

Flour functionality, physicochemical and sensory properties of steamed and baked maize meal enriched with defatted soybean

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Abstract

Abari is a traditional meal rich in carbohydrate and consumed in many parts of Nigeria. This study determined the physicochemical and sensory properties of steamed or baked *abari* enriched with defatted soybean. *Abari* samples were enriched with soybean at 20% and 40%, steamed or baked and the physical, proximate, and sensory attributes of the samples were evaluated. Addition of defatted soybean flour increased the protein, ash and fiber contents, of *abari*. Processing methods and soybean flour addition generally did not affect the appearance and color of the samples, but they did affect the textural properties of the samples. Steamed samples were rated higher in all sensory parameters and were softer than baked samples. Although baking provided another variety in the consumption of *abari*, steamed *abari* were preferred to baked samples due to the familiarity with steamed samples. The consumption of baked *abari* may be increased through consumers enlightenment on its superior nutritional value.

Practical applications

This study has demonstrated the possibility of improving the nutritional value and textural properties of a traditional food (*abari*) by enriching it with a protein-rich legume. The defatting step could be done in rural communities through mechanical or manual pressing of the ground seeds and the oil may be used with little processing for cooking. The major advancement in this study is to concentrate the protein of the food through defatting and to improve the textural properties, which otherwise would be soggy without defatting.

1 | INTRODUCTION

Abari is a traditionally maize pudding prepared from maize (*Zea mays*). It is prepared from fresh maize, ground with pepper, onions, salt, and palm oil, with the resulting paste wrapped in leaves and steamed to form a gel (Olanipekun et al., 2015). *Abari* is similar to cowpea pudding, called *moimoi* and it is consumed in many parts of Nigeria (Omueti & Morton, 1996). The meal is relished by both children and adults and high consumption of the meal alone or prolonged consumption may lead to malnutrition and kwashiorkor among children (Arise, Akintayo, Dauda, & Adeleke, 2019; Olanipekun et al., 2015).

Carbohydrate (33.54%–67.05%) is the main component of *abari*, while the protein content is very low and may vary between 5.90% and 9.43% depending on the source and variety of the maize grain (Arise et al., 2019; Olanipekun et al., 2015; Omueti & Morton, 1996). Due to the relatively low protein content of *abari*, efforts have been made to improve its nutritional value by enriching the meal with protein-rich legumes such as Bambara groundnut (Arise et al., 2019), kidney bean (Olanipekun et al., 2015), or whole soybean (Omueti & Morton, 1996). Leguminous crops such as soybean, kidney bean, and Bambara groundnut are well known to be good and cheap sources of proteins that could be potentially used for enriching common

staples in developing nations of the world. For example, the protein content of soybean may vary between 33% and 42% depending on variety and growing conditions (Edema, Sanni, & Sanni, 2005; El Tinay, Mahgoub, Mohamed, & Hamad, 1989; Redondo-Cuenca, Villanueva-Suárez, Rodríguez-Sevilla, & Mateos-Aparicio, 2007). Soybean has superior protein content and quality compared with dry beans including cowpea, kidney bean, and Bambara groundnut. Earlier studies found that the protein content of *abari* enriched with 40% kidney bean increased approximately by 32% (Olanipekun et al., 2015), while substantially higher increase (136%) in protein was reported for the same amount of soybean added to *abari* (Omueti & Morton, 1996). More recently, Arise et al. (2019) reported about fivefold increase in protein of *abari* enriched with 21% Bambara groundnut flour.

Although enriching *abari* with protein-rich leguminous crops is a very good initiative, the enrichment may affect the acceptability of the meal. For example, the use of whole soybean reportedly affected the sensory and textural properties of *abari* due to the high oil content of the bean (Omueti & Morton, 1996). The authors found that with higher levels of whole soybean flour, *abari* became soggy and had a loose surface, which could be due to the high amount of oil in the soybean flour. Thus, it is hypothesized that defatting soybean will decrease the oil content and also concentrate the protein present in the defatted flour. This may further enhance the protein content of the meal and provide *abari* with improved textural properties. In addition, this is the first time baking will be compared with steaming as a processing method in order to create variety. Therefore, the objective of this study is to determine the physicochemical and sensory properties of steamed or baked *abari* enriched with defatted soybean.

