized into a very thick gel. Cornstarch gel was prepared and added into the yoghurt samples as stabilizers at different concentration.

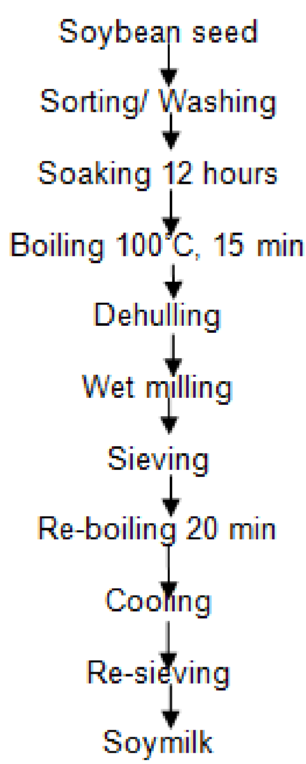

Fig. 1. Production of soymilk from soybean

2.3 Starter Culture Preparation

The culture was obtained in Direct Vat Set (DVS) form and stored at -18°C until use. This starter culture contained strains of *S. thermophilus* and *Lb. delbrueckii* subsp. *Bulgaricus* (1:1 ratio). 1 g of starter culture was inoculated into 100 ml of each pasteurized milk samples at 45˚C [18].

2.4 Preparation of Yogurt

Reconstituted powdered milk (400 g to 2 liters of distilled water) and soy milk were mixed in appropriate ratio of formulations (Table 1). For example, the yogurt sample (90:05:05), 90 ml of milk was mixed with 5 ml of soy milk. It was homogenized, pasteurized at a temperature of 75˚C for 5 minutes, cooled to 45˚C, inoculated directly with 1 g starter culture and incubated at a temperature of 43˚C for 6 hours undisturbed (Bristone *et al.,* 2016). Cornstarch gel (5 g) was then added; sugar (15 g) and flavor (10,000 ppm) were also added to the yogurt and then refrigerated at 4˚C [19]. Other yogurt samples were mixed in appropriate ratio of formulations as stipulated in Table 1.

2.5 Yogurt Treatments

The different formulations of composite yogurt resulting in 13 treatments are as given in Table 1.

2.6 Methods of Analyses

Analyses conducted on the thirteen yogurt treatments were pH, visual observation, proximate composition, microbial evaluation, sensory characteristics, total solids, total titratable acidity (TTA) and functional properties.

The pH of the yoghurt samples was determined using digital hand pH meter (Hanna Instruments, Singapore) [20].The titratable acidity of the yogurt samples was determined using titration method [20].

The moisture content was determined using gravimetric method [20]. The Protein content (total nitrogen)was determined using the Kjeldahl method [21]. Blight Dyer Technique was used for determination of fat content of yogurt samples [22]. Ash content was determined using the furnace incineration gravimetric method [21].

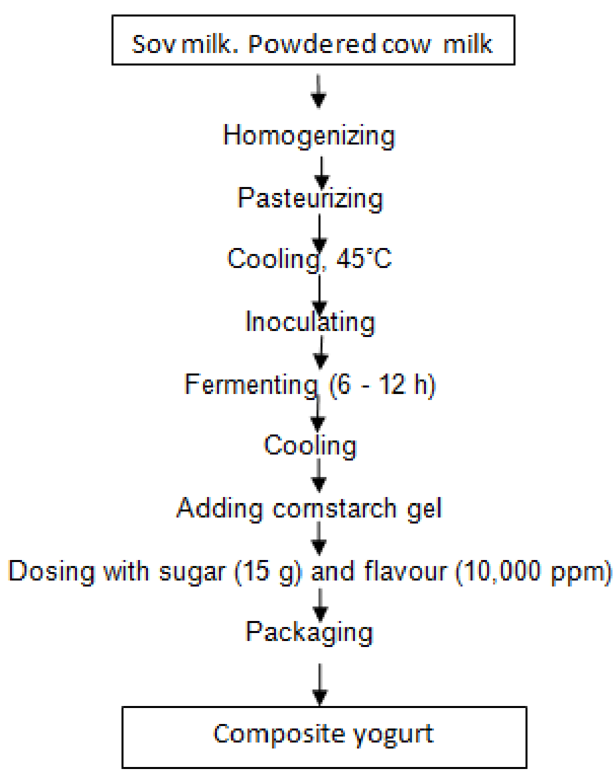

Fig. 2. Yogurt production from powdered cow milk, soymilk and cornstarch

Table 1. Different percentage combination ratios of powdered cow milk, cornstarch and soymilk used in yogurt production

No	Milk	Cornstarch	Soymilk	Code	Remark
1	100	00	00	ACS-1	Control
2	90	05	05	ACS-2	Non-control sample
3	80	10	10	ACS-3	”
4	70	15	15	ACS-4	”
5	70	20	10	ACS-5	”
6	70	10	20	ACS-6	”
7	60	20	20	ACS-7	”
8	60	25	15	ACS-8	”
9	60	15	25	ACS-9	”
10	50	30	20	ACS-10	”
11	50	20	30	ACS-11	”
12	50	25	25	ACS-12	”
13	Market sample	-	-	ACS-13	Control

Levels of powdered milk used in yogurt productions are 50 to 100%
Levels of soymilk used in yogurt productions are 5 to 50%
Levels of cornstarch used in yogurt productions are 5 to 50%

Determination of carbohydrate [20] content was calculated as nitrogen free extractives using the formula where:

% CHO = 100-% (Protein + ash +fat +moisture content).

