The Roles of Okara Powder on the Processing and Nutrient Content of Roti and Paratha

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Abstract

Okara is a by-product from soy milk or tofu production and it has been under-utilized using only for animal feed. The aim of this research is to substitute the wheat flour by okara powder, processing and observation of nutrient content of roti and paratha. The result showed that increasing the okara powder at any ratio did not show any significant difference ($p<0.5$) in case of moisture content for both roti and paratha; however ash content was increased but not significantly differs. Protein, fat and crude fiber content was significantly ($p<0.5$) increased with increasing okara powder for both roti and paratha. Protein and crude fiber content was significantly ($p<0.5$) higher in roti than paratha at all ratio of okara powder, though fat content was higher ($p<0.5$) in paratha. For both roti and paratha, 50% okara powder substitution for wheat flour gave the highest amount of protein, fat and ash content, but 50% okara powder was not suitable to prepare roti and paratha due to low gluten content in the dough. However, substituting 30% okara powder could be used for processing of roti and paratha.

Keywords - *Okara powder, wheat flour, roti, paratha, genistein*

I. INTRODUCTION

Roti and paratha are the unleavened bread made from dough prepared with wheat flour (atta), water and a little bit salt. After dough is prepared and separated into small dough balls for the processing of roti and paratha. The dough balls roll into flat rounds and fried on either hot plate or frying pan with (paratha) or without (roti) ghee or oil. Roti and/or paratha are known as second staple food in Indian sub-continent. Peoples suffering from diabetes are suggested to eat roti or paratha in the breakfast and dinner. But peoples suffering from heart disease or severe diabetics are not recommended to eat paratha due to its high fat content. Wheat flour (atta) contains busk bran, germ and endosperm of wheat. Wheat flour also contained gluten and this gluten is responsible for celiac disease. People suffering from celiac disease are suggested to reduce or ignore gluten content. Substitution of wheat flour by *okara* powder will reduce the gluten content as well as increased the nutrient content in roti and paratha.

Okara is the by-product from soy milk or tofu production. This *okara* has been under-utilized as it used only for animal feed in many countries. In USA and other Western countries, *okara* is utilized as a waste product due to its strong beany flavor. *Okara* is largely agro waste and also used for landfills, which creates an ecological problem. Though, *okara* is known for high fiber and protein content [1-2] and it might also be used for human foods [3]. Every year a large quantity of *okara* produced which creates a disposal problem. To solve this disposal *okara* could be used as dietary additives. As it contained crude fiber composed of cellulose, hemicelloluse, and lignin. It also contained 25% protein, 10-15% fat, and small amount starch or carbohydrate [3]. Presently, *okara* is used as a dietary additive in biscuits and snakes as it increases dietary fiber and reduces calorie intake. Its high quality protein has the very good water holding as well as emulsifying qualities and has a peptide with anti-hypertension effects [3]. The pectic polysaccharide is also suitable for thickening acid milk products. Besides, *okara*'s application as an animal feed, it is also used directly in food dishes too, such as soups, salads, tempeh in Asian countries. However, there was no industrial product is currently available commercially that made from soy *okara*. One of the possible ways to use *okara* is in baked goods due to high protein and crude fiber. The even higher value of *okara* could be added if it could properly introduce as gluten-free flour. The market value of gluten-free formulations and flour is increasing day by day due to the increasing of celiac disease. Therefore, gluten-free all-purpose flour formulated with *okara* is might be one of the main ingredients should offer a value added application to reduce the agro waste and increasing the nutritional value of gluten-free baked goods. The ultimate goal of this research was to identify the roles of *okara* during preparation of roti and paratha and the nutritional composition of roti and paratha.

II. MATERIALS AND METHODS

Whole soybean and wheat flour were collected from local market (Mymesningh, Bangladesh), food grade sodium bi-carbonate was supplied by Paradise Scientific Co. Ltd., Bangladesh.

