Effect Of Germination on the Physicochemical, Proximate, Amino Acid and Sensory Properties of Soybean and Tiger Nut Yoghurt

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Abstract
Soymilk and tigernut milk prepared from germinated soybean and tigernut tuber was fermented at 42 °C for approx. 12 h to produce soy and tigernut yogurt with the combined cultures of Lactobacillus bulgaricus and Streptococcus thermophiles. The effect of germination on the physicochemical, proximate, amino acid and sensory characteristics of the fermented products were subsequently investigated using standard methods. Results showed that yoghurt prepared from germinated soybean and tigernut milk displayed lower pH and higher titratable acidity, and appeared more viscous after 12 h of fermentation. Proximate analysis demonstrated that the protein and ash content of germinated soybean and tigernut yoghurt was significantly higher (5.87 and 5.33%, 0.96 and 0.84%) than the ungerminated counterpart (4.74 and 4.37%, 0.73 and 0.67%) whereas fat and carbohydrate content decreased from 3.30 to 3.21%, 2.76 to 2.44% and from 7.34 to 6.15%, 7.35 to 7.18%, respectively, in ungerminated and germinated soybean and tigernut yoghurt. Total amino acids content namely Leucine (6.90 and 9.03mg/100g), Histidine (3.41 and 6.43 mg/100g) and Valine (2.54 and 8.93 mg/100g) were higher in the germinated soybean and tigernut yoghurts than in the ungerminate samples. Sensory characteristics showed that germinated soybean and tiger nut yoghurt were rated high in terms of aroma and flavour over ungerminated sample while ungerminated was scored highest for thickness, however, both samples were accepted by the panelists. From the study, it can be concluded that germination significantly improve the physicochemical and proximate, amino acid and sensory characteristics of Soybean and tigernut yoghurts.

Keyword: *Soybean, Tigernut, germinated, ungerminated, physicochemical, proximate, amino acid, sensory*

Introduction

Yoghurt is a coagulated milk product produced by fermenting milk with pure starter cultures of Lactobacillus bulgaricus and Streptococcus thermophilus (FAO, 2007). The bacterial activity of both homofermenters converts lactose to lactic acid as the main product of the fermentation (Del Toma et al., 2007). Yoghurt is nutritionally rich in protein and vitamin (calcium, riboflavin, vitamin B6 and vitamin B12). The fermentation process during yoghurt production makes the nutrients easier to absorb by the body providing many health benefits such as boosting immunity, reducing yeast infections, and lowering the risk of colon cancer (Dairy Council of California 2015). The nutritional value of yoghurt may decrease due to the presence of ant-nutritional factors such as trypsin inhibitors, oxalate, and phytic acid. Germination enhances the bioactive compounds in cereals and pulses', including anti-diabetic, anti-hypertensive, and anti-cancer activities; in addition, germination enhances the bio-availability and bio-accessibility of nutrients and bioactive substances in the human gut by improving the digestibility of complex molecules in cereals and pulses. Germination, breaks the seed dormancy by activating endogenous enzymes, this has been identified as the most effective and economical option to boost the nutritional qualities and reduce the activity of anti-nutrients in cereal and pulses.

Soybean is rich in protein, essential amino acid, unsaturated fat, minerals, vitamins, and dietary fiber and carbohydrates. Soybean help improve human immunity and cardiovascular disease and other physiological functions (Yang et al., 2020; Sun, 2013). It also contains a number of anti-nutritional factors such as trypsin inhibitor, lectins, lipoxygenase and phytic acid, which have adverse effects on the digestion, absorption and utilization of nutrients. However, germinated soybeans have high nutritional value, crude protein levels of up to 46% with high amounts of essential and non-essential amino acids have been reported, the concentration of the total amino acids varies across different soybean genotypes and during the days of germination (Li, Jeong, Lee, Chung, 2020). Oil content decreased from 15% to 10% during germination and also the sugar content in soybean seed decreased during the germination process, Lemmens, Moroni, Pagand, Heirbaut, Ritala, Karlen, (2019) found that sugar content in soybean seed was 19.9% but decreased to 14% after 7 days of germination. Many studies have shown that germination can awaken dormant soybean seeds, activate various key enzymes of endogenous metabolism, promote physiological changes of soybean, and increase the contents of nutrients, the content of anti-nutritional factors such as lipoxygenase and phytic acid decreased, and promote protein decomposition and Lipid hydrolysis oxidation process. Hence, germination is considered to be the most direct and effective means to enrich the nutrient content of soybean and reduce the harmful content (.Handa, Kumar, Panghal, Suri, Kaur, 2017).