The total solids content of yogurt was determined after oven drying at 105˚C for 24 hours as described for moisture content above.

The total viable bacteria count was determined using a standard procedure [23] with slight modification and total coliform count was determined using a method [24].

Syneresis (Whey separation) of yogurt sample was measured using drainage method [25] with minor modification. While the water absorption capacity of the yogurt sample was determined [10] using centrifuge method. The 10 ml of yogurt sample was centrifuged for 30 minutes at 3000 rpm. The quantity of whey expelled after centrifugation was expressed as millimeters of water bound in yogurt sample.

The viscosity of the yogurt samples were measured using a Brookfield viscometer (Brookfield Viscometer DV-E USA) with a spindle number 64 [26]. Yogurt sample was filled into a 100 ml beaker and allowed to just cover the grove of the cylindrical spindle. The speed was set at 100 rpm and three continuous readings were taken for each sample at each replication. Results were recorded in centipoise (cP) after 60 seconds of shearing.

Sensory evaluation using a seven-point Hedonic scale was used to assess the different samples of yogurt as regards to their taste, texture, flavor, appearance and overall acceptability [27]. The semi-trained panelists used comprised of thirty (30) students from Nnamdi Azikiwe University, Awka made up of Food Science and Technology final year (500 Level) students.

For statistical analyses, the data generated from the experiments were analyzed using one-way analysis of variance (ANOVA) procedure in Statistical Package for Social Science (SPSS) version 20.0 software [28] to determine significant difference among the yogurt samples at 5% probability (< 0.05). Differences between the means obtained were ascertained using Duncan's Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1 Results of pH and Proximate Compositions of Soybean and Soy Milk

Table 2 represented the pH and proximate compositions of soybean and soy milk.

The pH of the soy milk and soybean was 7.4 and 6.2 which is within the range of 7.2 and 6.4 [29]. The moisture content of soybean was 8.30% which within the range of the study [29] and was higher (4.14%) than that reported by other researcher [19]. The difference may be as a result of the variety of soybean used. The protein, fats and ash content tallied with the work of [29] and [30]. Proximate composition of soy milk showed that it had moisture content of 87.77% which was within the range of the research reported [29] where moisture content was 89.60%. The protein content was 3.78%, fat content 3.42% and ash content 1.26% which were within the range of research [29] and [31] where the protein, fat and ash content were 3.15%, 3.42% and 1.17% respectively.

3.2 Results of Proximate Composition of Yogurts

The proximate composition of yogurt produced with different blends of cow milk, soymilk and cornstarch is shown in Table 3. The moisture content values for yogurt samples ranged from 83.40 – 86.20%.Yogurt produced with 50% powdered milk, 20% corn starch and 30% soy milk (ACS-11) recorded the highest value of 86.20% while yogurt produced with 50% powdered milk, 30% cornstarch and 20% soy milk (ACS-10) had the lowest value of 83.40%. It was observed that the moisture content of the yogurt samples increased with substitution with soymilk and decreased with cornstarch substitution. Addition of cornstarch resulted to a highly viscous liquid, thick consistency and low moisture content while increased substitution of soymilk resulted to a loose consistency and high moisture yoghurt samples. Yogurt (Market) sample used as control (ACS-13) was not significantly different (*P*> .05) among all the yogurt samples.

The protein content ranged from 3.05 – 6.10%. Yogurt produced with 50% powdered milk, 20% cornstarch and 30% soy milk (ACS-11) had the highest value of 6.10% while yogurt (market) sample used as control (ACS-13) had the least value of 3.05%. The protein content of the composite yogurt samples were observed to increase with higher percentage of soymilk substitution than in cornstarch. Yogurt's starter culture brings about proteolysis during fermentation resulting in changes in the nitrogenous compounds in yogurt. Researchers reported the capacity of *Streptococcus thermophilus* to increase the level of ammonia nitrogen in cultured milk by splitting urea [32]. The protein content obtained is comparable to the [33] value from 3.70 – 4.30% for soy-corn yogurt.

The fat content ranged from 2.14 – 4.20% with yogurt produced with 100% powdered milk (ACS-1) having the highest value of 4.20% while Control (ACS-13) had the least value of 2.14%. The high fat content of yoghurt produced with 100% powdered milk (ACS-1) could be attributed to cow milk containing nearly twice as much fat and 10 times more fatty acids than soymilk as reported in a research carried out by other researchers [34]. Addition of soymilk lead to increased fat content of yogurt samples. These results were within the range of those reported by other researcher with values for soy-corn yogurt 2.60% [33].

