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Nutritional, Physical and Sensory Properties of Soybean Mayonnaise

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Abstract
The unrivalled nutritional and health benefits derivable from soybean consumption need to be harnessed maximally to combat the increasing prevalence of notable non-communicable diseases. This study was therefore designed to determine the nutritional and sensory properties of soybean mayonnaise. Conventional mayonnaise is an oil-in-water emulsion mixture of egg, vinegar, oil and spices. Egg and vinegar were replaced with soymilk and lemon juice to give soy mayonnaise samples: LRS1 (full-fat) and LLS1 (low-fat) while a conventional commercial mayonnaise brand served as control (BS1). Proximate, vitamins, cholesterol, fatty acid profile, texture, colour and sensory evaluation were carried out using standard methods. Mean data were compared using analysis of variance at p=0.05. Protein content for BS1, LRS1 and LLS1 were; 1.03, 1.90 and 2.80% respectively while the fat content were; 72.93, 31.53 and 10.40 for BS1, LRS1 and LLS1, respectively. Soy mayonnaise samples were significantly higher in protein, ash, carbohydrate, thiamine, riboflavin and niacin than the control and they contained no cholesterol unlike the control sample. Soy mayonnaise samples were significantly higher in unsaturated fatty acids (oleic and linoeic acids) but significantly lower in saturated fatty acids than the control sample. For texture parameters the soy mayonnaise samples were significantly higher than the control in peak force, stickiness, area and gradient but at par with the control in stringiness, peak time and adhesiveness. LRS1 and LLS1 were significantly higher than control in Lightness but significantly lower in redness than control. The sensory evaluation test scores were within acceptable range for both control and soy mayonnaise samples except for the texture score for soy mayonnaise which was neither liked nor disliked. This study shows that soymilk has good potential in the production of mayonnaise as a functional food. Soy mayonnaise is more nutritious and heart friendly than the conventional commercial mayonnaise brand and is suitable for all, even vegans.

Keywords: Functional food, Mayonnaise, Soybean,

Introduction
A functional food is a food that offers additional function often related to health promotion and disease prevention and example of such is soybean. Soybean isoflavones may prevent the proliferation of cancerous growth (Romagnolo *et al*., 2017; Wan *et al*., 2017; Ganesan and Xu., 2017; DeMejia and DeLumen., 2016) and has also been observed to prevent osteoporosis and its symptoms in menopausal women. Osteoporosis is the decrease in bone strength or density common in the elderly especially in menopausal women. This results from the decalcification of bone after menopause due to lack of production of the hormone oestrogen, which has been known to prevent this decalcification. Isoflavones in soybean, that is, diadzein and genistein, are phytoestrogens that can exert the effect to protect against bone loss or decalcification of the bone in post-menopausal women. Several studies have reported the efficacy of soybean phytoestrogen in the prevention and treatment of osteoporosis (Nie *et al*., 2017;

Lambert *et al*., 2017; Yang et al., 2016; Ma *et al*., 2008). The possibility of the efficacy of soybean in the prevention and management of cardiovascular diseases has also been established (Balk and Lichtenstein., 2017; Yamori *et al.*, 2017 Tokede *et al*., 2015; Hang *et al*.,2016; Liu *et al*., 2014) . The unrivalled health benefits of soybean have also been affirmed in the prevention and management of diabetes both in laboratory animals and human subjects (Faria *et al.*, 2018 ;Ramdath *et al*., 2017; Saad *et al.,* 2017 ;Nguyen *et al.,* 2017; Kareem and Davies, 2016; Ko *et al.*, 2015; Matsukawa *et al.*, 2015; Fei *et al*., 2014 ; Huang *et al*., 2014) .