Tigernut tubers (Cyperus esculentus), is consumed widely in Nigeria raw, dried, roasted or grated and used as flour or plant milk. It yield more milk upon extraction and contains lower fat with higher protein and less anti-nutritional elements especially polyphenol. Tigernut milk is an alternative beverage for celiac patients who are intolerant to gluten and lactose (Okorie, Nwanekezi, 2014). It has high nutritional qualities and potential health beneficial bioactive compounds. The starch content (30–40%) of tigernut tubers constitutes one of the main production limits for plant milk as it can contains polysaccharide on extraction and grinding (Belewu and Belewu, 2007). Hence, tigernut milk is not suitable for pasteurization, due to the risk of gelatinization. Various works have shown interest of germination of tigernut tubers, especially in the production of malted flour, this operation leads to healthy nutrients.

During the initial stages of germination, several biochemical changes occur inside the seed. For instance, macro-molecules such as proteins, polysaccharides and fats may break down into oligopeptides and free amino acids, monosaccharides and oligosaccharides, and fatty acids, respectively (Li et al., 2020). This process initiates the accumulation of several primary metabolites and increases the overall content of available nutrients, thereby improving the nutritive value of the sprouts. Germination of both soybeans and tiger nuts before processing into yoghurt can significantly impact the physicochemical properties (like pH, titratable acidity), proximate composition (protein, fat, carbohydrate content), amino acid profile, and ultimately the sensory attributes of the resulting yoghurt leading to an improvement in nutritional value and potentially a more desirable taste and texture due to increased enzyme activity and nutrient availability during germination. This paper therefore, focused on the effect of germination on the physicochemical, proximate, amino acid and sensory properties of soybean and tiger nut yoghurt.

Materials and Methods
Materials
Source of raw materials
The soybean, tiger nut were purchased from Mile 3 Market, Port Harcourt, Rivers State Nigeria. Starter culture used was composed of *Lactobacillus bulgaricus* and *Streptococcus thermophiles* manufactured by NP Selection LTD, London, UK.

Chemicals and reagents
Chemicals and reagents of analytical grade were obtained from the Department of Food Science and Technology, Rivers State University.

Methods
Production of germinated soybean and tigernut flour
The method described by Barber *et al*. (2020) was employed to produce the germinated soy and tigernut flour. Hundred (100 g) grams of soybean were sorted to remove stones and broken seeds and washed; soybean was soaked in distilled water for 12 h to soften. After 12 h, the soaked seeds was washed and allowed to drain. Then, the seeds were allowed to germinate for 27 h. Germination was done by spreading the drained soybeans on a jute bag with water sprinkled at intervals at room temperature to allow sprouting. After germination, the soybean seed was oven-dried at 60℃ for 30 min. The dried seeds were dehulled, winnowed and milled using locally fabricated attrition mill. The flour obtained was packed in an air tight container after sieving at 0.45 mm mesh size until required for use.
For the production of tigernut flour, dried tigernut tuber was used, one hundred (100 g) grams of tiger nut tubers was weighed, and sorted to remove unwanted matter (organic matter and damaged tubers) by visual observation before washing. The washed tubers were soaked in distilled water for 12 h at room temperature. After soaking, the tubers were spread on a jute bag and water sprinkled at intervals for it to sprout at room temperature. The process continued for 96 h for germination to occur. The sprouted tubers were oven dried, allowed to cool, milled and then sieved (0.45 mm) mesh size. The flour obtained was packaged in a container, and stored in refrigerator till required for yoghurt production as described by Obinna-Echem *et al.* (2020) with modification.