A. Processing of okara powder

Prior to grinding whole soybean was soaked at 0.5% sodium bi-carbonate solution at the 60^{o}C for 4 h in a water bath (Schufzart, MembartGmBH+ Co., Bϋchenbach, Germany). Soybean and water ratio for soaking was 1:2. The water was discarded and soaked bean was dehulled before grinding to remove unwanted substances using hands. Hydrated beans were blanched in 0.5% sodium bicarbonate solution at 90^{o}C for 10 min. The solution was drained well and washed with water for three times [4-6]. The blanched soybean was ground with the addition of hot water (100°C) using super mass colloider (Masuko Sangyo Co., Ltd. Kawaguchi, Japan). The ratio of soybean to water was 1:4. After obtaining the soy milk through filtration *via* double layers of cheese cloths, the remaining residue was collected called soy *okara*. Soy *okara* was dried in cabinet drier (Dayton Electric MFG. Co. Ltd., USA) at 60^{o}C for 24 h and grinding using a grinder. The ground *okara* powder was sieved with the help of a sieve (420 micron mesh size). The *okara* powder was kept in phosphorus pentaoxide (P_2O_5) to reduce the moisture content up to 5%. The powder was finally kept in a sealed aluminum foil laminated with polyethylene bag and kept at -20^{o}C prior to analysis and further processing.

B. Preparation of roti

Sixty milliliter (60 ml) of water was added to the *okara* powder and wheat flour and mixed properly (Table 1). Again 20 ml of water was added and kneaded for 2 min. Another 10 ml of water was added and kneaded for 1 min to make the dough smooth. The dough was rested for 15 min. A small portion of dough was taken and rolled into a ball. The ball was rolling to roti. The flame was turned on and heated a fry pan on high flame and roti was placed on fry pan. The roti was fried until flipped both sides.

TABLE 1 - Ratio of okara and wheat flour for the processing of dough (200g) to prepare roti and paratha

% Soy okara	Soy okara powder (g)	Wheat flour (g)
10	20	180
20	40	160
30	60	140
40	80	120
50	100	100

C. Preparation of paratha

Sixty milliliter (60 ml) of water was added to the okara powder and wheat flour and mixed properly (Table 1). Again 20 ml of water was added and kneaded for 2 min. Another 10 ml of water was added and kneaded for 1 min to make the dough smooth. The dough was rested for 15 min. A small portion of dough was taken and 10 ml of sunflower oil was mixed with the dough. The dough was rested for 30 min and rolled into a ball. The ball was rolling to roti. The flame was turned on and heated a fry pan on high flame. 8-10 ml of sunflower oil was placed in a heated fry pan before placing the raw roti on fry pan. The paratha was fried until flipped both sides.

D. Chemical analysis

Moisture, ash, protein, fat and crude fiber content of *okara* powder, wheat flour, roti and paratha was determined adopting AOAC [7] method.

E. Determination of genistein by HPLC method

Genistein was extracted from *okara* powder, roti and paratha and the quantification were performed with some modification from Coward *et al.* [8] and Fukutake *et al.* [9]. Ten gram (10g) samples were extracted with 100 ml of 80% methanol by sonication (Chrom Tech, Taipei 104, Taiwan) for 30 min at 50^{o}C. The solution was then centrifuged at 5000 rpm for 10 min. The supernatants were evaporated to dryness using a rotary evaporator. The dried samples were rehydrated in 10 ml of 50% methanol. The lipid content of the samples was removed by liquid-liquid extraction using 30 ml of n-hexane. The aqueous methanol phase was evaporated and the residue was dissolved in 5 ml of 80% methanol. An aliquot (2 ml) was filtered through solvent resistance 0.2 µm membrane filter (Fluoropore^{TM}Membrane Filters, FGLP02500, R2PA14822, Ireland) before HPLC analysis.

Acetonitrile and trifluoroacetic acid were filtered separately through 0.45 µm PTFE and de-gassed in a sonicator (Chrom Tech, Taipei 104, Taiwan) for 45 min before HPLC use. Seven (7) standard concentrations of genistein (≥98% purity) were prepared at the concentration of 0.1 µg/g, 1 µg/g, 5 µg/g, 10 µg/g, 20 µg/g, 30µg/g and 40 µg/g in 99.9% ethanol. Twenty microliter (20 µL) were injected into an octadecyl saline (ODS) column of particle size 5 µm, 4.6 x 250 mm and a mobile phase of a gradient 0-60% acetonitrilein 0.1% trifluoroacetic acid at a flow rate of 1.2 ml/min at 25^{o}C. Genistein was screened by 262 nm UV absorbance. The genistein contents were estimated from standard curves and the retention time for genistein was 60 min.

F. Color determination

Color of the roti and paratha was measured using a Minolta colorimeter (Chorma Meter, Japan). Results were analyzed according to the CIELB system with reference to the illuminant D65 and a visual angle of 10^{o}. The parameters determine were L* (luminosity or brightness: L* = 0 black and L* = 100 white), a* (red-green component: - a* = greenness and +a* = redness) and b* (yellow-blue component: - b* = blueness and +b* = yellowness). All analyses were performed in triplicate.

