



Production and Physicochemical Properties of Cake with Different Ratios of Soy Lecithin

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Authors' contributions

This work was carried out in collaboration among all authors. Author HOA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors RCE and JEO managed the analyses of the study. Author CCE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This research was geared towards producing and evaluating the physicochemical properties of cake with different ratios of soy lecithin. Soy lecithin was produced by the degumming of raw soy oil by adding 2% water content to the oil and heating to 70°C. Soy oil yield was 31% while lecithin yield was 2.18%. The soy lecithin produced had a yellow-brownish colour. Mixture design was used for the experiment. The soy lecithin was used to replace 50% and 100% egg content in two different cake samples while a third sample had no lecithin. The first sample was made up of 250g wheat flour, 100g Margarine, 65g sugar, 5g baking powder, 2 eggs, 1.25g soy lecithin and 2g salt (MEL2), the second sample was made up of 250g wheat flour, 80g Margarine, 65g sugar, 5g baking powder, 2.5g soy lecithin and 2g salt (MEL3) while the third sample was made up of 250g wheat flour, 100g Margarine, 65g sugar, 5g baking powder, 4 eggs and 2g salt (MEL1). The margarine content of sample MEL3 was reduced by 20%. The physical properties of the cake samples were examined and sample MEL2 gave a better physical appeal than the other samples after baking. The specific volume of sample MEL2 (4.21cm³) was higher than those of samples

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MEL1 and MEL3. The proximate composition of the samples showed that the moisture content ranged from 32.9 – 34.1%, protein content 5.89 – 6.14%, ash content 1.61 – 1.64%, fat content 14.5 – 15.3% and carbohydrate 43.09 – 44.85%. Sensory evaluation was carried out on the samples to determine the most acceptable and analysis of variance was used to check for significant difference. Sample MEL2 was preferred in taste, colour, texture, flavour and general acceptability and was significantly different from samples MEL1 and MEL3 in general acceptability. It was observed that egg and some fat content in cakes could be replaced with soy lecithin. This study forms a basis for new product development for the pastry food industry.

Keywords: Margarine; cake; egg; soy; lecithin.

1. INTRODUCTION

Cakes are ready-to-eat baked desserts which are sweet and eaten by many in the society [1]. This is mainly due to its ready-to-eat nature; its availability in different varieties besides its reasonable cost. Cakes are among the cereal products mainly composed of wheat flour and characterized by a flexible and elastic alveolar crumb [1]. The ingredients like wheat flour, egg, sugar, fat and leaveners, and the process (mixing and baking) conditions involved in cake making determine the quality of the cakes [2]. Egg has good emulsifying, foaming and gelation effect and has the ability to influence colour and aroma, and enhance moistness and soft texture of cakes [2].

Products made out of soy are becoming very popular to increase protein content. According to the United States Food and Drug Administration (FDA), adding more soy to the diet reduces the risk of heart disease, cancer, and decreases discomfort in menopausal women [3]. Twenty five grams of soy combined with a diet low in saturated oil and cholesterol may reduce the risk of heart disease [4].

Soy protein is a subject of intense investigation and has had an increasing role in human nutrition over the last few decades [5]. Health benefits include: reduced blood pressure, lower cholesterol levels and improved bone health [6]. Soy protein also contains all nine essential amino acids [7].

In reality, minute amounts of soy protein always remain in lecithin as well as in soy oil [8]. Soy lecithin is a brownish-yellow fatty substance used as an emulsifier [9] and is an additive found in many foods, but is normally used in such small amounts that rarely exceed one percent of the weight of any food product [10]. Lecithin is a combination of naturally-occurring phospholipids that are extracted during the processing of soybean oil [11].

Soy lecithin is a complex fatty substance, derived from soybeans through mechanical or chemical methods of preparation. And soy lecithin gives the benefit of reducing triglyceride and bad cholesterol (Low Density Lipoprotein), while increasing the amount of good cholesterol (High Density Lipoprotein) in the body [12].

