RESEARCH ARTICLE

Chemical composition and sensory properties of soy-tiger nut cheese

M.A. Balogun*, **S.A. Oyeyinka, F.L. Kolawole, J.K. Joseph and G.E. Olajobi**

Department of Home Economics and Food Science, University of Ilorin, Ilorin, Kwara State, Nigeria.

Abstract: Soy-cheese was produced from blends of soymilk and tiger nut milk at varying proportions of 100:0, 95:5, 90:10, 85:5, 80:20 and 75:25 respectively. The proximate, mineral and sensory properties of the cheese samples were evaluated. Cheese yield and protein content significantly reduced with increase in tiger nut milk addition. The protein content of the soy-tiger nut cheese blends decreased from 19.04% to 13.25%, while fat contents increased from 7% to 9.14%. Calcium (126.42-189.80 mg/kg) and potassium (145.27-194.33 mg/kg) are the major minerals in the cheese samples, while the iron content was substantially low (11.03-14.67 mg/kg). Phytate and trypsin inhibitor contents of the cheese samples significantly reduced with increasing levels of tiger-nut, suggesting improvement in digestibility. Cheese produced from 95% soy milk and 5% tiger-nut milk had the highest rating in all sensory parameters. This study demonstrated the possibility of utilizing blends of soymilk and tiger-nut milk in cheese production with comparable nutritional and sensory quality to the common 100% soy cheese. Furthermore, producing soy-cheese from soymilk and tiger nut milk blend may be a promising means of value addition to further promote utilisation of tiger-nut milk beyond traditional usage.

Keywords: Soymilk, Tiger nut milk, Soy-cheese, Anti-nutritional factor.

INTRODUCTION

Cheese is a food derived from milk that is produced by coagulation of the milk protein casein. It comes in a wide range of flavours, textures, and is primarily made from cow milk. Other milk types that have been used include those from buffalo (Bontempo et al., 2019; Da Silva *et al*., 2019), goats (Darnay *et al*., 2019; Leclercq-Perlat *et al*., 2019) and sheep (Cipolat-Gotet *et al.*, 2016; Derar and El Zubeir, 2014; Nguyen *et al*., 2019; Renes *et al.,* 2019;). However, due to the high fat content of foods of animal origin and the consumers' awareness of the relationship between diet and health, there is a growing demand for vegetable milk such as soymilk with lower fat content. Soymilk is a good source of high quality proteins and contains no lactose and thus, may be explored in formulating diet for the lactose intolerant (Scalabrini *et al*., 1998). In addition, soymilk can effectively be used for supplementing cereal based products because of its balanced amino acid pattern. However, the undesirable beany flavour of soymilk (Liu and Lin, 2000)

has reportedly limited the consumption of the milk as well as its products (Wang *et al*., 2002). The undesirable taste is associated with the presence of indigestible oligosaccharides such as stachyose and raffinose, which are the major oligosaccharides found in soymilk (Wang *et al*., 2002). These sugars are known to be responsible for flatulence in humans after eating soybean foods. For these reasons, soymilk is fermented to produce more palatable and digestible products such as soy-yoghurt and soy-cheese. Wang *et al.* (2003) reported that *Lactobacillus acidophilus* reduced the level of stachyose, raffinose and sucrose while it increased the content of fructose, glucose and galactose in soymilk. Besides soymilk, other promising vegetable milk source that is currently being explored in producing fermented food include tiger-nut (*Cyperus esculentus* L.). Tiger-nut is an edible perennial grass-like plant. It has been used in the production of milk (Belewu and Belewu, 2007; Ukwuru and Ogbodo, 2011), milk blends with soymilk *(Okorie et al*., 2014; Udeozor, 2012) or yoghurt (Oladipo *et al*., 2014; Sanful, 2009). Exploring vegetable milk blends in the production of fermented foods may be one of several ways of increasing utilization and producing value added products to tiger-nut and other underutilized crops. To the best of our knowledge, there is no report on the use of soybean milk and tiger-nut milk blends in cheese production. Hence, this study investigated the chemical composition and sensory properties of cheese produced from soybean and tiger-nut milk blends.