III. RESULTS AND DISCUSSION

A. Chemical composition of okara powder and wheat flour

Table 2 showed the nutritional composition of laboratory prepared okara powder and wheat flour.

Table 2 Nutritional composition of okara powder and wheat flour

Composition (mg/100 g)	Okara powder	Wheat flour
Moisture	14.70^a±1.20	13.90^a±1.50
Protein	30.25^a±1.50	12.50^b±1.10
Fat	10.40^a±1.00	1.50^b±0.30
Crude fiber	32.70^a±2.00	2.50^b±0.50
Ash	4.25^a±0.50	1.70^b±0.25
Genistein (mg/100 g of okara powder)	5.25±0.05	-

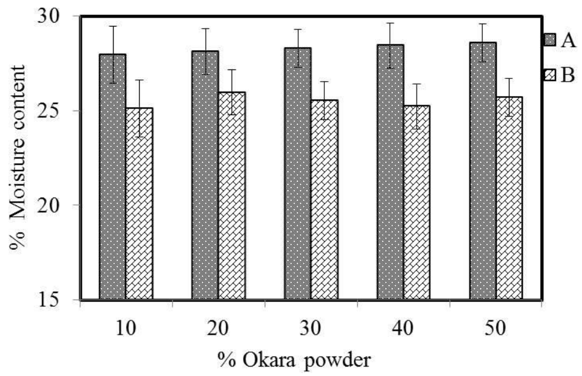
* Superscripts with different letters in a row indicate significant differences with each other's

Okara powder showed significantly (p<0.5) higher amount of protein, fat, crude fiber and ash content than wheat flour. However, for the processing of roti and paratha, it is necessary to add wheat flour due to its gluten content, as gluten gives adhesive and cohesiveness to the dough. Now-a-days, peoples try to reduce the consumption of gluten content as it is responsible for celiac diseases. In this research, we try to substitute wheat flour with *okara* powder at different ratio (Table 1).

Okara powder contained 5.05±0.05 mg genistein per 100 g of soy *okara* powder (Table 2). Research revealed that soy isoflavone and their glycosides associated with lower incidence of cardiovascular disease [10], breast and prostate cancers [11], colon cancers [12], menopausal systems [13], osteoporosis [14] and atherosclerosis [15]. Genistein could be used for osteoporosis for post-menopausal women and elderly men [16] and genistein shows its anti-oxidant and anti-browning affects both in *in vitro* and *in vivo* [17].

B. Effect of wheat flour substitution by okara powder on the nutrient content of roti and paratha

Moisture content of roti and paratha was significantly (p<0.5) different as shown in Fig 1; however, increasing the okara powder content did not show any significant difference in case of moisture content for the roti and paratha. During processing of paratha, 8-10 ml sunflower oil was used for the frying of raw dough sheet. Prior to frying heat is transferred to paratha and water is evaporated [18]. Generally, frying is known as simultaneous heat and mass transfer process. In this process, heat is transferred from the oil to the paratha, water is evaporated from the pararta and oil is taken up [19]. As a result, fat content was increased in the paratha rather than roti. Increasing the *okara* powder increased the ash content. Protein and crude fiber content of the roti and paratha was significantly increased with increasing *okara* powder content (Fig. 2).



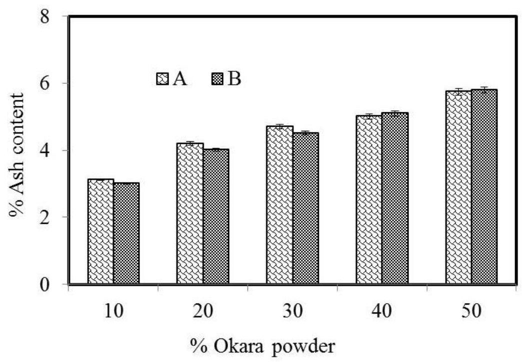
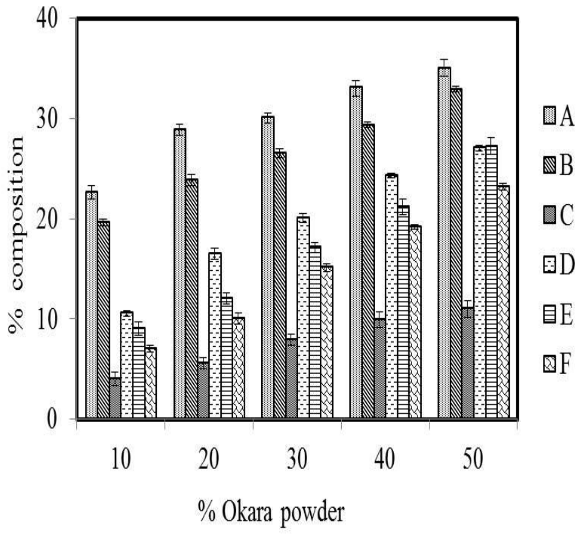