2 | MATERIALS AND METHODS

2.1 | Materials

Yellow maize (*Zea mays* L.), soybean (*Glycine max* L.) and other ingredients like pepper, onions, palm oil, salt, and leaves for packaging were purchased from a local market in Ilorin, Kwara State, Nigeria and were immediately transferred to the Food Processing Laboratory of the Department of Home Economics and Food Science, University of Ilorin.

2.2 | Flour preparation and thermal processing

Maize and soybean flours were prepared as previously described except that soybean flour was defatted (Omueti & Morton, 1996). Soybean was defatted using a single-screw oil press (KK20F Universal, KernKraft, Germany). The throughput of the press was 660 g soybeans per hour. The soybean oil was discarded and the defatted soy cake was crushed using mortar and pestle, air-dried for 2 hr and immediately used for the formulation. The flours were mixed in different ratios of 100:0, 80:20, and 60:40 and sieved using

a screen size of 350 μm . The ratios were selected based on earlier studies, where these ratios were acceptable (Omueti & Morton, 1996).

Flour (100 g) was mixed with other ingredients including, 7 g of salt, 0.25 g pepper 20 g of freshly ground onion, and 20 ml of palm oil into a smooth paste and the paste were subjected to two processing methods. A portion was steamed at 100°C for 1 hr, while the other portion was baked at 170°C for 15 min. The baking time was selected after preliminary studies with a different combination of temperature and time, until a good textured product with similar appearance to steamed *abari* was obtained.

2.3 | Proximate composition of flours and *abari*

Moisture, fat, and ash contents of the flours and *abari* samples were determined using AOAC (2000) methods. Protein content was determined by the Kjeldahl method ($6.25 \times N$) and total carbohydrate was calculated by difference. Fiber contents were determined by digestion in sulfuric acid and sodium hydroxide (Kirk & Sawyer, 1991).

2.4 | Functional properties of flour

Loose and packed bulk densities of the flour were determined using the method of Mpotokwane, Gaditlhatlhelwe, Sebaka, and Jideani (2008). A measuring cylinder (100 ml) was filled with flour to mark (100 ml), and the content weighed. Packed bulk density (PBD) was also obtained by following the same procedure, but with additional tapping for 50 times prior to weighing. Bulk density was calculated as the ratio of the bulk weight and the volume of the container (g/ml).

Water absorption capacity (WAC) of the flours were determined as described by Falade and Oyeyinka (2015). Briefly, 1 g of flour sample was mixed with 10 ml of distilled water. The mixture was allowed to stand at room temperature ($27 \pm 2^\circ\text{C}$) for 30 min and then centrifuged (Model K241R, Centurion Scientific, Chichester, UK) at $2,000 \times g$ for 30 min. WAC was expressed as gram of water per gram flour. The same procedure was repeated for oil absorption capacity (OAC), except that 10 ml of refined soybean oil (sp. Gravity = 0.9092) was used instead of water.

2.5 | Color

The CIE tristimulus L , a , and b parameters of the samples were measured using a Colorflex-EZ bench top spectrophotometer (A60-1014-593, Hunter Associates, Reston, VA, USA) as previously described (Oyeyinka et al., 2018). The colorimeter operates on the CIE L , a , and b color schemes, L (lightness) axis—0 is black, 100 is white, a (red-green) axis—positive values are red; negative values are green and 0 is neutral, b (yellow-blue) axis—positive values are yellow; negative values are blue and 0 is neutral. The instrument was standardized

and the samples were placed in the sample holder. Color measurement was determined in five replicates.

2.6 | Sensory properties

Sensory evaluation of the samples were carried out as described by Karim, Kayode, Oyeyinka, and Oyeyinka (2015). Briefly, a 9-point hedonic preference scale and a multiple comparison test were used to assess the acceptability of the samples. Thirty semi-trained panellists consisting of 15 males and 15 females with age ranging between 20 and 28 years were selected from student of the Department of Home Economics and Food Science, University of Ilorin, Nigeria were used for the evaluation. The samples were prepared in identical sample containers, coded with three-digit random numbers, and each sample was presented with different number. The randomized order of the sample was presented once at a time to each panelist. The panelists were instructed to rinse their mouth thoroughly with potable water and were requested to taste the samples one by one. Between each testing of samples, they were requested to drink/rinse their mouth with a mouthful of water. The selected students were those accustomed to eating *abari*. Prior to the sensory analysis, they were screened with respect to their interest and ability to differentiate food sensory properties. The samples were evaluated for appearance, taste, aroma firmness and overall acceptability.