MATERIALS AND METHODS

Soybean and tiger-nut seeds were obtained from a local market in Ilorin, Kwara State, Nigeria. The samples transferred to the Food Processing Laboratory of the Department of Home-Economics and Food Science, University of Ilorin, Nigeria for processing. All chemicals used are laboratory grade and were obtained from Sigma Aldrich (St. Louis, MO, USA).

Production of soymilk, tiger-nut milk and soy-tiger-nut cheese

Soymilk was produced as previously described (Belewu and Belewu, 2007), while tiger-nut milk was produced using the method reported by Udeozor (2012).

Soy-tiger-nut cheese was produced using the method

described for cheese from soymilk and coconut milk (Adejuyitan *et al*., 2014). Briefly, blends of soymilk and tiger nut milk were prepared by substituting soymilk with tiger-nut milk at 0, 5, 10, 15, 20 and 25% levels. Each blend was boiled for10 min prior to curdling the milk. Cheese yield was determined as reported by Balogun *et al.* (2016).

Analyses

Proximate composition

Moisture, fat, fibre, ash contents were determined using AOAC (2000) methods. Protein content was determined by Kjeldahl method (6.25×N) and total carbohydrate was calculated by difference.

PH and TTA

The pH of the samples were determined using a pH meter (Jenway 3505, Bibby Scientific, London, UK), while the titratable acid (TTA) content was determined as previously reported (Oyewole and Afolami, 2001). Briefly, 4 drops of phenolphthalein indicator were added to the sample and 0.1 M NaOH was added until the color changed to pink, signifying the endpoint. The volume of NaOH added was multiplied by a factor of 0.09 to obtain the percentage titratable acidity as lactic acid.

Mineral composition

Mineral contents of the cheese was determined as described by Amonsou *et al.* (2014) using the Inductively Coupled Plasma (ICP) spectroscopy. Samples were acid-digested by the addition of 1 mL of 55% (v/v) HNO_3.

Phytate content

Phytate content of the samples was determined using established methods as described below. Briefly, sample (0.5 g) was stirred using a magnetic stirrer in 10 ml of 3.5% HCL for 1 h. The contents were centrifuged at 3000xg for 10 min. A suitable aliquot of the supernatant was diluted with 3.5% HCL to make up to the 3 ml mark. A 10 ml of Wade reagent (0.03% solution of $FeCl_3$. $6H_2O$ with 0.3% sulphosalicylic acid) was added and centrifuged. Absorbance was read at 500 nm where pure phytic acid (Sigma Aldrich, USA) was used as the standard. Phytate content was estimated from a calibration curve prepared by the standard (Vaintraub and Lapteva, 1988).

Trypsin inhibitor activity

Trypsin inhibition was determined as previously reported by Jayaraman, (1981). Trypsin inhibition in the samples was indicated by trypsin activity falling below the tyrosine standard activity. The control 0.9 mL of the casein bovine substrate and 0.1 ml of 0.25% trypsin were added to a test tube, mixed well and incubated for 30 min at room temperature. Then 1.5 mL of 10% TCA was added to stop the reaction. After 15 min, the test tube was put into boiling water for 10 min and filtered using Whatman no. 1 filter paper. The filtrate (0.5 mL) was added to the test tube together with 1 mL of distilled water 0. 5 mL of 0.5 N NaOH and 1.5mL of diluted Folin Ciocalteau (FC) reagent. Five grams of each yoghurt samples was added

to 200 ml of distilled water and allowed to shake for 24 h at 37°C. After 24 h, the yoghurt samples were filtered with Whatman no.1 filter paper. Each of the yoghurt samples (0.1 ml) was added to 0.9 mL of the substrate and 0.1 mL of 0.25% trypsin. Tyrosine (Sigma, USA) was used as a standard to measure trypsin activity. A blank was prepared by adding 1.5 mL of water to 5 mL of 0.5 N NaOH together with 1.5 mL of Folin Ciocalteau (FC) reagent. Absorbance (Abs) was read at 650 nm.