Soy has been researched when incorporated in cookies, bread, extruded puffs, and pasta or in combination with rice or with corn [13]. There are two ways to extract the oil out of soy: mechanical expelling and solvent extraction [14].

In a large scale production, soy lecithin is manufactured from soybean by using appropriate solvents like hexane in a specific proportion. The main phospholipids in lecithin from soya and sunflower are phosphatidyl choline (PC), phosphatidyl inositol (PI), phosphatidyl ethanolamine (PE), and phosphatidic acid (PA) [15]. Various studies have been conducted with an objective to find soy lecithin benefits and side effects [10]. The aim and objectives of this research are: (i.) to produce soy lecithin from soy bean (ii.) to replace eggs and some fat in cake recipe with soy lecithin (iii.) to analyse these cakes for its physicochemical properties.

2. MATERIALS AND METHODS

2.1 Sources of Material

Raw soy oil used was produced at Fortune oil Ltd, Kano. All analysis were carried out at the Department of Food Science and Technology, Federal Polytechnic Bauchi, Nigeria.

2.2 Production of Soy Lecithin

Soy lecithin was produced by simple degumming. Soybeans were heated for 30 min to 71°C in a cooker to facilitate dehulling. They were cracked into 6-8 pieces using corrugated rolls, the hulls were removed by a zig-zag

aspirator, the cotyledons were heated to 76.7°C and flaked to 0.011 inch with a twin roll stand flaker, extruded at 98.9°C with an extruder which yielded fine shreds of full-oil soybean. The oil content was reduced to 6% by using the screw oil expeller which then gave raw soy oil. 20 ml of the oil was hydrated with 2% water (0.4 ml) to give maximum yield of lecithin. The hydrated oil was heated in a bath to 70°C and 5 ml pipetted into centrifugal tubes each. The tubes were held at the same temperature in the bath for 20 min, while being agitated to enhance sludge formation. The tubes were then placed in a centrifuge and centrifuged for about 15 min. at 4000 rpm. The excess oil was decanted and the lecithin was obtained.

2.3 Production of Cake

Soy lecithin was then used to replace eggs at 50% and 100% levels in test samples and margarine content was reduced for sample MEL3 (Table 1.) and mixture design was adopted for the experiment. The various ingredients were prepared based on 100% wheat flour standard according to [16]. The sugar and shortening were mixed until fluffy. The beaten eggs were added one at a time until all eggs were added. The flour and baking powder were sieved and added gradually to the mix until a fine paste was obtained. The pans were greased and the mix poured into the pan and baked at 120°C for 30 minutes.

2.4 Sensory Evaluation

A group of 20 semi- trained panelists from Federal Polytechnic Bauchi students were used to evaluate the three products based on the appearance in terms of colour, texture, taste, flavour and general acceptability using a nine point hedonic scale. The results were compiled and treated using Analysis of Variance (ANOVA) to ascertain if the samples significantly differed from each other.

2.5 Proximate Analysis

The proximate analysis was carried out according to the methods outlined by [17,18].

2.5.1 Moisture content

Two grams of the dried ground sample was weighed into a crucible and placed in an oven at a controlled temperature of 105°C. The sample was allowed to dry in the oven to a constant weight. The percentage moisture content was then expressed as the percentage of the original weight of the sample. The experiment was carried out in triplicates the percentage moisture was thus calculated:

$$\text{Percentage moisture} = \frac{W2 - W3}{W1} \times 100$$

$$W2 - W1$$

Where W1 = Mass of dried crucible, W2 = Mass of dry crucible+ Sample before drying, W3 = Mass of dry crucible + Sample after drying

2.5.2 Ash content

Two grams of the dried sample was measured into a crucible and placed in the muffle furnace at 550°C until it was burnt to ash. The crucible and content were then allowed to cool in a desiccator and weighed. This was done repeatedly until a constant weight of the ash was obtained. The percentage ash content was then expressed as percentage of the original weight of the sample on dry basis. The experiment was done in triplicates. Percentage ash content was thus calculated:

$$\% \text{ Ash} = \frac{W2 - W3}{W1} \times 100$$

Where W1 = Weight of sample analysed, W2 = Weight of empty crucible, W3 = Weight of crucible + Ash