Fig 1: Moisture (left) and ash (right) content of roti and paratha with different *okara* powder and wheat flour ratio. A = Roti and B = Paratha. Bar represents standard deviation.

Roti contained significantly higher amount of protein and crude fiber content than paratha. Both *okara* powder and wheat flour contained protein and carbohydrate, as a result, there must be initiated of Maillard reaction. Maillard reaction resulted reduction of nutrient content specially protein and carbohydrate. Prior to frying Maillard reaction was initiated, protein and crude fiber content was reduced. Roti and paratha were fried in a fan with or without sunflower oil, respectively, which initiated Mailllard reaction and loss of nutrient. Paratha showed lower amounts of protein and crude fiber content. This might be due to the higher amount of Maillard reaction product as paratha contains protein, crude fiber and as well as fat. As paratha was fried with oil, there might be lipid oxidation, which takes place in Maillard reaction too. As a result, paratha contained lower amounts of protein and crude fiber content (Fig. 2).



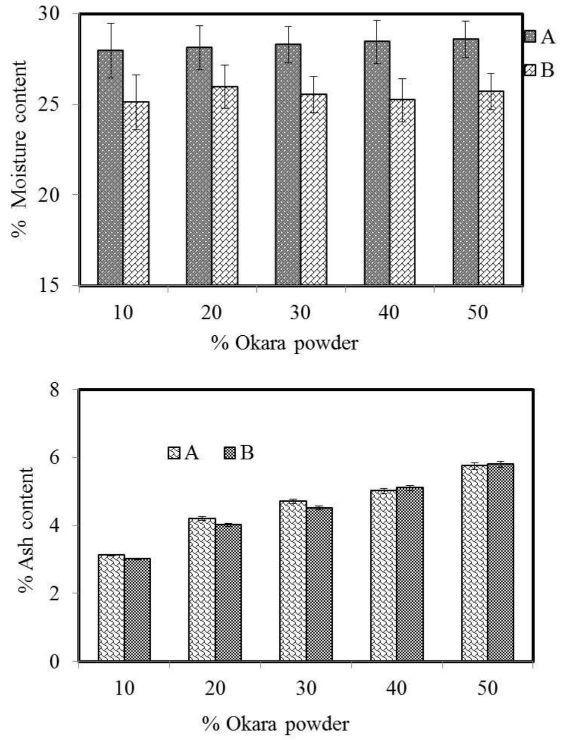


Fig 2: Protein, fat and crude fiber content of roti and paratha with different okara powder and wheat flour ratio. A = protein content of roti, B = protein content of paratha, C = fat content of roti, D = fat content of paratha, E = crude fiber content of roti, F = crude fiber content of paratha. Bar represents standard deviation.

For both roti and paratha, wheat flour substitution by 50% okara powder gave the highest amount of protein, fat and ash content. Increasing the *okara* powder content increased the protein, fat and ash content of roti and pararta, however, decreased the gluten content too. Substitution of wheat flour with 10 and 20% did not affect the gluten content of the dough and easily could prepare roti and paratha. However, 40 and 50% *okara* powder mixing with wheat flour is not suitable to make dough and sheet for making roti and paratha due to less gluten content in total mixer. The research suggested using 30% *okara* powder with wheat flour for the processing of roti and paratha. 30% *okara* powder showed a considerable amount of protein, fat, crude fiber (Fig. 2), ash (Fig. 1), and genistein (Fig. 3) content in both roti and paratha. As paratha contained higher amount of fat than roti and paratha is not suitable for the people who are suffering from diabetes, heart disease and other chronic disease.