Sensory evaluation

The samples were presented to an untrained 20-member panel of judges who were familiar with the consumption of soy-cheese. The samples were assessed for appearance, chewiness, taste and overall acceptability using a nine-point hedonic scale, where 9 indicated "like extremely" and 1 indicated "dislike extremely". Each panelist was provided with enough privacy to avoid biased assessment.

STATISTICAL ANALYSIS

Duplicate samples were prepared and analyses done in triplicate. Data was analyzed using one way analysis of variance (ANOVA) and means were compared using the Fisher Least Significant Difference (LSD) test (p≤0.05) using the Statistical Package for the Social Sciences (SPSS) Version 16.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Cheese yield

The percentage yield of the soy-tiger-nut cheese varied from 13.79% to 18.94% and decreased with increasing levels of tiger-nut milk (Table 1). Cheese production mainly involves the coagulation of soy-protein to remove water and carbohydrates from the milk (Ahmad *et al*., 2008). Soybean proteins are relatively simple molecules that can be easily coagulated by acids and salts such as calcium sulphate (Han *et al*., 2001) or glucono-delta-lactone (Ahmad *et al*., 2008). The substitution of soymilk (up to 25% v/v) with tiger-nut milk reduced the amount of soy-protein available for curdling and this may explain the reduction in cheese yield. Previous studies on cheese produced from cow milk and coconut milk also reported a decrease in cheese yield (Balogun et al., 2016). The cheese yield in this study is in the range of values reported for 100% soy-cheese (17.6-18.3%) (Oboh, 2006). However, higher cheese yield (57.13-70.10%) has also been reported by some authors for 100% soymilk (Shokunbi et al., 2011). Differences in cheese yield may be attributed to milk composition and variation in protein content. Other factors that could account for variation in cheese yield could be due to soybean variety, coagulant type as well as processing conditions (Tripathi and Mangaraj, 2013).

pH and TTA

The pH and titratable acidity (TTA) of the cheese samples were significantly (p≤0.05) affected by the addition of tiger-nut milk (Table 1). With increase in the addition of tiger-nut milk to soymilk, there was a slight increase in TTA and a corresponding decrease in pH of the cheese

Table 1: Yield, pH and titratable acidity of soy-tiger-nut cheese.

Soymilk (%)	Tiger-nut milk (%)	*Yield (%)	pH	Titratable acidity (%)
100	0	18.94[a]±0.01	5.6[a]±0.00	0.21[c]±0.01
95	5	18.32[b]±0.02	5.6[a]+0.01	0.20[c]±0.01
90	10	17.41[c]±0.01	5.5[b]±0.00	0.23[bc]±0.02
85	15	16.01[d]±0.02	5.4[c]±0.00	0.24[b]±0.02
80	20	14.53[e]±0.03	5.4[c]+0.01	0.29[a]±0.01
75	25	13.79[f]±0.02	5.3[d]+0.00	0.32[a]±0.01

Mean ± SD. Means with same superscripts are not significantly different (p≤0.05)
* Yield was calculated based on the soybean and tiger-nut grain used

Table 2: Proximate composition of soy/soy-tiger-nut cheese blend (%).

Soymilk	Tiger-nut milk	Moisture	Protein	Fat	Fibre	Ash	CHO
100	0	61.11[e]+0.1	19.04[a]+0.2	7.00[f]+0.1	0.73[b]+0.1	2.32[a]+0.1	9.80[e]+0.3
95	5	61.27[d]+0.2	18.72[b]+0.2	7.22[e]+0.1	0.75[b]+0.2	1.90[b]+0.2	10.14[d]+0.2
90	10	62.01[c]+0.1	17.26[c]+0.3	7.52[d]+0.2	0.78[b]+0.1	1.84[c]+0.1	10.59[c]+0.2
85	15	62.72[b]+0.2	15.93[d]+30.2	8.16[c]+0.1	0.84[a]+0.2	1.80[c]+0.2	10.55[c]+0.2
80	20	63.23[a]+0.2	15.02[e]+0.2	8.46[b]+0.1	0.87[a]+0.1	1.71[d]+0.1	10.71[b]+0.1
75	25	64.21[a]+0.1	13.25[f]+0.3	9.14[a]+0.2	0.86[a]+0.2	1.70[d]+0.0	10.84[a]+0.2