The carbohydrate ranged from 4.28 - 9.91%. Yogurt sample used as control (ACS-13) had the highest carbohydrate value of 9.91% while yogurt sample produced with 50% powdered milk, 20% cornstarch and 30% soymilk (ACS-11) had the least value of 4.28%. All the yogurt samples differed significantly at 5% level of confidence. It was observed that increase in ratio of substitution with cornstarch increased the carbohydrate content of the yogurt samples. The ash content of the yogurt samples ranged from 0.40 – 1.36%. The results were within the range of those reported by other researcher [9] with values 0.46 – 0.72%. The result for carbohydrate content is inclusive of added sugar.

3.3 Results of Microbial Quality of Yogurts Produced with Different Ratios Powdered Milk to Soy Milk to Cornstarch

Table 4 represented the microbial quality of the yogurt samples.

Table 2. pH and Percentage proximate compositions of soybean and soymilk

Sample	Moisture	Protein	Fat	Ash	T-solid	CHO	pH
Soybean	8.30±0.20	35.40±0.00	24.60±0.00	4.50±0.40	91.50±0.30	27.10±0.10	6.2±0.20
Soymilk	87.77±0.86	3.78±0.54	3.42±0.00	1.26±0.07	12.23±0.88	3.77±0.24	7.4±0.00

Values are mean ± standard deviation of triplicate determinations

Table 3. The percentage proximate composition of yogurts produced with different blends of powdered cow milk to soymilk to cornstarch

Code	% Pm:Cs:Sm	Moisture	Protein	Fat	CHO	Ash
ACS-1	100:00:00	85.00^{ab}±1.00	4.21^{b} ±1.01	4.20^{a} ± 0.20	6.06^{e} ± 0.60	0.53^{b}±0.20
ACS-2	90:05:05	84.48^{ab}±1.00	4.43^{ab}±0.43	3.50^{abc} ±0.09	6.29^{e} ± 0.10	1.30^{a}±0.30
ACS-3	80:10:10	84.04^{a}±1.00	4.48^{ab} ±2.00	3.48^{abc} ± 1.30	6.75^{d} ± 0.20	1.25^{a}±0.25
ACS-4	70:15:15	84.28^{ab}±0.20	5.53^{ab} ±0.53	3.62^{ab} ± 0.01	5.33^{f}±0.33	1.27^{a}±0.20
ACS-5	70:20:10	83.84^{ab}±0.23	5.43^{ab}±1.00	2.53^{de}± 0.53	6.95^{cd}± 0.00	1.25^{a}±0.05
ACS-6	70:10:20	85.22^{ab}±1.00	5.69^{ab}± 0.69	3.65^{ab} ± 0.05	5.00^{g} ± 0.05	0.44^{b}±0.20
ACS-7	60:20:20	85.13^{ab}±2.00	5.53^{ab}±1.10	2.65^{de}± 0.30	5.46^{f}± 0.20	1.23^{a}±0.03
ACS-8	60:25:15	83.57^{b}±2.00	5.43^{ab}± 1.20	2.52^{de} ± 0.10	7.20^{bc} ± 0.15	1.28^{a}±0.28
ACS-9	60:15:25	86.02^{a}±2.00	5.91^{ab}±0.91	2.75^{cde}±0.20	4.82^{g}± 0.10	0.50^{b}±0.25
ACS-10	50:30:20	83.40^{a}±1.00	5.61^{ab}±0.21	2.33^{e}± 0.14	7.30^{b} ± 0.30	1.36^{a}±0.05
ACS-11	50:20:30	86.20^{a}±1.00	6.10^{a}±0.10	3.02^{bcd}± 0.02	4.28^{h}± 0.10	0.40^{h}±0.20
ACS-12	50:25:25	85.06^{ab}±0.00	5.03^{ab}±0.03	2.89^{bcde}± 0.14	5.37^{f}±0.10	1.23^{a}±0.20
ACS-13	Market-Sample	84.33^{ab}±1.41	3.05^{c}± 0.05	2.14^{e}± 0.14	9.91^{a}±0.01	0.57^{b}±0.03

Values are mean ± standard deviation of triplicate determinations.
Pm = Powdered milk
Cs = Corn starch
Sm = Soymilk

Table 4. Microbial quality of yogurts produced with different ratios of powdered cow milk, soy milk and cornstarch