Table 1. Recipe for cake at different proportions

Formula	%	Value (g)		
		Sample MEL1	Sample MEL2	Sample MEL3
Wheat Flour	100	250	250	250
Margarine	40	100	100	80
Sugar	26	65	65	65
Baking powder	2	5	5	5
Egg(s)	-	4 pieces	2 pieces	-
Lecithin	0.5-1	-	1.25	2.5
Salt	0.8	2	2	2

2.5.3 Crude fat content

Ten grams of the dried ground sample was weighed and wrapped with a clean filter paper and placed into the thimble in a soxhlet extractor. A round bottom flask was cleaned, weighed and 120ml of food grade hexane added. The flask was connected to the sample holder of the soxhlet extractor and heated slowly on a mantle for 6h. Refluxed hexane was recovered and the flask containing the lipid was dried in the moisture extractor in the oven at 60°C for few minutes to remove any residual solvent. After drying, the flask containing the oil was cooled in a desiccator and reweighed. By difference, the mass was determined and expressed as the percentage of the fat thus:

$$\text{Percentage (\%)} \text{ Crude fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

2.5.4 Crude fibre content

Two grams (2g) of the defatted dried sample was transferred into a 100ml flask, followed by addition of 200ml of 1.25% sulphuric acid. The flask was then placed in a digest apparatus on a pre-adjusted hot plate and boiled for 30min with rotation of the flask periodically to prevent solid from adhering to the bottom of the flask. At the end of 30min, the mixture was allowed to stand for one minute, and filtered immediately through the Buchner funnel lined with a muslin cloth. The insoluble matter was washed into the flask for alkali digestion using 0.3M sodium hydroxide. The digest was boiled for 30min and was allowed to cool for 1min and then filtered using a muslin cloth as before. The residue was then washed successively with 0.1M HCl and finally with boiling water until it was free of acid. It was then washed twice with alcohol and thrice with ether. The residue or insoluble matter was then transferred into a crucible and dried at 105°C in an oven to a constant weight, cooled and weighed. It was then ashed at 550°C, cooled and weighed. The difference in weight after ashing was then calculated as the fibre content of the sample and was expressed as a percentage of the original weight. The percentage crude fibre content was this calculated:

$$\% \text{ Crude Fibre} = \frac{W2 - W3}{W1} \times 100$$

Where W1 = Weight of sample
W2 = Weight of sample and crucible after drying at 105°C,
W3 = Weight of sample (as ash) and crucible after ashing

2.5.5 Crude protein content

An aliquot 0.6g of the dried ground sample was weighed into an already dried Kjeldahl flask. A few drops of water was added to the sample to moisten it, using a burette, 3ml of conc. H₂SO₄ acid was added into the flask followed by the addition of 0.5g of CuSO₄. The content of the flask was then digested in a fume cupboard with occasional stirring until a clear solution was obtained. The flask was allowed to cool and a small quantity of distilled H₂O added. The digest was then transferred into 100ml volumetric flask and the initial volume recorded. The mixture was shaken thoroughly to obtain a homogenous solution. The mixture was now ready for distillation. The distillation apparatus was steamed for 30min as to get rid of traces of alkali left in the flask. With the aid of a pipette, 10ml of the digest was added to the micro distillation apparatus using a funnel. 10ml of 50% NaOH solution was put in the funnel with measuring cylinder, with stopper glass rod in place. A water condenser set was connected with a 100ml conical flask used as a receiver which contained 10ml of 4% boric acid and two (2) drops of mixed indicator (bromocresol green/methyl red). The drop end of the condenser was immersed well into the boric acid. The stopper glass rod was gradually removed to allow the NaOH solution to thoroughly mix with the sample digest solution. The funnel was filled with distilled H₂O and the steam generator was closed at the top and steam passed into the distillation set. NH₃ was liberated and was distilled into 10ml 4% boric acid for 15 min. 50ml of the distillate of blue/green colour was collected and the drip end of the condenser was washed with distilled water into the 100ml conical flask containing the distillate. The distillate was then titrated against 0.1N hydrochloric acid till it changed to pink colour. A reagent blank was run as a control and the protein content was then calculated by multiplying Nitrogen obtained with the factor of 6.25, expressed on dry basis. The experiment was carried out in triplicates. The formula for % crude protein is given below:

$$\% \text{ Protein} = \% \text{ N}_2 \times 6.25$$

$$\% \text{ N}_2 = \frac{100 \times N}{W} \times 14 \times \frac{V_t}{V_a}$$

Where W = Weight of sample
N = Normality of titrant
V_t = Total digest volume
V_a = Volume of digest analyzed

T = Sample titre value

B = Blank titre value

2.5.6 Carbohydrate content

Carbohydrate content was determined by the difference method. This was done by summing up the % moisture, % protein, % fat, % ash and % crude fibre contents and then subtracting their sum from 100. It was also expressed in percentage (%)

2.6 Volume Measurement

Rapeseed displacement method described by [19] was used to determine the volume of the cakes. Rapeseeds were poured in a container to measure the volume, and then were measured in a graduated cylinder and marked as V1. Thereafter, the sample was placed in the same container and seeds poured till the test cake was covered. Again the rapeseeds were measured in a graduated cylinder and marked as V2. The volume of sample was then calculated with the formula:

$$\text{Loaf volume (ml)} = V1 - V2$$

Where V1 represents the volume of rapeseeds in the empty container (ml) and V2 represents volume of the rapeseeds in the container containing sample (ml).

3. RESULTS AND DISCUSSION

3.1 Physical Properties of Soy Lecithin and Cake Samples

Soy Lecithin was produced as part of the objective of this research. Soy oil yield was 31% while lecithin yield was 2.18%. The soy lecithin produced had a yellow-brownish colour.

Physical properties of the cake samples (Table 2) showed that Sample MEL2 [100g Margarine + 2 eggs + 1.25g soy lecithin) was more outstanding than Samples MEL1 (100g Margarine used + 4 eggs + No lecithin) and MEL3 (80g Margarine + No egg + 2.5g soy lecithin.). It gave a better flavour, excellent golden-brown crust, smoother surface and was more appealing to sight. This could be as a result of the combined effect of soy lecithin and egg in cake. Therefore, Sample MEL2 showed that lecithin could be used to 50% percentage of egg in cakes to achieve a very high quality product. Lecithin reduces viscosity, helps in homogenous

mixing of ingredients, improves flavour release, increases volume and leads to the incorporation of more air bubbles resulting to softer texture, reduced spotting, smoother surface with a more uniform grain distribution [20] while egg contains amino acids which aid in maillard reaction and browning of baked products [21].

3.2 Volume and Specific Volume

Sample MEL1 (100g Margarine used + 4 eggs + No lecithin) had the highest volume (70.34 cm³) and specific volume (4.21cm³) as shown in Table 3, while Sample MEL3 had the lowest volume (68.32 cm³) and lowest specific volume (3.86 cm³). Sample MEL1 had the highest volume possibly due to the higher egg to margarine ratio and the ability of egg to inculcate air and rise above their normal volume when beaten [21].

3.3 Proximate Composition of the Cake Samples

The moisture content of the cake samples were not significantly different (p<0.05). The highest moisture content was observed in Sample MEL3 (33.62%) while Sample MEL1 (32.90%) had the lowest moisture content as shown in Table 4. This may be partly due to the inability of the amount of soy lecithin added to retain more moisture than the eggs which inculcate air when beaten. The phospholipids naturally present in lecithin [22] were not able to attract and hold a significant amount of water and therefore couldn't increase hydration. It improved moisture and texture at the same time.