Different food products have been produced from soybean. These include; soymilk, soy nuts, soy sauce, soy cheese, Tempeh (fermented soybean) and other foods indigenous to different parts of the world but the use of soybean in the production of mayonnaise is yet to be explored. Mayonnaise is a thick, creamy dressing often used as a condiment or accompaniment in various cuisines. The word mayonnaise was believed to have been coined from the French word 'moyeu' which means 'egg yolk'. It is a stable emulsion commonly prepared with oil, egg, vinegar or lemon juice, herbs and spices (McGee, 2004). The colour may be white, cream colour or pale yellow while the texture varies from light cream to a thick gel. However, commercial egg-free alternatives are necessary for vegans, those who are allergic to eggs and those who avoid animal products due to the cholesterol content. Egg has been replaced with cow milk but the use of soybean in the production of mayonnaise is clearly a novel approach and would therefore be a measure to promote and encourage the consumption of the wonder bean so that the nutritional and health benefits of soybean can be harnessed maximally to improve public health nutrition. This study was therefore designed to evaluate the nutritional, physical and sensory properties of soy mayonnaise and compare these with that of a commercial egg mayonnaise brand.

Methodology

Preparation of soymilk concentrate

Soybean (TGX-1740) was used in this study. The soybean was cleaned manually by winnowing. (Ogundipe *et al*, 1989). Soybean (2kg) was soaked for 16 hours at ambient temperature after which it was drained to remove the water used for soaking. Clean water was added and soybean was heated to simmering temperature and allowed to simmer for 5 minutes. This was then wet-milled by plate attrition mill with the addition of 6.5litres of water. This was later sieved with cheese cloth and the extract was allowed to simmer for 5 minutes to give the soymilk concentrate.

Preparation of soy mayonnaise

Soy mayonnaise was prepared using the method of Nikzade *et al.,* 2012 with modification. The ingredients shown in table 1 were mixed in a Master Chef mixer (Model 3446256-China) for 10 minutes:

A commercial egg mayonnaise brand (BS1) served as control and these three samples were subjected to the following analyses; proximate, thiamine, riboflavin, niacin, cholesterol, fatty acid, texture,

Table 1: Ingredients in soy mayonnaise

Ingredients	LRS1 (full-fat)	LLS1 (low-fat)
Soymilk concentrate	400ml	600ml
Soy oil	400ml	160ml
Corn starch	60g	60g
Guar gum	15g	15g
Lemon juice	100ml	100ml
Vitamin E	10ml	10ml
Onion Powder	10g	10g
Ginger powder	10g	10g
Lemon oil	5ml	5ml
Sucrose	40g	40g
Table salt	2g	2g
Potassium sorbate	0.1% (w/v)	0.1% (w/v)

colour and sensory evaluation.

Moisture content determination

This was determined using the air oven method (Kirk and Sawyer, 2005). A known weight of the sample (3g) was put in a washed, dried and cooled crucible and this was dried at 103°C until a constant weight was obtained. This was allowed to cool in a desiccator and the difference in weight was used to calculate the moisture content.

Nutritional and Sensory property determination

The crude protein content was determined using the micro Kjeldahl method as described by Kirk and Sawyer, 2005. The soybean samples were analysed for their proximate composition (crude protein, crude fibre, crude fat, ash, carbohydrate, etc.) using standard methods as described by Kirk and Sawyer, 2005. The crude protein content was determined using the microkjeldahl method and the crude fat by saxhlet extraction method. The Ash content denotes the total amount of minerals present in the products which the crude fibre was expressed as the loss on ignition of burnt organic matter residue of the products. Carbohydrate, Thiamine, Riboflavin, Cholesterol and Niacin contents were also determined using the method as described by Kirk and Sawyer, 2005. The fatty acid profile and quantitative analysis was carried out using the Na-Methoxide (Esterification) method.

Colour analysis

The intensity of the colour in the samples (Lightness-L, Redness-a, and Yellowness-b) was determined using a colorimeter (Chroma meter CR-410, Japan). The samples were set in the sensor and the value was read from the reader (Gunal *et al*., 2008)

Texture analysis

The texture properties of the samples were determined using a texture analyzer (TexVol TVT 300 PH, Sweden). The texture parameters determined were: Peak force, stickiness, resilience, stringiness, peak time, area, gradient and adhesiveness (Li *et al*., 2011).

Sensory Evaluation

Mayonnaise samples were subjected to sensory evaluation with a total of 20 trained taste panellists using a 9 point hedonic scale with 1 denoting 'dislike extremely' and 9 denoting 'like extremely'. The following sensory properties were evaluated: colour, appearance, flavour, texture, taste, aroma and overall acceptability (Walfe, 1979).