S/N	Sample code	Ratio of Am:Cs:Sm	Total viable bacteria count (cfu/ ml)	Total coliform count (cfu/ ml)
1	AMCSM-1	100:0:0	1.90^{h} x 10^{7} ± 0.07	0.50^{h} x 10^{7} ±0.10
2	AMCSM-2	90:05:05	4.60^{g} x 10^{7} ±1.47	1.53^{g} x 10^{7} ±0.98
3	AMCSM-3	80:10:10	5.73^{efg} x 10^{7} ±2.65	1.56^{g} x 10^{7} ±0.60
4	AMCSM-4	70:15:15	5.73^{efg} x 10^{7} ±0.30	1.50^{g} x 10^{7} ±0.30
5	AMCSM-5	70:10:20	9.53^{bc} x 10^{7} ±0.25	1.53^{c} x 10^{7} ±1.55
6	AMCSM-6	70:20:10	7.23^{de} x 10^{7} ± 0.25	1.76^{e} x 10^{7} ±0.25
7	AMCSM-7	60:20:20	8.10^{cd} x 10^{7} ±0.17	1.50^{d} x 10^{7} ±0.30
8	AMCSM-8	60:15:25	10.73^{ab} x 10^{7}±0.46	3.50^{ab} x 10^{7} ±0.10
9	AMCSM-9	60:25:15	6.66^{def} x 10^{7} ±1.15	1.43^{d} x 10^{7} ±0.32
10	AMCSM-10	50:20:30	11.60^{a} x 10^{7} ±0.52	3.90^{a} x 10^{7} ±0.47
11	AMCSM-11	50:30:20	10.50^{ab} x 10^{7}±0.92	3.30^{b} x 10^{7} ±0.10
12	AMCSM-12	50:25:25	10.50^{ab} x 10^{7}±0.88	2.40^{c} x 10^{7} ±0.45
13	AMCSM-13	Market-Sp	2.50^{h} x 10^{7} ±0.88	1.00^{h} x 10^{7} ±0.03

**Values are mean ± standard deviation of triplicate determinations*
Market-Sp = Market sample

The microbial quality of yoghurt produced with different blends of powdered cow milk, soy milk and cornstarch is shown in Table 4. The total viable bacteria count of yoghurt samples ranged from 1.90 x 10^{7} - 11.60 x 10^{7}. The highest quantity was found in sample ACS-10 (50:30:20) and the lowest quantity found in sample ACS-1 (100:0:0). High bacteria count is also expected because of the presence of starter cultures which are mainly lactic acid bacteria. The results were higher than international standard for yoghurt which requires a minimum of total viable microorganisms of 10^{7} per 100 ml in the finished product [35]. The results were not satisfactory as indicated by their high bacterial loads.

The total coliform count ranged from 0.50 x 10^{7} – 3.90 x 10^{7}. The highest quantity of total coliform was found in sample ACS-10 (50:30:20) and the lowest quantity found in ACS-1 (100:0:0). The samples recorded very high number of coliform which indicates heavy contamination considered not safe for consumption. This could be as a result of poor sanitary practices during production and post pasteurization contamination during handling and packaging of the samples. The National Agency for Food and Drug Administration and Control (NAFDAC) stipulated that coliforms must not be detected in any 100 ml of yoghurt sample [36].

3.4 Results of Physical and Functional Properties of Yogurts Produced with Different Ratios Powdered Milk to Soymilk to Cornstarch

Table 5 represented the chemical and functional properties of the yogurt samples.

The percentage total solid ranged from 11.28-16.96%. It was observed that increased soymilk substitution decreased the total solids and increased cornstarch substitution increased the total solids among the samples. These results were comparable to those reported by other researcher [33] which recorded percentage total solid of soy-corn-yogurt 8.80% and 11.00% respectively. The titratable acidity ranged from 0.30-1.80%. Yogurt produced with 70% powdered milk, 20% cornstarch and 10% soy milk (ACS-5) recorded the highest value of 1.8% while yogurt produced with 60% powdered milk, 20% cornstarch and 20% soy milk (ACS-7) recorded the least value of 0.3%.

It was observed that inclusion of cornstarch and soymilk altered the acidity of yogurt. There was a significant increase in titratable acidity (0.30 - 1.80%) indicating that both soymilk and the cornstarch contributed to the titratable acidity value. The observed acidity values were accorded with the results reported by other researcher [37].

The pH of the yogurt samples ranged from 3.71 – 4.82.Yogurt produced with 50% powdered milk, 25% cornstarch and 25% soymilk (ACS-12) was the least accepted with a pH of 4.82 which does not correspond with the pH limit set by FDA, [38]. Also yogurt produced with 60% powdered milk, 25% cornstarch and 15% soy milk (ACS-8), yogurt produced with 60% powdered milk, 15% cornstarch and 25% soymilk (ACS-9),yogurt produced with 50% powdered milk, 20% cornstarch and 30% soymilk (ACS-10) and yogurt produced with 50% powdered milk, 30%

cornstarch and 20% soymilk (ACS-11) recorded a pH value of 4.71, 4.62, 4.80 and 4.70 which does not correspond with the pH limit set by FDA, [38].

The percentage water absorption capacity ranged from 0.00 - 75.33%. Yogurt produced with 100% powdered milk (ACS-1) recorded the highest value of 75.33% which could be as a result of higher percentage of cow milk used while control (ACS-13) recorded 0% which could be as a result of manufacturing procedure applied by the manufacturer.

The syneresis ranged from 0.00 - 28.33%. Yogurt produced with 50% powdered milk, 20% cornstarch and 30% soy milk (ACS-11) recorded the highest value of 28.33% while control (ACS-13) recorded absence of syneresis (0%) which could be as a result of preparation of yogurt under controlled condition by the manufacturer. The syneresis (0.00 - 28.33%) decreased with increase in cornstarch substitution and increased with increase in soy milk substitution. The values for syneresis were comparable to the results of [39].