2.7 | Trypsin inhibitor activity

Trypsin inhibitor activity (TIA) of maize and soybean flours as well as the *abari* samples was determined as previously described (Yalcin & Basman, 2015). TIA is expressed in terms of trypsin units inhibited. One trypsin inhibitory unit (TIU) is defined as an increase of 0.01 absorbance units at 410 nm per 10 ml of the reaction mixture.

2.8 | Textural properties

The firmness of *abari* was measured as previously described except that samples were compressed to 30% of its original height between

the two flat plates of an Instron Universal Testing Machine (Model 4301, Instron Ltd., High Wycombe, England) (Omu et al., 1996).

2.9 | Statistical analysis

Duplicate samples were prepared and analyses done in triplicate. Data were analyzed using one-way analysis of variance (ANOVA) and means were compared using the Fisher Least Significant Difference (LSD) test ($p \leq .05$) using the Statistical Package for the Social Sciences (SPSS) Version 16.0 for Windows (SPSS Inc., Chicago, IL, USA).

3 | RESULTS AND DISCUSSION

3.1 | Proximate composition of flours and abari samples

Differences were observed in the composition of maize and soybean flours. Protein content of the soybean flour (approximately 40%) was substantially higher (five times) than that of maize flour. The carbohydrate content of the flours were 53.5% and 76.6% for defatted soybean and maize flours, respectively. Fat (6.72%), fiber (4.75%), and ash (5.19) contents of the soybean flour was also higher than those of the maize samples (fat: 3.79%, fiber: 2.18%, and ash: 1.7%). The low fat content of the soybean flour is obviously due to the defatting step. The proximate composition of the soybean is within the range of values reported in the literature (Edema et al., 2005; El Tinay et al., 1989; Redondo-Cuenca et al., 2007).

Due to the high moisture content (42.23%–47.15%) of the *abari* samples, the proximate composition was reported on dry matter basis (Table 1). The protein content of the *abari* samples increased with increasing levels of the defatted soybean flour. Baked samples generally had significantly ($p < .05$) higher protein content (21.2%–45.9%) than the steamed *abari* (17.6%–44.7%). The higher protein content recorded for baked samples could be due to concentration effect, which presumably results from loss of moisture during baking. This may account for the slightly, but significantly ($p < .05$) higher dry matter contents of the baked samples compared with their steamed counterparts (Table 1). Omu et al.

TABLE 1 Proximate composition of *abari* (dry matter basis %)

Samples	Maize: soy flour	Dry matter	Protein	Fat	Ash	Fiber	Carbohydrates
Steamed	100:0	55.91 ^c ± 0.04	17.61 ^f ± 0.01	31.21 ^b ± 0.04	3.65 ^d ± 0.13	3.11 ^e ± 0.05	44.40 ^b ± 0.03
Baked	100:0	56.92 ^b ± 0.02	21.21 ^e ± 0.02	29.11 ^c ± 0.06	7.53 ^b ± 0.05	3.25 ^d ± 0.17	45.40 ^b ± 0.39
Steamed	80:20	52.90 ^d ± 0.03	33.52 ^d ± 0.00	26.30 ^e ± 0.21	3.99 ^c ± 0.05	3.35 ^d ± 0.02	28.21 ^c ± 0.03
Baked	80:20	53.90 ^d ± 0.02	37.80 ^c ± 0.05	24.90 ^f ± 0.05	8.76 ^a ± 0.00	3.65 ^c ± 0.07	21.91 ^d ± 0.13
Steamed	60:40	55.90 ^c ± 0.01	44.70 ^b ± 0.02	27.50 ^d ± 0.03	7.47 ^b ± 0.03	4.09 ^b ± 0.03	17.62 ^e ± 0.01
Baked	60:40	57.81 ^a ± 0.02	45.90 ^a ± 0.03	33.12 ^a ± 0.08	8.95 ^a ± 0.03	4.29 ^a ± 0.05	8.84 ^f ± 0.19

Note: Mean ± SD means with the same superscript (s) within the same column are not significantly ($p < .05$) different.

and Morton (1996), reported 15.06% protein (dry weight basis) and 22.32% protein (dry weight basis) for *abari* enriched with 20% and 40% whole soybean flour, respectively. These values were much lower than values obtained in this study for *abari* enriched with defatted soybean flour at the same level of inclusion. The variation in the protein contents may be associated with the defatting of soybean, which concentrated the protein available. This suggests that more protein are present in the defatted soybean compared to whole soybean of the same amount. Furthermore, the *abari* samples in this study had higher protein content than values reported for *abari* enriched with kidney bean (Olanipekun et al., 2015) and Bambara groundnut (Arise et al., 2019). Fat contents of the samples were generally high (24.90%–33.12%), while ash and fiber contents were low.