Production of germinated soybean and tiger nut yoghurt
Germinated soybean and tiger nut yoghurt was produced by the method described by Obinna-Echem *et al.* (2020) with some modification**.** Milk produced from germinated soybean and tiger nut flour was used to produce the germinated tiger nut yoghurt. Ten (10 mL) millilitres of date syrup and 0.1 g of xanthan gum were added to the milk, and then the mixture was homogenized, pasteurized at 72℃ for 15 min, and allowed to cool to 42℃. After cooling, the mixture was inoculated with commercial starter cultures (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*), packed in a container and allowed to ferment for 12 h at 40℃ before cooling at refrigerator temperature (4℃).
Soybean milk and tigernut milk produced from ungerminated seeds soaked for 12 h using the same procedure described above served as the control.

Laboratory Analysis

Physicochemical Analysis

The methods described by Obinna-Echem and Torporo (2018) were used for the determination of pH, titratable acidity (TTA), total soluble solid content (TSS), Viscosity and Syneresis

Proximate Analyses

Proximate analysis of yoghurt produced from germinate soybean and tiger nut milk was conducted using AOAC, (2019) methods. Moisture content was determined by drying the samples in an air oven at 105°C and calculating the weight loss. Protein was measured using the Kjeldahl method, which involved digestion, distillation, and titration. Fat was extracted by soxhlet extraction method while Ash content was calculated from the residue after incineration at 500-550°C and percentage found. Crude fiber was assessed by boiling with sulfuric acid, filtering, and igniting the residue. Carbohydrate content was calculated by difference; subtracting the sum of moisture, protein, ash, fat, and fiber from 100%.

Amino acid composition

Amino acid contents were determined using the method described by Grobbelaar, Makunga, Stander, Kossmann, and Hills (2014) with slight modifications. Amino acid separation and detection was performed using a Waters Acquity Ultra Performance Liquid Chromatograph (UPLC) fitted with a photodiode array (PDA) detector. Derivatization was performed using Waters AccQ Tag Ultra Derivatization kit, according to the manufacturer's guide. Sample/standard solution (1 µl) was injected into the mobile phase (AccQTag Ultra Eluent A and B (Waters)), which conveys the derivatized amino acids onto a Waters UltraTag C18 column (2.1 × 50 mm ×1.7 µm) held at 60°C.

Sensory characteristics

Thirty (30) semi-trained panellists were used to carry out the in-house acceptability test of the yoghurt on a 9-point hedonic scale, with the scale ranging from 1 (Dislike extremely) to 9 (like extremely).

Statistical Analysis

Deviations in the data collected and the statistical significance of the effect of germination were analyzed by the analysis of variance. The comparisons of means were made by Duncan's test at probability thresholds of 5%. Statistical data were analyzed using Minitab USA.

Results and discussion

Results presented in Table 1 shows the positive effect of germination on some physicochemical characteristics of soybean and tiger nut milk yoghurt fermented for approx. 12 h at 42 °C. All the samples had a pH value that ranged from 4.28 to 4.82 while titratable acidity ranged from 0.55 to 0.80%. The pH values (4.46 and 4.82) of germinated yoghurts were slightly lower (4.28 and 4.32) than of the ungerminated samples of yoghurt. The values obtained for pH was comparable to 3.68 – 4.30 reported for reconstituted skimmed milk yogurt by Sarafa, Oluwafemi and Ibrahim, (2018). The pH values obtained in this study were also within the acceptable limit ($p < 0.05$) of yoghurts. The highest titratable acidity (0.80 % lactic acid) was observed in GSY yoghurt, while a lowest titratable acidity of about 0.55 % was obtained in UGTN yoghurt. Previous studies have shown that fermentation of milk for few hours decreases the pH value and increases total titratable acidity. The values attained for pH and titratable acidity indicate that the yoghurt were acidic, and this could be favorable in the tartness of the yoghurt and obstruction of pathogenic and spoilage microorganism. Djomdi et al. (2020) demonstrated that acidity in Tiger nut milk is related to the production of lactic acid by the species of lactic acid bacteria during fermentation.