Statistical analysis

Data were analyzed with Statistical Package for the Social Science version 22.0 while mean data were compared using Analysis of Variance at p= 0.05 (Kim, 2014).

Results

Proximate and vitamin composition of soy mayonnaise

The protein, fat, ash, crude fibre and carbohydrate content of the soy mayonnaise samples are indicated in Table 2, while Table 3 shows the vitamin and cholesterol composition, all in Dry Weight Basis (DWB). The protein, ash and carbohydrate contents of the soy mayonnaise samples were significantly higher than that of the

Table 2: Proximate composition of soy mayonnaise

Samples	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
BS1(control)	1.03±0.11	72.93±0.15	1.30±0.10	0	24.73±0.12
LRS1	1.90*±0.10	31.53? ±0.21	1.53* ±0.06	0	65.00*±0.10
LLS1	2.80*±0.10	10.40? ±0.30	1.90*±0.25	0	84.90*±0.40

**: significantly higher than the control (data in same column) p= 0.05*
?: significantly lower than the control (data in same column) p= 0.05
BS1: Commercial mayonnaise brand
LRS1: Full-fat soy mayonnaise produced with lemon juice
LLS1: Low-fat soy mayonnaise produced with lemon juice

Table 3: Thiamine, riboflavin, niacin and cholesterol content (in mg/100g) of soy mayonnaise samples

Samples	Thiamine	Riboflavin	Niacin	Cholesterol
BS1 (control)	0.08±0.01	0.07±0.02	0.14±0.02	0.37±0.06
LRS1	0.15*±0.02	0.21* ±0.02	0.51*±0.03	0
LLS1	0.19*(±0.02	0.27*±0.01	0.73*±0.02	0

**: Significantly higher than the control (data in same column) p= 0.05*
BS1: Commercial mayonnaise brand
LRS1: Full-fat soy mayonnaise produced with lemon juice
LLS1: Low-fat soy mayonnaise produced with lemon juice

commercial brand while the latter was higher in fat.

Soy mayonnaise samples were significantly higher in thiamine, riboflavin and niacin than the commercial mayonnaise brand while only the commercial brand contained cholesterol (Table 3).

Fatty acid profile and content

The saturated and unsaturated fatty acids present in each sample and the content is expressed in Table 4. Only two of the fatty acids are unsaturated fatty acids (Oleic and Linoleic). Soy mayonnaise samples were significantly higher in unsaturated fatty acids than the commercial brand while the latter was significantly higher in the saturated fatty acids assayed for.

Texture properties

The result of the texture properties determined is expressed in Table 5. The commercial mayonnaise brand and soy mayonnaise samples were similar in stringiness, peak time and adhesiveness but there existed significant differences between the samples when other texture parameters are considered.

Table 4: Fatty acid composition (%) of soy mayonnaise samples (g/100g oil in each sample)

Fatty acid	BS1	LRS1	LLS1
Lauric	0.29 ± 0.01	0.17* ± 0.02	0.13* ± 0.02
Tridecanoic	0.57 ± 0.03	0.18* ± 0.02	0.13* ± 0.03
Myristic	0.21 ± 0.02	0.14* ± 0.01	0.14* ± 0.03
Pentadecanoic	0.12 ± 0.02	0.09* ± 0.02	0.05* ± 0.01
Palmitic	0.52 ± 0.03	0.04* ± 0.01	0.02* ± 0.01
Stearic	0.12 ±0.02`	0	0
Nonadecanoic	0.32 ± 0.03	0	0
Arachidic	0.18 ± 0.02	0	0
Behenic	0.22 ± 0.03	0	0
Lignoceric	0.11 ± 0.01	0	0
Oleic	13.97 ± 0.79	24.05** ± 1.58	21.19** ± 1.11
Linoleic	34.69 ± 2.36	46.81** ± 2.19	42.49** ± 2.47
Undecanoic	-	-	-
Heptadecanoic	-	-	-
Heneicosenoic	-	-	-