3.2 | Flour functionality

Loose bulk density (LBD), packed bulk density (PBD), oil absorption capacity (OAC), and water absorption capacity (WAC) of the maize flour, defatted soybean flour, and their composite were the functional properties determined (Figure 1). Defatted soybean flour had a significantly ($p < .05$) lower LBD and PBD compared with the maize flour, which could be attributed to the removal of oil (defatting) from the soybean flour. This seems plausible since the composite flour with higher soybean (40%) displayed lower densities (LBD & PBD) compared to the flour samples with lower amount of soybean (20%). Higher loose and packed bulk densities show greater compactness of particles (Falade & Oyeyinka, 2015). Previous studies similarly reported that soy flour displayed lower bulk density than corn flour (Akubor & Onimawo, 2003).

Defatted soybean flour absorbed more water than maize, but the maize flour showed greater ability for oil absorption than the defatted soybean (Figure 1). Furthermore, addition of soybean flour at 20% and 40% levels to maize flour resulted in approximately 26% and 35% increase in WAC (Figure 1). Higher (five times) protein content of the soybean flour compared with the maize flour may also explain why it absorbed more water than maize flour. Akubor and Onimawo (2003), similarly reported higher WAC in maize flour enriched with soybean flour. According to Mohajan, Orchy, and Farzana

(2018), proteins are capable of binding large quantities of water due to their ability to form hydrogen bonds between water molecules and polar group on the polypeptide chain. Differences in starch content, starch composition (i.e., amylose content) as well starch granular structure may also explain the variation in WAC (Falade & Oyeyinka, 2015). For example, starches with high amylose content reportedly displayed high WAC compared with those with low amylose (Oyeyinka, Singh, Adebola, Gerrano, & Amonsou, 2015; Shujun et al., 2006; Singh, Sandhu, & Kaur, 2004).

3.3 | Color and appearance of abari

Processing method and soybean flour addition generally did not significantly ($p > .05$) affect the color of the *abari* samples as depicted in the *L*, *a*, and *b* values (Table 2). The similarity in "*a*" values may be associated with the general masking effect of palm oil, which imparted redness to all the samples (Omueti & Morton, 1996). Omueti and Morton (1996), working with *abari* enriched with whole soybean flour found significant differences in *L* and *b* values. Differences in the color result presumably results from the variation in oil content, since defatted soybean flour was used in the current study. The objective color result (Table 2) is in agreement with the appearance of the samples (Figure 2), suggesting that incorporating defatted soybean flour is preferable to produce *abari* without significantly altering the appearance of the samples.

3.4 | Sensory properties of abari

In general, processing method and the addition of soybean did not significantly ($p > .05$) affect the appearance, aroma, taste, and firmness of *abari* (Table 2). However, the overall acceptability results of the samples were affected. Baked *abari* had lower ratings for all the sensory parameters measured including overall acceptability compared with the steamed samples. The higher rating of the steamed samples may not be unconnected with the fact that sensory panel members are accustomed to eating steamed and not baked *abari*. Baking of the pudding was an initiative to provide variety for

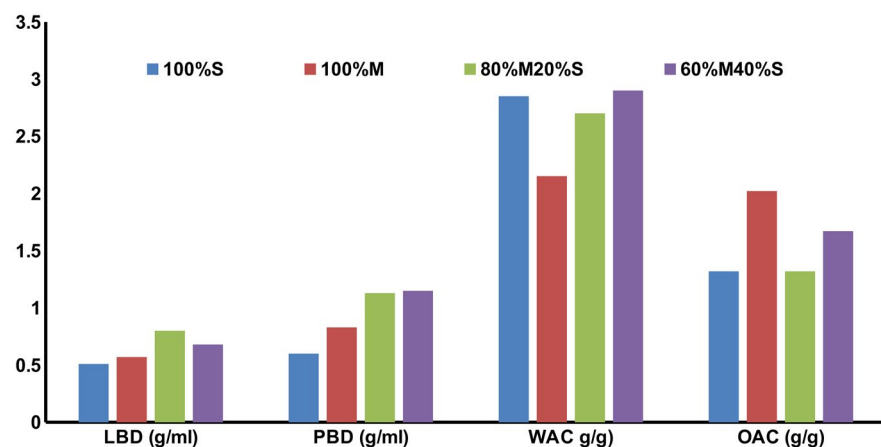


FIGURE 1 Selected functional properties of maize and soybean flours. LBD, loose bulk density; M, maize flour; OAC, oil absorption capacity; PBD, packed bulk density; S, soybean flour; WAC, water absorption capacity