Total soluble solids (TSS) also referred to as 'Brix ontent' ranged from 7.20 to 11.10% in the germinated and ungerminated yoghurts. The slight variations in Brix content among the samples can be attributed to the different treatments, which might affect the sugar content during fermentation. Brix influences the sweetness and overall flavor profile of the yoghurt (Garofalo et al., 2024).

The effect of germination on the viscosity of germinated yoghurts ranged from 0.68 to 0.74 PaS. Germination significantly improved the viscosity characteristic of yoghurts. Rheological properties of coagulated yogurt products are, to a great extent, determined by their internal structure.

Syneresis or whey separation of a protein gel is an important parameter in yoghurt manufacturing. After centrifugation, the whey separations of germinated yoghurts (Table 1) were found to be slightly higher than that ungerminated yoghurt sample. Lower whey separation is partly due to the unstable gel network of yogurts (Donkor, Henriksson, Vasiljevic, Shah, 2007). In which the weak colloidal linkage of protein micelles cannot entrap water within its three-dimensional network

Table 1: Effect of germination on the physicochemical properties of yoghurt

Sample	**pH**	TTA (%)	TSS (%)	Viscosity(PaS)	Syneresis (%)
GSY	4.46±0.01^{b}	0.80 ±0.00^{a}	7.20 ±0.28^{d}	0.72±0.00^{d}	8.90±0.14^{a}
UGSY	4.28±0.01^{c}	0.72±0.00^{c}	10.95±0.07^{b}	0.74±0.00^{a}	8.05±0.00^{b}
GTNY	4.82±0.01^{a}	0.65±0.00^{c}	9.10±0.14^{c}	0.68±0.00^{a}	7.40±0.14^{c}
UGTNY	4.32±0.01^{c}	0.55±0.00^{c}	11.10±0.14^{a}	0.70±0.00^{a}	5.25±0.00^{d}

Values are means ± standard deviation of duplicate determination. Means that do not share a letter are significantly different ($p<0.05$); GSY = Germinated soybean yoghurt, UGSY = Ungerminated soybean yoghurt, GTNY = Germinated tiger nut yoghurt, UGTNY = Ungerminated tiger nut yoghurt. TTA= total titriable acidity, TSS= total soluble solids

The result of the proximate composition of germinated and ungerminated soybean and tiger nut yoghurts are presented in Table 2. The moisture contents of the yoghurts ranged from 83.05 to 86.12%, this was close to the values of 76. 10 to 85.23% reported by Ndife et al. (2014) for milk-based yoghurt enhanced with coconut cake but lower than 88.13% moisture content of raw cow milk reported by USDA. Moisture content is an important indication of shelf life of food items. Hence, the low moisture content of a product is important for it to last longer.

Protein content varied from 4.55 to 5.87% in the germinated and ungerminated soybean and tiger nut yoghurts, lower values were found in the ungerminated yoghurts samples. Protein content is an important factor that affects the quality of acid coagulation of protein gel products. During germination, nitrogen mobilizes into water during steeping and a part of protein was used to provide energy for germination. Nevertheless, within 24 to 72 h of germination, the protein content increased by 4% because of the synthesis of new proteins and less utilization of proteins for respiration in the latter part of germination (Liu et al., 2018). Consumption of plant base milk such as soybean and tigernut milk should be integrated into human diet to fight protein deficiency, as they are cheap source of cow milk substitute.