The apparent viscosity ranged from 1337 - 4338 cP. It was observed that yogurt samples with higher substitution with cornstarch were more viscous than soy milk substitution. The apparent viscosity (1337-4338 cP) of the yogurt samples decreased with increase in the ratio of soy milk substitution and increased with increase in the ratio of cornstarch substitution.

3.5 Results of Sensory Evaluation of Samples

Table 6 showed the results of sensory qualities of the yogurt samples. The taste attribute ranged from 1.90 – 6.10 relating to “dislike extremely” to “like moderately” on the 7-point hedonic scale. Yogurt sample produced with 100% powdered milk (ACS-1) was the most preferred while yogurt sample produced with 50% of powdered milk, 20% of cornstarch and 30% of soy milk (ACS-11) was the least preferred as it was observed to have an unfavorable beany-taste of soy milk. The taste evaluation indicated good acceptance of the yoghurt samples except yoghurt samples produced with 60% of powdered milk, 25% of cornstarch and 15% of soy milk (ACS-8), 60% of powdered milk, 15% of cornstarch and 25% of soy milk (ACS-9), 50% of powdered milk, 30% of cornstarch and 20% of soy milk (ACS-10) and 50% of powdered milk, 20% of cornstarch and 30% of soy milk (ACS-11).

The flavor attribute ranged from 2.80 – 7.58 relating to “dislike moderately” to “like extremely” on the 7-point hedonic scale. Yogurt sample produced with 100% powdered milk (ACS-1) was the most preferred while yogurt sample produced with 50% of powdered milk, 20% of cornstarch and 30% of soy milk (ACS-11) was the least preferred. The yoghurt samples were acceptable from the standpoint of flavour except the beany-flavour observed in yoghurt samples with high soy milk substitution.

The texture attribute ranged from 1.51- 6.23 relating to “dislike extremely” to “like slightly” on the 7-point hedonic scale. Yogurt sample produced with 100% powdered milk (ACS-1) was the most preferred while yogurt sample produced with 50% of powdered milk, 30% of cornstarch and 20% of soy milk (ACS-10) was the least preferred which was observed to be highly thick and have a very unpleasant consistency and texture. The result of texture analysis indicated good acceptance as it was observed that cornstarch improved the texture of the samples thereby prevented syneresis from occurring while samples with increased substitution of soy milk were observed to be thinnest as viscosities seem to be decreased.

The appearance attribute ranged from 3.76- 6.60 relating to “dislike slightly” to “like moderately” on the 7-point hedonic scale. Yogurt sample used as control (ACS-13) was the most preferred while yogurt sample produced with 50% of powdered milk, 30% of cornstarch and 20% of soymilk (ACS-10) was the least preferred. The yoghurt samples indicated good acceptance in terms of appearance except ACS-10 sample that was disliked slightly by the panelists.

In overall acceptability, the mean ranged from 1.76- 6.80 relating to “dislike extremely” to “like moderately” on the 7-point hedonic scale. Yogurt produced with 100% powdered milk (ACS-1) was the most accepted while yogurt sample produced with 50% of powdered milk, 30% of cornstarch and 20% of soymilk (ACS-10) was the least accepted as it was observed to have a very thick and unpleasant consistency, mouth-feel and texture than other yogurt samples. The results of sensory evaluation indicated good acceptance from the standpoint of overall acceptability except ACS-10 which was disliked extremely and ACS-11 which was disliked moderately.

Table 5. Functional and Chemical analyses of yogurts produced with different ratios of powdered cow milk, soymilk and cornstarch

No	Sample code	% Pm:Cs:Sm	Total solids %	Titratable acidity %	Syneresis %	WAC %	Apparent viscosity cP	pH
1	ACS-1	100:00:00	15.00^{f}±1.00	0.80^{de}±0.10	20.66^{e}±0.60	75.33^{a}±1.10	3063^{b}±3.00	4.00^{e}± 0.25
2	ACS-2	90:05:05	15.52^{e}±0.02	0.70^{e}±0.10	25.00^{cd}±1.00	72.66^{b}±1.20	2862^{c}±1.00	4.11^{de}± 0.05
3	ACS-3	80:10:10	15.96^{cde}±0.02	0.60^{e}± 0.10	24.33^{cd}±0.60	51.00^{c}±1.00	2126^{cd}±4.90	4.30^{cde}±0.10
4	ACS-4	70:15:15	15.72^{de}±0.02	1.20^{b}± 0.20	24.00^{d}±1.00	44.33^{de}±1.5	2334^{c}±0.50	4.31^{cd}±0.00
5	ACS-5	70:20:10	16.16^{bcd}±0.04	1.10^{ab}±0.10	27.33^{ab}±1.20	45.33^{d}±1.2	1960^{d}±120.6	4.50^{a}±0.05
6	ACS-6	70:10:20	14.78^{f}±0.01	1.80^{a}±0.10	26.00^{bc} ±1.00	42.33^{e}±1.5	3270^{b}±0.50	4.51^{a}±0.05
7	ACS-7	60:20:20	14.87^{f}±0.02	0.30^{f}±0.10	28.00^{a}±1.00	21.66^{g}±2.1	3156^{bc}±1.50	4.50^{a}±0.05
8	ACS-8	60:25:15	16.43^{abc}±0.03	0.70^{e}±0.10	24.33^{cd}±0.60	42.66^{e}±1.5	1528^{d}±1.10	4.62^{a}±0.05
9	ACS-9	60:15:25	13.98^{g}±0.01	0.90^{cd}±0.20	21.66^{e}±1.50	36.00^{f}±2.0	3554^{b}±28.8	4.71^{ab}±0.00
10	ACS-10	50:30:20	16.60^{ab}±0.01	0.80^{de}±0.00	18.33^{f}±1.50	24.00^{g}±1.0	4338^{a}±0.50	4.80^{a}±0.10
11	ACS-11	50:20:30	13.80^{g}±0.01	0.60^{e}±0.10	28.33^{a}±1.50	45.66^{d}±2.1	1337^{e}±3.70	4.70^{ab}± 0.20
12	ACS-12	50:25:25	14.94^{f}±0.02	0.70^{e}±0.00	18.66^{f}±1.20	42.00^{e}±1.0	3227^{b}±8.50	4.82^{a}± 0.20
13	ACS-13	Market-Sp	16.67^{a}±0.02	1.0^{cd}±0.30	0.00^{g}±0.00	0.00^{h}±0.0	2648^{c}±3.40	3.73^{f}± 0.00