** Significantly lower than the control ($p<0.05$ for data in same row)*
*** Significantly higher than the control ($p<0.05$ for data in same row)*
BS1: Commercial mayonnaise brand
LRS1: Full-fat soy mayonnaise produced with lemon juice
LLS1: Low-fat soy mayonnaise produced with lemon juice

Table 5: Texture properties of soy mayonnaise samples

Texture properties	BS1	LRS1	LLS1
Peak force (g)	19.67 ± 1.53	65.00** ± 1.73	30.67** ± 1.53
Height (cm)	17.62 ± 0.52	25.88** ± 0.74	24.29** ± 0.88
Weight (g)	32.67 ± 2.08	26.33* ± 2.08	33.33 ± 2.52
Stickiness (g)	1.33 ± 0.58	8.67** ± 1.53	7.00** ± 1.00
Resilience	0.23 ± 0.58	0.12* ± 0.07	0.12* ± 0.09
Stringiness (mm)	0.05 ± 0.00	0.06 ± 0.00	0.06 ± 0.00
Peak time (s)	9.97 ± 0.04	10.23 ± 0.23	9.52 ± 0.03
Area (J)	148.33 ± 3.22	482.67** ± 5.03	207.67** ± 2.08
Gradient	0.83 ± 0.58	5.57** ± 0.35	2.10** ± 0.10
Adhesiveness	0	0	0

* Significantly lower than the control ($p<0.05$ for data in same row)
** Significantly higher than the control ($p<0.05$ for data in same row)
BS1: Commercial mayonnaise
LRS1: Full-fat soy mayonnaise produced brand with lemon juice
LLS1: Low-fat soy mayonnaise produced with lemon juice

Table 6: Colour analysis of mayonnaise samples

Samples	L (Lightness)	a (Redness)	b (Yellowness)
BS1	86.94±0.13	-0.24±0.05	15.42±0.03
LRS1	123.30**±0.48	-2.78*±0.05	27.31**±0.08
LLS1	93.69**±0.36	-0.54*±0.06	15.00*±0.12

** Significantly lower than the control ($p<0.05$ for data in same column)*
*** Significantly higher than the control ($p<0.05$ for data in same column)*
BS1: Commercial mayonnaise brand
LRS1: Full-fat soy mayonnaise produced with lemon juice
LLS1: Low-fat soy mayonnaise produced with lemon juice

Colour:
Table 6 shows the result of the colour analysis for the mayonnaise samples.

The values for lightness for soy mayonnaise samples were significantly higher than that of the commercial brand while for redness that of the commercial brand was significantly higher.

Sensory evaluation:
Even though the scores for the soy mayonnaise samples were significantly lower than that of the commercial brand for the sensory properties the values still fall within the likeness range except for the texture which was neither liked nor disliked (Table 7).

Discussion
The significantly higher ($p= 0.05$) protein and ash content of the soy mayonnaise samples compared with the commercial brand (control) could be as a result of the higher proportion of soymilk in the samples than the egg in the conventional mayonnaise brand (Table 2). The percentage increase in the protein content of the soy mayonnaise samples relative to

Table 7: Scores of the evaluation of the sensory properties of the mayonnaise samples

Samples	Colour	Mouth-feel	Flavour	Texture	Taste	Aroma	Overall Acceptability
BS1	8.15a±0.67	8.45a±0.61	8.15a±0.59	8.35a±0.67	8.15a±0.75	7.75a±0.25	8.70a±0.47
LRS1	7.45b±0.60	7.35b±0.59	7.55c±076	5.80b±0.89	7.45d±0.61	7.05b±0.61	7.25c±0.85
LLS1	7.25b±0.72	7.70b±0.66	7.35c±0.81	5.25b±0.80	7.30e±0.66	7.25b±0.72	7.15d±0.75