The effect of germination on the proximate composition of yoghurt prepared from germinated and ungerminated soybean and tigernut milk showed fat content in the range of 2.70 to 3.30%. There was a decrease in the fat content of germinated yoghurts. Fats serve as an energy source and are broken down for the biochemical and physiological changes occurring in the tuber during germination for the synthesis of new components, including proteins, isoflavonoids, and vitamin C (Sun et al., 2018). Thus, germination altered the fatty acid profile of soybeans and used the stored lipids as an energy source, causing the lipid concentration to drop, these incidents led to a decrease in storage lipids from 3.30 to 3.23 and from 2.76 to 2.70%, respectively, for germination and ungerminated soybean and tigernut yoghurt. Fat is an important source of energy in the body (Eke, Olaitan and Sule, 2013).

There were significant ($p<0.05$) differences in the fibre contents across all yoghurt with Ungerminated tiger nut yoghurt having the highest value (0.10%) and ungerminated soybean yoghurt having the least (0.06%). Dietary fiber is a complex mixture consisting mainly of hemicellulose, gum, cellulose, pectin and β-glucan with mixed bonds (Wu et al., 2012). It alters peripheral tissue sensitivity to insulin, raises serum insulin levels and regulates blood glucose levels (Sun & Yu, 2021). Dietary fiber can inhibit the absorption of fatty substances such as cholesterol and triglyceride, lower blood lipids, reduce hunger and promote gastrointestinal peristalsis, improve defecation function. Wang et al. (2014) in the experiment found that the soybean cellulose showed the trend of rising first and then decreasing with the germination time.

The ash content ranged from 0.67 to 0.96% with germinated soybean yoghurt having the highest value. The ash content in food is a measure of mineral element present in the food material (Adedokun, Okorie, Onyeneke and Anoruo, 2013).

There was significant ($p<0.05$) decrease in carbohydrate content of germinated yoghurts. Values ranges from 6.15 to 7.35%. The decrease in carbohydrates in germinated grains may be ascribed to increase in alph amylase activity which breakdown complex carbohydrates into simpler and more absorbable sugars as reported by Hung, Maeda, Yamamoto, Morita, (2012). Bueno et al., (2020), Atudorei et al., (2021) reported that carbohydrate content present in black soybeans was reduced by 4% within 72 h of germination at 25 C under dark conditions.

Ma et al. (2020), reported decrease in the total sugar present in ungerminated soybeans within 2 to 4 days of germination due to the utilization of sugars in respiration and production of ATP during germination.

Table.2: Effect of germination on the proximate composition of yoghurt

Proximate composition	Moisture	Protein	Fat	Crude Fibre	Ash	Carbohydrate
GSY	83.05 ± 0.01^d	5.87 ± 0.01^a	3.23 ± 0.01^a	0.08 ± 0.01^c	0.96 ± 0.01^a	6.15 ± 0.01^d
UGSY	84.24 ± 0.01^c	5.63 ± 0.01^b	3.30 ± 0.01^b	0.09 ± 0.01^d	0.84 ± 0.01^a	7.34 ± 0.06^b
GTNY	85.92 ± 0.01^b	4.74 ± 0.01^c	2.70 ± 0.01^d	0.09 ± 0.01^b	0.73 ± 0.01^b	7.18 ± 0.03^c
UGTNY	86.12 ± 0.08^a	4.55 ± 0.01^d	2.76 ± 0.01^c	0.10 ± 0.01^a	0.67 ± 0.01^c	7.35 ± 0.04^a

Values are means ± standard deviation of duplicate determination. Means that do not share a letter are significantly different ($p<0.05$).