There was also no significant difference (p<0.05) in the protein values of the cake samples. The highest protein was found in Sample MEL1 (6.43%), and the lowest was in sample MEL3 (5.89%). Generally, the protein content of the cake samples increased with increased egg addition. The increase in protein content of the cakes with increased egg addition could be content of protein due to the high content of protein in eggs. This improved the nutritive value of the cake and also helped in maillard reaction.

There was no significant difference (p<0.05) for the % ash values of the cake samples. Sample MEL2 had the highest ash content (1.77%) while Sample MEL1 had the lowest ash value (1.61%). The varied ingredients (margarine, egg and Lecithin), at the amounts varied, hadn't the ability to significantly (p<0.05) influence the ash content. The ash content indicated the mineral content of the cake.

Table 2. Baking test result for the cake samples

Sample	Physical examination results
MEL1	It had a velvety crumb, golden brown surface, moist surface and good volume with uniform cell wall
MEL2	It had a good volume, golden brown surface and very fine cell wall and gave a unique flavor
MEL3	It had a good volume, golden brown surface, well distributed cell walls

Sample MEL1 = 100g Margarine used + 4 eggs + No lecithin, Sample MEL2 = 100g Margarine + 2 eggs + 1.25g soy lecithin, Sample MEL3 = 80g Margarine + No egg + 2.5g soy lecithin.

Table 3. Volume measurements for cake sample

Sample	Volume (cm ³)	Specific volume (cm ³)
MEL1	70.34 ± 0.01	4.21 ± 0.01
MEL2	69.50 ± 0.01	4.15 ± 0.01
MEL3	68.32 ± 0.01	3.86 ± 0.01

Values are mean ± standard deviation. Sample MEL1 = 100g Margarine used + 4 eggs + No lecithin, Sample MEL2 = 100g Margarine + 2 eggs + 1.25g soy lecithin, Sample MEL3 = 80g Margarine + No egg + 2.5g soy lecithin

There was significant difference ($p < 0.05$) between the fat content of sample MEL3 with the other two samples; MEL1 (100g Margarine used + 4 eggs + No lecithin) and MEL2 (100g Margarine + 2 eggs + 1.25g soy lecithin). Sample MEL1 and MEL2 were not significantly different ($p < 0.05$) from each other. Fat content was highest (15.92%) for Sample MEL1 and lowest for Sample MEL3 (15.30 %). Sample MEL3 was significantly lower in fat content than the other samples possibly because of the fact that 20g of margarine was reduced from it during preparation. Samples MEL1 and MEL2 with the same amount of margarine (100g) but 0g and 1.25g soy lecithin didn't vary significantly ($P < 0.05$) indicating that soy lecithin couldn't significantly influence the fat content at the level added. Liquid soy lecithin contains 30% oil but most of the oil was removed from the powder form leaving about 97% pure lecithin with about 2% residual oil [22]. Soy lecithin is said to contain more unsaturated fats than saturated fats, indicating reduced health risk [22]. There was no significant difference ($p < 0.05$) in the

carbohydrate content of the cake samples. The carbohydrate content of Sample MEL3 (42.14%) was the highest while that of Sample MEL2 (41.17%) was lowest. The similar carbohydrate values for the cake samples could be as a result of the constant weight (250g) of wheat used for all the samples.

3.4 Sensory Evaluation of the Cake Samples

There was no significant difference ($p < 0.05$) in flavour between Samples MEL1 and MEL2 as shown in Table 5. However, these two samples differed significantly from sample MEL3. Samples MEL1 and MEL2 were preferred in flavour to sample MEL3. This is somewhat due to the soy-like aroma of soy lecithin which it impacts on baked goods when added in liquid form [23].

The result showed no significant difference ($p < 0.05$) in colour between the cake samples as obtained after analysis of variance.