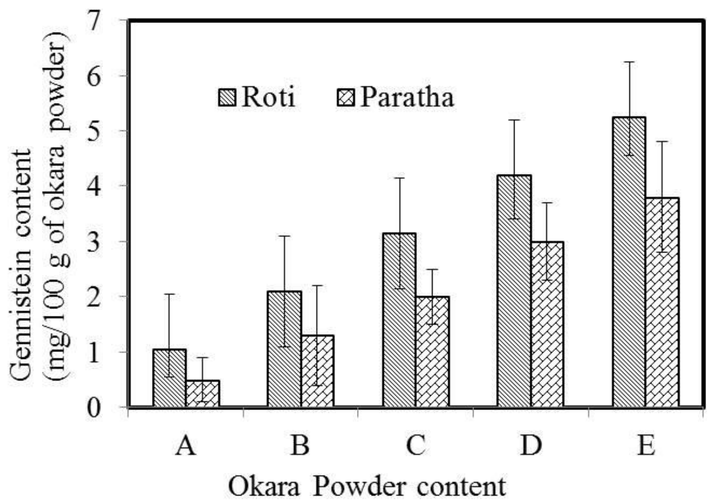


Fig 3: Genistein content of roti and paratha okara powder. A = 10% okara powder, B = 20% okara powder content, C = 30% okara powder content, D = 40% okara powder content and E = 50% okara powder content. Bar represents standard deviation.

C. Effect of wheat flour substitution by okara powder on the color of roti and paratha

The luminosity (L*-value) of roti was increased with increasing the *okara* powder content (p<0.5) (Fig. 4) indicating the reduction of brown pigments. At 10% *okara* powder, the luminosity was very low; this might be due to the formation of brown pigments. However, 50% *okara* powder gave the highest amount of L* value, indicating less brown pigment formation. The result suggested that *okara* powder could reduce the brown pigments, as it contained genistein (Fig. 3). Genistein had the ability to reduce brown pigments formation [20]. Luminosity (L*) value was higher in roti rather than paratha suggesting the higher Maillard reaction products in paratha than roti.

The a*-values of roti and paratha decreased with increasing okara powder content, pointing the shift from white color (or greenness) to red color for roti and paratha (Fig. 4). The b*-values increased with decreasing *okara* powder content, pointing the yellowish color of roti and paratha (Fig. 4).

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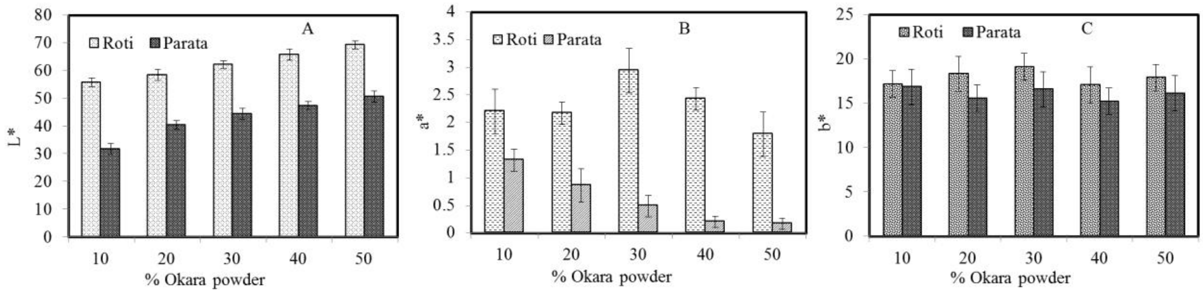

Fig 4: Effect of wheat flour substitution by okara powder on the color parameter of roti and paratha; L*-value (A); a*-value (B); b*-value (C). Bars represent standard deviation.

IV. CONCLUSIONS

Soy *okara* powder contained significantly higher amount protein, fat, crude fiber and ash content than wheat flour. Substitution of wheat flour by *okara* powder at different ratio increased the nutrient content of roti and paratha. Roti contained higher amount of protein and crude fiber content than paratha. Fat content was higher in paratha then roti, as pararta absorbed oil during frying with oil. Prior to the processing of roti and paratha, there might be initiation of Maillard reaction due to reaction between protein and carbohydrate. Maillard reaction resulted reduction of nutrient content specially protein and carbohydrate. Paratha showed lower amounts of protein and crude fiber might be due to development of more Maillard reaction products. 40 and 50% okara powder mixing with wheat flour is not suitable to make dough and sheet for making of roti and paratha due to less gluten content in total mixer. However, 30% okara powder substitution with wheat flour for the processing of roti and paratha exposed considerable amount of protein, fat, crude fiber, and genistein in both roti and paratha. The research suggested substituting 30% *okara* powder with wheat flour for the processing of roti and paratha. However, further research is necessary to find the effect of wheat flour substitution by *okara* powder for other baked products.

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