TABLE 2 Effect of processing methods on objective colour and sensory properties of *abari*

Processing method	Maize: Soy flour	L	a	b	Appearance	Taste	Aroma	Firmness	Overall acceptability
Steamed	100:0	54.47 ^b ± 0.99	7.060 ^a ± 0.89	24.18 ^{ab} ± 1.90	6.60 ^{ab} ± 1.38	6.20 ^a ± 1.85	6.43 ^a ± 1.38	6.63 ^a ± 1.59	7.30 ^a ± 1.15
Baked	100:0	53.90 ^b ± 1.02	7.738 ^a ± 1.46	24.42 ^{ab} ± 1.69	6.10 ^{ab} ± 1.97	5.83 ^a ± 1.64	6.30 ^a ± 1.54	5.70 ^a ± 1.49	6.40 ^b ± 1.22
Steamed	80:20	54.23 ^b ± 1.16	7.206 ^a ± 0.27	23.49 ^{ab} ± 1.16	7.00 ^a ± 1.17	6.20 ^a ± 1.47	6.47 ^a ± 1.25	6.50 ^a ± 1.73	6.80 ^{ab} ± 1.50
Baked	80:20	54.41 ^b ± 1.12	8.142 ^a ± 0.53	24.95 ^{ab} ± 1.88	6.23 ^{ab} ± 1.65	5.57 ^a ± 1.79	6.20 ^a ± 1.83	5.93 ^a ± 1.95	6.03 ^b ± 1.81
Steamed	60:40	56.28 ^a ± 0.59	7.530 ^a ± 0.22	25.99 ^a ± 1.22	6.40 ^{ab} ± 1.45	6.03 ^a ± 1.87	6.13 ^a ± 1.66	6.53 ^a ± 1.76	6.70 ^{ab} ± 1.24
Baked	60:40	54.12 ^b ± 1.27	7.412 ^a ± 0.47	24.89 ^{ab} ± 1.56	5.76 ^b ± 2.15	5.72 ^a ± 1.33	6.38 ^a ± 1.29	6.03 ^a ± 1.70	6.24 ^b ± 1.85

Notes: Mean ± SD means with same the superscript (s) within the same column are not significantly ($p < .05$) different. L (lightness) axis—0 is black, 100 is white, a (red-green) axis—positive values are red; negative values are green and 0 is neutral, b (yellow-blue) axis—positive values are yellow; negative values are blue and 0 is neutral.

consumer who relish the consumption of *abari*. Among the steamed *abari* samples, the level of acceptability decreased, but not significantly ($p > .05$) with increasing levels of soybean. Thus, *abari* with similar appearance and acceptability may be prepared from maize and defatted soybean up to 40%, confirming previous studies where whole soybean was used (Omuetti & Morton, 1996).

3.5 | Textural properties of *abari*

Steamed *abari* were softer compared with baked samples, while the addition of defatted soybean flour decreased the hardness of *abari* samples, but the decrease was not significant (Table 3). Hardness of food samples is related to the structure of the swollen starch granules and it is measured by the force required to compress a given area of a product (Karaoglu & Kotancilar, 2009). The hardness of *abari* may be associated with the retrogradation of the starch components in the maize flour, which presumably results from reassociation of amylose-amylose chains as well as amylopectin chains to form junction zones. Previous research reported that the linear amylose chains, as well as the linear part of amylopectin forms cross-links through hydrogen bridges (Wang, Li, Copeland, Niu, & Wang, 2015). Amylose chains may also form double helices and junction zones which enhances the formation of firm gel structure. Thus, the decrease in hardness of the *abari* samples, following the addition of soybean may be due to two factors. First, low amount of amylose from the maize flour due to the soybean addition, could limit the amounts of amylose to participate in the formation of junction zones. Second, the added protein from the defatted soybean flour may participate in starch-protein interactions, forming complexes, which may also prevent the formation of junction zones and double helices by amylose during cooling. This seems plausible since starch-protein interactions contribute to starch gel-matrix weakening (Fu, Chen, Luo, Liu, & Liu, 2015). For example, the addition of soy protein isolate to starch was found to produce soft gels as measured by texture profile analysis (Ribotta, Colombo, León, & Añón, 2007). Furthermore, these authors reported that soy protein isolate retarded gel retrogradation during the storage period, indicating that proteins might readily interact with amylose and exposed branches of amylopectin through non-covalent bonding such as hydrogen bonds (Fu et al., 2015; Ribotta et al., 2007).