Note: data in the same column with different alphabets are significantly different (p=0.05)
BS1: Commercial mayonnaise brand
LRS1: Full-fat soy mayonnaise produced with lemon juice
LLS1: Low-fat soy mayonnaise produced with lemon juice

the control (BS1) were; 84.47% (LRS1) and 171.85% (LLS1). The higher protein content in LLS1 could be attributed to the higher soymilk composition in this sample relative to LRS1. Tofu and skimmed milk protein have been used in soybean salad cream preparation. The protein and fat content of a salad cream produced by replacing egg and soy oil with tofu and coconut oil were 4.79% and 27.59%, respectively (Sirison *et al.,* 2017). The protein content was higher than that obtained in this study which was 1.90% for LRS1 and 2.80% for LLS1. This could be as a result of the fact that tofu is more dense in nutrients than soymilk. On the other hand the fat content of the full fat soy mayonnaise sample in this study was higher than that reported by Sirison *et al*., 2017 and may be attributable to the varying proportion of oil added. The use of skim milk powder protein and soy oil in another study yielded mayonnaise with 49.54% carbohydrate, 38.64% fat, 34.54% protein, 35.3% moisture and 0.32% ash (Gaikwad *et al.,* 2017).

Judging from the fact that the proximate composition of mayonnaise thus produced as reported already exceeds 100%, this could not be used appropriately for comparison. Surprisingly all the soy mayonnaise samples in this study as well as the control were void of crude fibre. Olaoye, 2015 however reported a crude fibre content of between 1.34 and 2.14% in condensed sweetened soymilk produced from different soybean varieties. The absence of crude fibre in the soy mayonnaise samples may be due to the fact that the fibre portion of the soya milk used to produce it has been sieved and discarded. In the same vein, the crude fibre content of the commercial mayonnaise brand (control) was similar to that of selected mayonnaise brands in Malaysian market which was observed to contain no total dietary fibre (Rashed *et al*., 2017).

The significantly higher (p= 0.05) carbohydrate content (Table 2) of the soy mayonnaise when compared with the control may be as a result of the guar gum added to stabilize the emulsion. This may not be present in the control. The soy mayonnaise samples were significantly lower (p=0.05) in fat than the control (Table 2), hence, may be suitable for weight reduction or maintenance of healthy weight. The proximate composition of the commercial mayonnaise brand used in this study was completely different from that of selected brands in Malaysian markets as reported by Rashed *et al*., 2017 who observed average values of 1.53% protein, 43.15% fat, 53.14% carbohydrate, 2,20% ash and 0% total dietary fibre. The disparity

in these values from that of the control in this study may be as a result of the fact that this was an average of six selected commercial Malaysian mayonnaise brands coupled with the fact that the control in this study was not produced in Malaysia, hence, ingredient formulated may be different. It is of pertinent importance to note that the soy mayonnaise brands in this study was higher in protein but lower in fat than the Malaysian commercial mayonnaise brands as reported by Rashed *et al*., 2017.

Even though the soy mayonnaise samples were significantly higher (p=0.05) than the control (Table 3) in thiamine, riboflavin and niacin the values were still low putting into consideration the Recommended Dietary Allowances which are thiamine: 1.1mg for women/ 1.2mg for men; riboflavin: 1.1mg for women/1.3mg for men; and niacin: 14mg for women/ 16mg for men. This is an indication that soy mayonnaise needs to be consumed with foods rich in these vitamins (such as whole grains, fish, beef, etc) for adequate nutrition. The higher vitamin content of the soy mayonnaise may be attributed the concentrated form of soymilk which was used since these vitamins were found to be trace (0.07mg/100gthiamine, 0.05mg/100g riboflavin and 0.065mg/ 100g niacin) in conventional soymilk (Uwoke and Umelo, 2015). The onion and ginger powder used in the preparation of the soy mayonnaise samples could also contribute to the vitamin content. The thiamine, riboflavin and niacin content of the control were 0.08, 0.07 and 0.14mg/100g respectively and this was in disparity with the values observed in Malaysian commercial mayonnaise brands which contained 0.03 mg/100g thiamine, 0.15mg/100g riboflavin and 0.64mg/100g niacin (Rashed *et al.,* 2017). This disparity may be as a result of differences in regions of production which could have prompted the use of ingredients as dictated by indigenous cultural food habits coupled with the fact the Rashed *et al*, 2017 observation was an average of six different commercial mayonnaise brands.