**Values are mean ± standard deviation of triplicate determinations*
WAC = Water absorption capacity
Market-Sp = Market sample

Table 6. Sensory evaluation and pH of yogurt samples produced with different ratios of powdered cow milk, soymilk and cornstarch

S/N	Sample code	% Pm:Cs:Sm	Taste	Flavour	Texture	Appearance	Overall acceptability
1	ACS-1	100:00:00	6.10^{a}± 1.64	7.58^{a}± 1.45	6.23^{a}±7.90	6.40^{ab}±1.85	6.80^{a}± 1.40
2	ACS-2	90:05:05	5.32^{ab} ± 1.90	7.22^{ab}± 1.76	5.82^{ab}±1.40	5.90^{b}± 2.09	6.36^{a}± 1.73
3	ACS-3	80:10:10	5.82^{ab}±2.23	4.42^{def}± 1.01	5.32^{ab}±1.50	5.22^{c}± 1.20	5.50^{b} ± 1.50
4	ACS-4	70:15:15	5.10^{abc}±1.31	4.60^{def}±1.19	5.81^{ab} ±4.10	5.21^{c}± 1.74	5.42^{b}± 0.70
5	ACS-5	70:20:10	5.10^{abc}±1.90	5.92^{abc}± 1.65	5.62^{ab}±1.40	4.61^{cd}± 1.20	5.12^{bc}± 4.50
6	ACS-6	70:10:20	5.71^{ab} ± 2.21	5.26^{bcd}±1.30	5.01^{bc}± 0.98	4.60^{cd}± 1.30	5.50^{b}± 1.50
7	ACS-7	60:20:20	4.70^{bc}± 1.87	4.48^{def}±1.11	4.26^{cd}±1.50	4.11^{de} ± 1.50	4.48^{c}± 1.05
8	ACS-8	60:25:15	3.90^{cd}± 1.55	4.96^{cde}±1.17	4.31^{cd}±1.40	5.02^{bc}± 1.60	4.80^{c}± 1.10
9	ACS-9	60:15:25	4.60^{bc}± 1.83	4.48^{bcd}±1.72	4.90^{cd}±1.97	4.30^{cd}±1.32	4.24^{c}± 1.13
10	ACS-10	50:30:20	2.13^{de} ± 0.70	4.18^{ef}± 1.04	1.51^{e}±0.78	3.76^{e}±0.77	2.04^{de}±0.72
11	ACS-11	50:20:30	1.90^{e}± 0.90	2.80^{f}± 0.90	1.96^{e}±1.00	4.34^{cd}±1.11	1.76^{e}± 0.77
12	ACS-12	50:25:25	2.60^{de}± 1.10	5.34^{bcd}± 1.09	2.02^{de}±1.00	4.20^{cd}±1.13	6.46^{a}± 1.24
13	ACS-13	Market-Sample	5.00^{abc}± 1.49	7.08^{ab}± 7.19	6.22^{a}± 1.78	6.60^{a}±1.84	6.58^{a}± 1.48

Values are mean ± standard deviations of 50 sensory scores of 30 semi-trained panelists