GSY = Germinated soybean yoghurt, UGSY = Ungerminated soybean yoghurt, GTNY = Germinated tiger nut yoghurt, UGTNY = Ungerminated tiger nut yoghurt

The effect of germination on the Amino acid content of yoghurt was measured as shown in Table 3. There was significant increase in the free amino acid content after germination, the total contents of free amino acid in soymilk and tigernut yoghurts increased from 9.74 to 11.63 mg/mL and from 10.79 to 16.79 mg/mL, respectively. In this study, Arginine was the most abundant acid in both germinated and ungerminated soybean and tigernut yoghurt. Desobgo, (2012), reported that the amounts of all the essential amino acids including leucine, phenylalanine, and cysteine increased during germination, the content of all non - essential amino acids also increased except glutamic acid, aspartic acid and serine. These views have also been reported by Noort et al. (2022), during their work on the germination of sorghum. Increases in amino acids would be due to the synthesis of enzymes in these sprouted products. Li & Wang (2009) found that the contents of soluble protein, ammonia nitrogen and peptide in 0 ~ 96 h after germination of soybean seeds were higher than those of non-germinated seeds, and the peak of soluble protein appeared at 9 ~ 12 h after seed germination, but the contents of amino acids and peptides increased during 96 h. Free amino acids were mainly released due to the hydrolysis of polypeptide chains of storage proteins by exopeptidases (Desobgo, 2012) after the imbibition of soybean or tigernut tuber. The results obtained in this study are higher than that reported by the FAO/WHO.

Table 3: Effect of germination on the Amino acid content of yoghurt

Amino acid (mg /100g)	**UGSY**	**GSY**	**UGTNY**	**GTNY**
Essential amino acid				
Histidine	$1.72^{e} \pm 0.04$	$3.41^{c} \pm 0.03$	$4.43^{b} \pm 0.14$	$6.43^{a} \pm 0.02$
Isoleucine	$6.85^{b} \pm 0.12$	$8.06^{a} \pm 0.01$	$4.84^{d} \pm 0.12$	$6.84^{b} \pm 0.04$
Leucine	$4.48^{d} \pm 0.01$	$6.90^{b} \pm 0.20$	$5.03^{c} \pm 0.05$	$9.03^{a} \pm 0.07$
Lysine	$1.31^{e} \pm 0.11$	$1.18^{f} \pm 0.07$	$1.50^{c} \pm 0.04$	$1.21^{d} \pm 0.11$
Methionine	$1.08^{d} \pm 0.10$	$1.03^{e} \pm 0.04$	$4.83^{a} \pm 0.02$	$4.51^{b} \pm 0.12$
Phenylalanine	$1.66^{d} \pm 0.07$	$1.46^{e} \pm 0.14$	$4.27^{b} \pm 0.00$	$3.27^{c} \pm 0.05$
Theronine	$4.34^{a} \pm 0.14$	$3.49^{b} \pm 0.02$	$3.59^{b} \pm 0.02$	$2.59^{c} \pm 0.02$
Valine	$1.15^{f} \pm 0.02$	$2.54^{e} \pm 0.11$	$5.93^{c} \pm 0.01$	$8.93^{a} \pm 0.12$
Non- Essential amino acid				
Alanine	$3.69^{d} \pm 0.02$	$5.56^{c} \pm 0.02$	$6.24^{b} \pm 0.08$	$9.24^{a} \pm 0.07$
Arginine	$9.74^{d} \pm 0.01$	$11.63^{c} \pm 0.00$	$10.79^{b} \pm 0.11$	$16.79^{a} \pm 0.15$
Aspartic acid	$5.35^{d} \pm 0.00$	$7.25^{c} \pm 0.02$	$9.79^{b} \pm 0.02$	$11.79^{a} \pm 0.04$
Cysteine	$0.36^{f} \pm 0.01$	$0.88^{d} \pm 0.12$	$0.69^{e} \pm 0.32$	$1.09^{c} \pm 0.12$
Glutamic acid	$5.10^{d} \pm 0.14$	$8.66^{b} \pm 0.22$	$8.14^{c} \pm 0.52$	$12.14^{a} \pm 0.25$
Glycine	$4.93^{d} \pm 0.10$	$6.56^{b} \pm 0.32$	$6.35^{c} \pm 0.04$	$8.35^{a} \pm 0.12$
Proline	$1.02^{f} \pm 0.11$	$1.25^{e} \pm 0.11$	$5.00^{b} \pm 0.11$	$9.00^{a} \pm 0.07$
Serine	$1.11^{e} \pm 0.00$	$1.06^{f} \pm 0.01$	$4.96^{a} \pm 0.04$	$3.96^{c} \pm 0.41$
Tyrosine	$1.29^{f} \pm 0.12$	$1.95^{e} \pm 0.40$	$3.31^{b} \pm 0.00$	$6.31^{a} \pm 0.11$