Table 4. Proximate composition of cake samples

Sample	Ash (%)	Moisture (%)	Protein (%)	Fat (%)	Crude Fibre (%)	Carbohydrate (%)
MEL1	1.61 ^a ± 0.014	32.90 ^a ± 1.414	6.43 ^a ± 0.544	15.92 ^a ± 0.764	1.37 ^a ± 0.502	41.37 ^a ± 0.523
MEL2	1.77 ^a ± 0.177	33.46 ^a ± 0.651	6.26 ^a ± 0.851	15.90 ^a ± 0.134	1.44 ^a ± 0.212	41.17 ^a ± 0.990
MEL3	1.64 ^a ± 0.481	33.62 ^a ± 0.460	5.89 ^a ± 0.014	15.30 ^b ± 0.020	1.41 ^a ± 0.141	42.14 ^a ± 0.198

Values are means ± standard deviation of triplicate determinations. Values with different superscripts in the same column are significantly different ($p < 0.05$). Sample MEL1 = 100g Margarine used + 4 eggs + No lecithin, Sample MEL2 = 100g Margarine + 2 eggs + 1.25g soy lecithin, Sample MEL3 = 80g Margarine + No egg + 2.5g soy lecithin

Table 5. Mean Scores for the sensory evaluation of the cake samples

Samples	MEL1	MEL2	MEL3
Flavour	6.80 ^a ± 0.05	7.20 ^a ± 0.05	6.40 ^b ± 0.05
Colour	6.70 ^a ± 0.01	6.40 ^a ± 0.01	6.50 ^a ± 0.01
Taste	7.00 ^a ± 0.05	6.90 ^a ± 0.05	6.10 ^b ± 0.05
Texture	6.00 ^a ± 0.01	6.50 ^b ± 0.01	6.30 ^a ± 0.01
Overall acceptability	6.60 ^a ± 0.05	6.95 ^b ± 0.05	6.30 ^a ± 0.05

Values are mean + standard deviation. Mean values with different superscripts on the same row is significantly different ($p < 0.05$) from each other. Sample MEL1 = 100g Margarine used + 4 eggs + No lecithin, Sample MEL2 = 100g Margarine + 2 eggs + 1.25g soy lecithin, Sample MEL3 = 80g Margarine + No egg + 2.5g soy lecithin

There was no significant difference ($p < 0.05$) between samples MEL1 and MEL2 in taste. However, there was significant difference between the two samples and sample MEL3. Sample MEL3 had the least score for taste. This can be attributed to the soy-like taste of liquid soy lecithin [23].

The texture of the samples showed no significant difference ($p < 0.05$) between samples MEL1 and MEL3. However, there was significant difference between the two samples and sample MEL2. This could be attributed to the combined effect of eggs and soy lecithin in sample MEL2. Egg and soy lecithin are good emulsifiers which enhance the texture of food products.

The result showed that all the samples were accepted. There was no significant difference ($p < 0.05$) in the overall acceptability between Samples MEL1 and MEL3. However, sample MEL2 had the highest overall acceptability and differed significantly ($p < 0.05$) from the other two samples (MEL1 and MEL3).

4. CONCLUSIONS

This study was on the production of soy lecithin and also the production of cake using varying ratios of the produced soy lecithin to replace eggs at 50% and 100% levels. The study has shown that sample MEL2 which was made up of 250g wheat flour, 100g Margarine, 65g sugar, 5g baking powder, 2 eggs, 1.25g soy lecithin and 2g salt gave a better cake appearance, colour, flavour, texture and taste than sample MEL3 which was made from 250g wheat flour, 80g Margarine, 65g sugar, 5g baking powder, 2.5g soy lecithin and 2g salt) and sample MEL1 (250g wheat flour, 100g Margarine, 65g sugar, 5g baking powder, 4 eggs and 2g salt). In addition, sample MEL3 which was made from 100% soy lecithin (with no egg) still gave a good texture, colour and an acceptable taste and flavour

indicating that eggs in cakes can be replaced with soy lecithin.

Good quality cakes with lower amounts of egg and higher quantities of soy lecithin can be produced which can help to achieve a reduction in cholesterol levels in cakes as soy lecithin has no cholesterol content [23]. This can go a long way in reducing cholesterol related diseases.

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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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