Soybean addition significantly ($p < .05$) improved the springiness in comparison with the control *abari* samples (Table 3). Steamed samples showed higher springiness than the baked samples. Highest springiness value was obtained in steamed *abari* enriched with 40% soybean. Springiness is the rate at which a deformed sample goes back to its undeformed condition after the deforming force is removed (Karaoglu & Kotancilar, 2009). Thus, steaming may be preferred to baking for *abari* enriched with soybean that would be stacked during packaging.

Steamed samples similarly showed higher cohesiveness and chewiness values compared with their baked counterparts (Table 3). Chewiness is the energy required to masticate solid food to a state

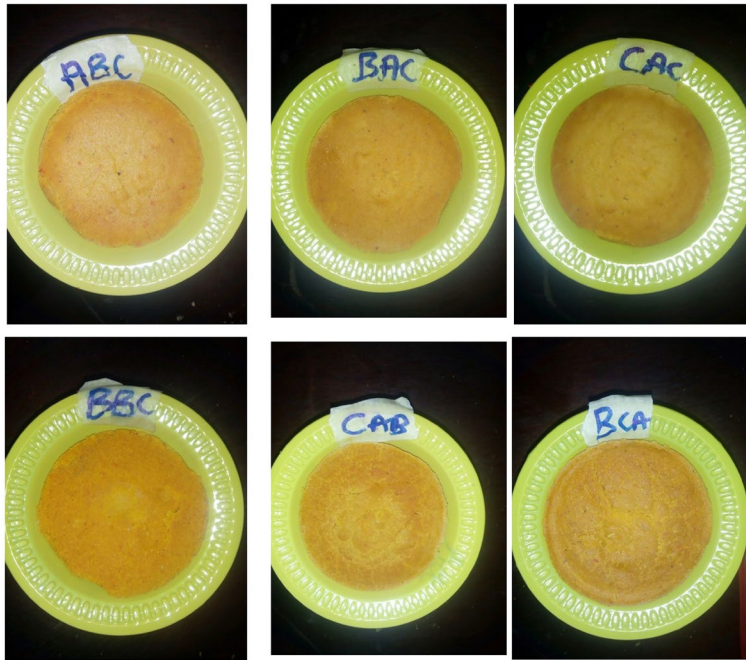


FIGURE 2 Appearance of steamed and baked abari prepared from maize and defatted soybean. ABC, cooked abari prepared from 100% maize; BBC, baked abari prepared from 100% maize; BAC, cooked abari prepared from 80% maize and 20% defatted soybean; CAB, baked abari prepared from 80% maize and 20% defatted soybean; CAC, cooked abari prepared from 60% maize and 40% defatted soybean; BCA, baked abari prepared from 60% maize and 40% defatted soybean

TABLE 3 Effect of processing methods on textural properties of *abari*

Processing method	Maize: soy flour	Hardness	Springiness	Cohesiveness	Chewiness
Steamed	100:0	11.20 ^{ab} ± 3.46	0.39 ^b ± 0.64	0.25 ^c ± 0.02	12.20 ^a ± 0.85
Baked	100:0	13.80 ^a ± 0.18	0.13 ^d ± 0.07	0.14 ^d ± 0.01	10.52 ^c ± 0.42
Steamed	80:20	11.21 ^{ab} ± 1.27	0.44 ^b ± 0.01	0.30 ^b ± 0.02	12.00 ^a ± 2.12
Baked	80:20	14.10 ^a ± 1.48	0.28 ^c ± 0.07	0.17 ^d ± 0.01	6.57 ^b ± 0.88
Steamed	60:40	8.14 ^b ± 0.35	0.52 ^a ± 0.21	0.35 ^a ± 0.03	14.60 ^a ± 2.40
Baked	60:40	13.10 ^a ± 0.35	0.30 ^c ± 0.07	0.18 ^d ± 0.01	6.57 ^b ± 0.88

Note: Mean ± SD means with same the superscript (s) within the same column are not significantly ($p < .05$) different.