Mean ± SD. Means with same superscripts are not significantly different (p≤0.05)

samples. The pH of the cheese samples were generally in the acidic region (5.3-5.6), which could be due to the acidic nature of tiger-nut milk. The pH (3.9-6.12) of tiger-nut milk (Akoma et al., 2000; Belewu and Belewu, 2007; Ukwuru and Ogbodo, 2011) is generally more acidic than that of soybean milk (6.23-6.99) (Belewu and Belewu, 2007; Ono *et al*., 1993). The TTA values of the cheese samples have similar values (0.20% - 0.29%) reported for cow-coconut milk cheese (Balogun *et al*., 2016).

Proximate composition

The moisture contents of the cheese samples were substantially high varying between 61.11-64.21% (Table 2). Cheese samples showed increasing moisture content with increasing levels of tiger-nut milk. Moisture content contributes significantly to the textural properties of food samples (Aworh and Akinniyi, 1989). Cheese with the highest moisture content gave the lowest cheese yield (Table 1). As previously stated the increase in tiger-nut milk, possibly reduced the amount of proteins available for curdling, thus increasing the moisture available in the curdled cheese. The high moisture values of the cheese samples may also be attributed to the hydrophilic nature of soy proteins (Noyes, 1969), which could impact the safety and stability of the cheese products.

Other major components in the cheese samples are protein (13.25-19.04%), fat (7.00-9.14%) and carbohydrate (9.80-10.84%) (Table 2). Both fat and carbohydrate contents of the cheeses increased, but carbohydrate decreased with increasing levels of tiger-nut milk. The increase in fat contents of cheese samples with increasing levels of tiger-nut milk may be attributed to the high fat contents of tiger-nut milk. Tiger-nut milk reportedly showed higher (approx. 6times) fat content compared to soymilk (Belewu and Abodunrin, 2006; Belewu and Belewu, 2007). Furthermore, the increase in fat content of the soy-cheese with tiger nut milk supplementation makes the protein link weaker, entrapping more water, making them softer (Poysa and Woodrow, 2002).

Ash (1.70-2.32%) and fibre (0.73-0.87%) contents of the cheese samples were generally low (Table 2). However, these values are in agreement with values previously reported for cheese made form cow milk and coconut milk (Balogun et al., 2016). Fibers contain food components such as cellulose, hemicellulose, pectin, gum which remain undigested on entering the human large intestine. These food components are useful in the management of diseases such as obesity, diabetes, cancer and gastrointestinal disorders (Saldanha, 1995).

Mineral composition

Among the minerals evaluated, calcium (126.42-189.80 mg/kg) and potassium (145.27-194.33 mg/kg) are the abundant minerals in the cheese samples (Table 3). The iron content (11.03-14.67 mg/kg) of the cheese samples were much lower (approx. 13 times) than calcium and potassium (Table 3). With increasing levels of tiger-nut milk, the iron and potassium contents of the cheese samples increased, while the calcium contents decreased. Calcium and potassium are necessary for the formation of bone and teeth in growing children. Furthermore, high levels of potassium in human diet is important for the protection against life-threatening diseases such as hypertension, and osteoporosis (Demigne *et al*., 2004; Lewu *et al*., 2010).

Table 3: Mineral composition of soy/soy-tiger-nut blend.

Soymilk (%)	Tiger-nut milk (%)	Iron mg/kg	Calcium mg/kg	Potassium mg/kg
100	0	11.03± 0.01[f]	189.80±0.00[a]	145.27±0.02[f]
95	5	11.34±0.03[e]	174.16±0.01[c]	152.14±0.01[e]
90	10	12.51± 0.02[d]	185.47±0.03[b]	156.62±0.02[d]
85	15	13.12±0.04[c]	160.09±0.02[d]	164.89±0.02[c]
80	20	14.02±0.02[b]	143.58±0.02[e]	182.76±0.03[b]
75	25	14.67±0.03[a]	126.42±0.05[f]	194.33±0.02[a]

Mean ± SD. Means with same superscripts are not significantly different (p≤0.05)

Table 4: Anti-nutrient composition of soy/soy-tiger-nut blend.