4. CONCLUSION

This study showed that addition of soymilk and cornstarch affected the physicochemical, functional and sensory qualities of yogurt. This study revealed the mix ratios of composite yoghurt that were generally acceptable and had the pH following yoghurt standard. The substitution of powdered cow milk with soy milk and cornstarch up to 30% showed level of acceptability by consumers from 5% to 20% and had pH in accordance with yoghurt standard. Nutritionally, the yoghurt samples from mixtures of soymilk and cornstarch met the dietary requirements of yoghurt without significant difference when compared with that of literature. This product minimized the cost of production of yoghurt such that overdependence and cost of importation of powdered milk is reduced and consumers are provided with high protein quality product at an affordable price. The adjuncts (soymilk and cornstarch) are readily available and are considered nutritionally balanced diet. The yogurt samples were recommended for individuals that have health-related issues such as cow's milk protein allergy and intolerance, lactose intolerance, high cholesterol level, obese patients and vegans. Therefore, production of soy-cornstarch-yogurt should be encouraged because soybeans and cornstarch are local substitutes which are readily available and seem to be more affordable than using only powdered cow milk to produce yoghurt that is expensive due to importation.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tamime AY, Robinson RK. Background to manufacturing practice. In Tamime and Robinson's Yogurt: Science and Technology, 3rd edition, Woodhead Publishing Ltd: Cambridge, UK. 2007;11–118.
2. Fox PF, McSweeney P. Advanced Dairy Chemistry: Lipids. 2006;2. ISBN 978-0-387-26364-9
3. Dabrowski WM, Sikorski, ZE. Toxins in Food. CRC Press; 2004. ISBN 978-0-8493-1904-4
4. Davoodi H, Esmaeili S, Mortazavian AM. Effects of milk and milk products consumption on cancer: a review. Comp. Reviews in Food Sci and Food Safety. 2013;12:249-264. Doi: 10.1111/1541-4337.12011
5. Shakar R, Abu-Jdayil B, Jumah R, Ibrahim S. Rheological properties of set yogurt during gelation process (Impact of incubation temperature). Foodmicrobial. 2001;56:622–625.
6. Hassan A, Ipsen R, Janzen T, Qvist K. Microstructure and rheology of yogurt made with cultures differing only in their ability to produce exopolysaccharides. Dairy Sci. 2003;86:1632–1638.
7. Jimoh KO, Kolapo AL. Effect of different stabilizers on acceptability and shelf stability of soy-yoghurt. Afri J of Biotech. 2002;6(8):1000–1003.
8. Saleh A, Mohamed AA, Alamri MS, Hussain S, Qasem AA, Ibraheem MA. Effect of Different Starches on the Rheological, Sensory and Storage Attributes of Non-fat Set Yogurt. Foods. 2020;9:61.
9. Ukwo SP. Physiochemical, profile and sensory attributes of plain yoghurt from cow milk and soymilk blends. Nigerian J of Agric Environ. 2015;11:20- 23.
10. Iwe MO. Sensory Methods and Analysis. Rejoint communication Publisher Enugu, Nigeria. 2002;49-52.
11. Lee WJ, Lucey JA. Impact of gelation conditions and structural breakdown on the physical and sensory properties of stirred yogurts. Dairy Sci. 2006;89:2374-2385.
12. Phillip GO, Williams PA. Handbook of hydrocolloids. Second edition, Wood head Publishing India Private Limited, NewDelhi-110002 India; 2009.
13. Vedamuthu ER. Starter cultures for yogurt and fermented milks. Chandan, R.C., Edition, Blackwell Publishing: Ames, IA, USA. 2006;89–117.