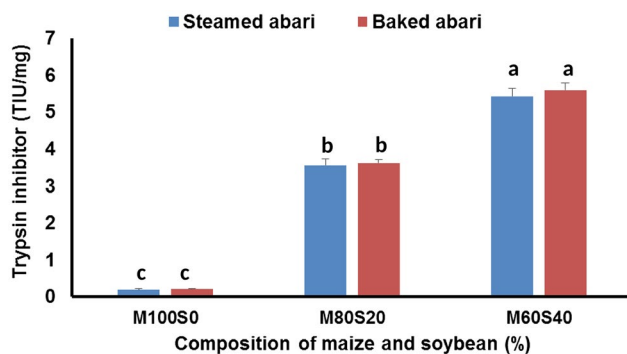


FIGURE 3 Trypsin inhibitor of steamed and baked abari enriched with defatted soybean. Error bars indicates standard deviation ($N = 3$)

of readiness for swallowing (Karaoğlu & Kotancilar, 2009), while cohesiveness measures the rate at which a food product disintegrates under the mechanical action of mastication (Abbas et al., 2006). Therefore, steamed samples may require more energy for mastication, while the addition of soybean may sufficiently decrease this energy. The result

of chewiness confirms the hardness result, where soybean addition significantly decreased the hardness of the samples (Table 3). Previous research similarly reported that chewiness values are dependent on hardness values (Karaoğlu & Kotancilar, 2009).

3.6 | Trypsin inhibitor of flour and abari

Defatted soybean flour had substantially higher (35.4 TIU/mg) trypsin inhibitor content (TIC) compared to maize flour (approximately 2 TIU/mg). The TIC of soybean flour may vary between 32.6 and 93.5 TIU/mg depending on variety and processing methods (Kumar et al., 2017; Yalcin & Basman, 2015).

The *abari* samples had significantly ($p < .05$) lower TIC contents compared with the defatted soybean flour. It should be noted that *abari* samples were enriched with defatted soybean flour at 20% and 40% levels, thus it is expected that the flour mixture will have approximately 7 TIU/mg and 14 TIU/mg of trypsin inhibitor prior to thermal processing, respectively. After baking or steaming, the *abari* samples showed a significant ($p < .05$) decrease in the TIC

(Figure 3). Both processing methods had similar effect on the TIC of the samples. Trypsin inhibitor is a thermolabile compound which is inactivated by various heat treatments including infrared treatment, autoclaving and cooking (Kadam & Smithard, 1987). Among all the anti-nutrients present in wide variety of foods, trypsin inhibitors are of high importance as they interfere with protein utilization and its digestion (Vagadia, Vanga, & Raghavan, 2017). Trypsin inhibitors is known to decrease the biological activity of digestive enzymes such as trypsin and chymotrypsin. Khan, Anjum, Pasha, Sameen, and Nadeem (2012), reported TIC of 1.97 TIU/mg for chapattis prepared from 90% wheat flour and 10% heat treated defatted soy flour. Slightly lower value of trypsin inhibitor (1.74 TIU/mg) was reported for nixtamalized maize containing 40% sprouted soy flour (Inyang, Akindolu, & Elijah, 2019). Variation in the TIC may be attributed to different processing methods such as sprouting, quantity of soybean added as well as the initial amount of trypsin inhibitor in the samples.

4 | CONCLUSION

Enriching abari with defatted soybean flour may be a better alternative to using whole soybean flour due to concentration effect of nutrients especially protein. Soybean addition improved the nutritional value of *abari* substantially. Baked samples showed superior protein content than steamed samples. Addition of defatted soybean and processing method did not significantly affect the appearance and color of the samples, but affected the textural properties of the samples due to gel-weakening effect of protein. Steamed samples were rated higher in all sensory parameters and were softer than baked samples. Baking provided another variety in the consumption of abari samples. However, steaming is preferred to baking by consumers due to their familiarity with the processing method. Future studies may be required to enlighten consumers on the possibility of consuming baked *abari* due to the better protein content than the steamed counterparts. Additionally, the amino acid profile, in vitro protein digestibility, and microbial quality of the samples may require further investigation.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

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