Lauric, tridecanoic, myristic, pentadecanoic and palmitic acids were the saturated fatty acids present in both the control and soy mayonnaise samples while there are other saturated fatty acids present in the control but not in the soy mayonnaise samples.(Table 4). However, the composition of these fatty acids was significantly higher (p=0.05) in the control than the soy mayonnaise samples. This may be due to difference in the ingredients used. In the control sample total saturated fatty acid was 2.66g/100g oil in the sample while total unsaturated fatty acid was 48.68g/100g oil as can be deduced from Table 3. In LRS1 (full-fat soy mayonnaise produced with lemon juice) total saturated fatty acid was 0.62g/100g oil in the sample and total unsaturated fatty acid was 70.86g/100g oil in the sample. Similarly, total saturated fatty acid in LLS1 (low-fat soy mayonnaise produced with lemon juice) was 0.47g/100g oil in the sample while total unsaturated fatty acid was 63.68g/100g oil in the sample (Table 4). It is clearly evidenced that the soy mayonnaise samples were significantly lower in saturated fatty acid and higher in unsaturated fatty acids than the control (p= 0.05). This may be due to the use of soy milk and soy oil for the experimental samples while egg and oil was used for the commercial brand as expressed in the label. This was reflected in the cholesterol content

which was zero in soy mayonnaise samples and 0.37mg/100g in the control.

There was a notable contrast between the fatty acid composition of the commercial mayonnaise brand used in this study and that of the selected Malaysian commercial mayonnaise brands as reported by Rashed *et al.,* 2017. They observed 12.49g/100g total saturated fatty acids and 18.22g/100g total unsaturated fatty acids with a cholesterol content of 25.67mg/100g. The disparity in these fatty acid compositions of the two different sets of commercial mayonnaise brands may be as a result of variation in the ingredients used. Furthermore, the cholesterol content of the commercial mayonnaise brand used in this study may be considered negligible (0.37mg/100g) compared with that of the Malaysian commercial brands (25.67mg/100g). In overall, soy mayonnaise in this study could be considered to be more heart friendly than the commercial mayonnaise brands.

The texture parameters of the mayonnaise samples are expressed in Table 5. Peak force of the soy mayonnaise samples were significantly higher ($p=0.05$) than that of the control (commercial brand) showing that the control was higher in physical textural consistency so it was able to resist the force of penetration of the sensor. On the other hand, the soy mayonnaise samples were lighter in consistency thus giving a higher peak force and a significantly lower ($p= 0.05$) resilience relative to the control sample. Stickiness values of the experimental samples (soy mayonnaise) was also significantly higher than that of the control and this may be as a result of the guar gum used as the emulsion stabilizer which may not be present in the control. There was no significant difference ($p= 0.05$) in stringiness, peak time and adhesiveness (Table 5). For the colour analysis, LRS1 was highest in lightness, followed by LLS1 while the control had the least value. The soy mayonnaise samples were significantly lower ($p= 0.05$) than the control in redness while LRS1 was highest in yellowness (Table 6). There is paucity of available scientific reports on the texture and colour parameters of mayonnaise and soy mayonnaise, hence, comparison could not be made with past findings.

The nutritional value of a food is as important as its sensory properties because no matter how nutritious a food is, if the palatability and consumer acceptability is low it will mostly end up in the garbage bin. Table 7 shows that even though the scores for colour, mouth feel, flavour, taste, aroma and overall acceptability for the control sample were significantly higher than that of the soy mayonnaise samples, these were in close proximity and the scores for the soy mayonnaise samples were within the likeness range except the texture.. This shows that only a minimal or little improvement is needed for the soy mayonnaise to be at par with the commercial brand for these sensory properties, hence, consumer acceptability. However, the scores for texture of soy mayonnaise samples were too low and within neither liked nor disliked score range, hence; it is of pertinent importance that the texture of the soy mayonnaise samples be worked upon diligently for notable improvement.

Conclusion

Soy mayonnaise contained no cholesterol and is more nutritious than the conventional commercial mayonnaise brand.

Furthermore it is suitable for all, even vegans. Its colour and sensory properties may compete favourably with that of the commercial brand but the texture needs to be improved upon.

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