14. White P, Yao N. Yogurt and cottage cheese enhanced with nutritionally beneficial oat fiber. Midwest Dairy Foods Research Center Annual Report. 2007;204–208.
15. Narpinder S, Jaspreet S, Lovedeep K, Navdeep SS, Balmeet SG. Morphological, thermal and rheological properties of starches from different botanical sources. Food Chem. J. 2003;81:218-231.
16. Walstra P, Wouters JTM, Geurts TJ. Dairy science and technology. CRC Press, Boca Raton, FL, USA. 2006;497-512.
17. Rukaya SK. Effect of dehulling and ratio of water extraction to the quantity of soybean (Glycine max) on the quality of soymilk. B. Tech. Department of Food Science and Technology, Kano University of Science and Technology, Wudil, Kano State, Nigeria; 2017.
18. Lee SJ, Lee S, Ahn J, Kwak HS. Property changes and cholesterol-lowering effects in the evening primrose oil enriched and cholesterol reduced yoghurt. Intl. Jof Diary Tech. 2007;60:22-30.
19. Bristone C, Igwe EC, Badau MH, Boafo O, Zira VG. Microbial ecology and effectiveness of different starter cultures in yoghurts produced from whole cow milk and soy beans. Afri J of Food Sci and Tech. 2016;7(5):107-117.
Available:http://dx.doi.org/10.14303/aijfst
20. AOAC. Official methods of analysis. Association of Official Analytical Chemists (18th Edition). Gaithersburg, USA; 2010.
21. James CS. Analytical chemistry of foods. Blackie Academic and Professional press, New York. 1996;158-163.
22. Onwuka GI. Food analysis and Instrumentation, theory and practice. Napthali prints, HG support Nigeria Ltd. 2005;58-67.
23. Atallah A. Development of new functional beverages from milk permeate using some probiotic bacteria and fruit pulp. Egyp J of Dairy Sci. 2015;111- 125.
24. Micanel N, Haynes I, Playne M. Viability of probiotic cultures in commercial Australian yogurts. Aust J of dairy tech. 1997;52(1):24.
25. Tamime AY, Marshall VME, Robinson RK. Microbiological and technological aspects of milks fermented by bifidobacteria.DairyResearch. 1995;62:151–187.
26. Djurdjevic DJ, Macej O, Jovanovic S. The influence of investigated factors on viscosity of stirred yoghurt. J of Agric Sci. 2002;47(2):219-231.
27. Drake MA, Jones VS, Russell T, Harding R, Gerard PD. Comparison of lexicons for descriptive analysis of whey and soy protein in New Zealand and U.S.A. Sensory Studies. 2007;22:433-52.
28. Statistical Package for Social Science. IBM SPSS for intermediate statistics: Use and Interpretation (4th edition). Routledge/Taylor & Francis Group; 2011.
29. Oshundahunsi OT, Amosu D, Ifesan BOT. Quality evaluation and acceptability of soy-yoghurt with different colors and fruit flavours. Ameri J of Food Tech. 2007;2(4):273-280.
30. Ogbemudia RE, Nnadozie BC, Anuge B. Mineral and proximate composition of soybean. Asia J of Phy and Chem Sci. 2017;4(3):1-6.
31. Nwoke FU, Umelo MU, Okorie JN, Ndako KJ, Maduforo AN. Nutrient and Sensory Quality of Soymilk produced from different improved varieties of soybean. Pak J of Nut. 2015;14:898-906.
32. Tamime AY, Deeth HC. Yoghurt: technology and biochemistry. Food Protectio. 1980:43(12) 939-977.
33. Olakunle MM. Production and quality evaluation of soy-corn yoghurt. Advanced J of Food Sci. and Tech. 2012;4(3):130-134.
34. Bahareh H, Peiyman M. Comparison of soymilk and cow milk nutritional parameter. Research J of Bio Sci. 2008;3:1324-1326.
35. Codex Alimentarius Commission. Codex standard for fermented milks. Codex Stan. 2010;243-2003.
36. Mbaenyi-Nwoha IE, Egbuche NI. Microbiological evaluation of satchet water and street-vended yoghurt and Zobo drinks sold in Nsukka Metropolis. Intl J of Bio and Chem Sci. 2012;6(4):1703-1717.
37. Mahmood A, Abbas N, Gilani AH. Quality of stirred buffalo milk yogurt blended with apple and banana fruits. Pak J of Agric Sci. 2008;45:275-279.
38. FDA. Department of Health and Human Services. Food Labeling: Soy protein and coronary heart disease. 21 CFR Part 101. Docket No. 98P-0633. Fed Reg64:57700-2; 2009.
39. Farooq K, Haque ZU. Effect of sugar esters on the textural properties of nonfat low calorie yoghurt. Dairy Sci.1992:75(10):2676-2680.

Score card for sensory evaluation of composite yogurts produced with different ratios of substitution with powdered cow milk, soy milk and cornstarch

Questionnaire for scoring

You are presented with a coded sample for quality tests; please score them individual as you like or dislike it in the scale below. You can taste the sample more than once.

Name: ……………………………………………………………………………………..

Sensory quality factors	**Samples**													
Taste	Score	ACS-1	ACS-2	ACS-3	ACS-4	ACS-5	ACS-6	ACS-7	ACS-8	ACS-9	ACS-10	ACS-11	ACS-12	ACS-13
Dislike extremely	1													
Dislike moderately	2													
Dislike slightly	3													
Neither like nor dislike	4													
Like slightly	5													
Like moderately	6													
Like exteremely	7													
Texture	Score	ACS-1	ACS-2	ACS-3	ACS-4	ACS-5	ACS-6	ACS-7	ACS-8	ACS-9	ACS-10	ACS-11	ACS-12	ACS-13
Dislike extremely	1													
Dislike moderately	2													
Dislike slightly	3													
Neither like nor dislike	4													
Like slightly	5													
Like moderately	6													
Like exteremely	7													
Flavour	Score	ACS-1	ACS-2	ACS-3	ACS-4	ACS-5	ACS-6	ACS-7	ACS-8	ACS-9	ACS-10	ACS-11	ACS-12	ACS-13
Dislike extremely	1													
Dislike moderately	2													
Dislike slightly	3													
Neither like nor	4													

Sensory quality factors	**Samples**													
dislike														
Like slightly	5													
Like moderately	6													
Like exteremely	7													
Appearance	Score	ACS-1	ACS-2	ACS-3	ACS-4	ACS-5	ACS-6	ACS-7	ACS-8	ACS-9	ACS-10	ACS-11	ACS-12	ACS-13
Dislike extremely	1													
Dislike moderately	2													
Dislike slightly	3													
Neither like nor dislike	4													
Like slightly	5													
Like moderately	6													
Like exteremely	7													
Overall acceptability	Score	ACS-1	ACS-2	ACS-3	ACS-4	ACS-5	ACS-6	ACS-7	ACS-8	ACS-9	ACS-10	ACS-11	ACS-12	ACS-13
Dislike extremely	1													
Dislike moderately	2													
Dislike slightly	3													
Neither like nor dislike	4													
Like slightly	5													
Like moderately	6													
Like exteremely	7													

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