Values are means ± standard deviation of duplicate determination. Means that do not share a letter are significantly different ($p<0.05$).

GSY = Germinated soybean yoghurt, UGSY = Ungerminated soybean yoghurt, GTNY = Germinated tiger nut yoghurt, UGTNY = Ungerminated tiger nut yoghurt

The sensory evaluation results for yoghurt produced from germinated and ungerminated soybean and tigernut milk are presented in Table 4. Germination significantly improved the sensory attributes of the yoghurts compared with the control sample (ungerminated soybean and tiger nut yoghurts). The sensory score for taste attribute of the yoghurt ranged from 4.10 to 6.50, with germinated tiger nut yoghurt having the highest score. The low score recorded for ungerminated soybean yoghurt could be as a result of the beany flavor of soybean. Scores for color varied from 4.10 to 5.95, with significant ($p<0.05$) different between the samples. Tigernut has brigher colour than soybean. For mouthfeel there was significant different between the scores reported. Germinated tigernut yoghurt was more acceptable in terms of mouthfeel, scores ranged from 4.30 to 5.90 while thickness score was highest in ungerminated soybean yoghurt, this might be attributed to the thickness, creaminess and viscous nature of soymilk. In terms of general acceptability, yoghurt prepared from germinated tigernut milk had the highest scores and can be a good plant-based milk substitute for yoghurt production. The overall acceptability of the yoghurt ranged from 6.10 to 8.80, with significant difference ($p<0.05$).

Table 4.6.1 Effect of germination on the sensory characteristics of yoghurt

Sample	Taste	Colour	Mouth feel	Thickness	Overall acceptability
GSY	$6.30^{d}\pm0.86$	$4.10^{c}\pm0.78$	$5.35^{c}\pm0.93$	$5.50^{ab}\pm0.76$	$5.31^{b}\pm0.83$
UGSY	$4.10^{c}\pm0.83$	$5.35^{c}0.93$	$4.30^{b}\pm0.80$	$6.20^{a}\pm0.83$	$4.98^{c}\pm0.83$
GTNY	$6.50^{b}\pm0.76$	$4.95^{c}\pm0.94$	$5.90^{b}\pm1.25$	$5.20^{b}\pm0.95$	$5.63^{a}\pm0.83$
UGTNY	$4.30^{b}\pm0.86$	$5.95^{b}\pm0.88$	$5.00^{ab}\pm1.07$	$6.10^{a}\pm0.64$	$5.33^{b}\pm0.83$

Values are means ±standard deviation of degree of likeness from panellist.
Means that do not share a letter are significantly different ($P<0.05$).
GSY = Germinated soybean yoghurt, UGSY = Ungerminated soybean yoghurt, GTNY = Germinated tiger nut yoghurt, UGTNY = Ungerminated tiger nut yoghurt

Conclusions

The results of this present study indicate that germination improved nutritional attributes (protein, and amino acids content) as well as some sensory characteristics (taste and mouthfeel) of yoghurt made from germinated soybean and tigernut when compared with ungerminated sample (control). This shows that milk extracted from germinated soybean and tigernut can be a better substitute to cow milk in yoghurt production. Germination before milk extraction for yoghurt production from these plants is highly recommended considering the high potential health and organoleptic benefits.

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