Soymilk (%)	Tiger-nut milk (%)	Phytate g/100g	Trypsin inhibitor TIU/mg protein
100	0	0.48±0.01[a]	2.28± 0.01[a]
95	5	0.42±0.00[ab]	1.97±0.03[b]
90	10	0.34±0.01[b]	1.82± 0.01[c]
85	15	0.29±0.02[c]	1.69±0.01[d]
80	20	0.27±0.01[c]	1.58±0.02[e]
75	25	0.24± 0.00[c]	1.43±0.01[f]

Mean ± SD. Means with same superscripts are not significantly different (p≤0.05)

Table 5: Mean scores soymilk-tiger nut milk cheese blend.

Soymilk (%)	Tiger-nut milk (%)	Colour	Taste	Chewiness	Aroma	Overall acceptability
100	0	6.50[a]±0.31	5.70[b]++0.26	6.00[b]±0.37	5.80[b]±0.30	6.30[a]++0.21
95	5	7.30[a]±0.37	7.00[a]±0.42	7.70[a]±0.40	7.00[a]±0.45	7.40[a]±0.54
90	10	6.30[a]±0.30	5.60[bc]±0.43	5.60[bc]±0.43	5.70[b]±0.45	6.30[a]±0.36
85	15	5.10[b]±0.38	3.50[d]±0.22	4.80[b]±0.63	4.80[bc]±0.44	4.80[b]±0.45
80	20	4.30[b]±0.30	3.50[d]±0.22	3.40[c]±0.22	4.10[c]±0.43	4.30[b]±0.40
75	25	5.00[b]±0.45	4.80[bc]±0.46	4.70[b]±0.48	5.00[bc]±0.42	4.90[b]±0.38

Mean ± SD. Means with same superscripts are not significantly different (p≤0.05)

Phytate and trypsin inhibitor

The phytate (0.24-0.48 g/100 g) and trypsin inhibitor (1.43-2.28 TIU/mg protein) contents of the cheese samples generally decreased with increasing levels of tiger-nut milk (Table 4). Phytate and trypsin inhibitor are antinutritional factors of concern in most plant foods including soybean. Phytate has been long recognized to bind with minerals such as Zinc and interferes with its absorption (Anderson and Wolf, 1995). On the other hand trypsin inhibitor is well known to reduce protein digestibility in the body. Hence, adequate heat treatment is usually recommended to achieve maximum nutritional value due to denaturation of trypsin inhibitor. However, phytate and trypsin inhibitors have also been found to have anticarcinogenic activity (Messina and Barnes, 1991). The result in this study suggests that the bio-availability of protein and minerals may be improved by the addition of tiger nut milk, since there was a progressive decrease in these anti-nutrients when tiger-nut milk was added.

Sensory parameters

The mean sensory scores for soy-tiger-nut cheese samples produced with varying proportions of added tiger nut milk are shown in Table 5. Cheese produced form 95% soy milk and 5% tiger-nut milk had the highest rating in all sensory parameters, followed by cheese made from 100% soymilk. Beyond 5% tiger-nut milk addition, the ratings significantly reduced. The significant reduction in the chewiness of the cheese samples may be attributed to the high moisture content of the cheese samples (Table 1). High moisture in cheese may result in softening and making the product less chewy since high moisture content is suggested to contribute to textural properties of foods (Aworh and Akinniyi, 1989).

CONCLUSIONS

The addition of tiger-nut milk to soymilk reduced the cheese yield, but increased the fat contents appreciably. Acceptable cheese with superior sensory quality was produced from 95% soymilk and 5% tiger-nut milk. Calcium and potassium were abundant in the cheese samples, but the iron content was generally low. Producing soy-cheese from soymilk and tiger nut milk blend may be a promising means of value addition and to further promote the utilisation of tiger-nut milk beyond traditional usage.

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