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Standardization of the process of okara based (A by product of soymilk) dehydrated chunks

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ABSTRACT : Chunks (Wadian), a traditional savoury food is usually legume-based and are more popular in northern India, while starch-based types are more popular in south India. Chunks are prepared from a thick, spiced batter, which is formed into balls of varying sizes (15-40g), and then dried. Traditionally, drying of these chunks is practiced under the sun. Hot air drying is an alternative method that decreases drying time and improves the quality of the dried product. Chunks were prepared using wet okara to partially replace black gram and green gram dhal to improve the nutritional quality. Okara and whole dhals were used in the formulations. The products were compared with control and market samples prepared with dhals only and then after sun-dried. The bulk density, optimum cooking time, water absorption capacity, hardness and sensory attributes revealed that the products with incorporation of 20 per cent okara and hot air drying at 60^0C was found to be the most effective treatment to obtain better quality dehydrated chunks.

KEY WORDS : Okara, Traditional savoury food, Batter, Chunks, Drying

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Okara is the by-product of soy beverage and tofu production. Okara is used as a food material for its high content of protein and fibre. Okara is the pulp fibre residue generated as a byproduct in large quantities from the soymilk production process. Raw okara contains about 75 per cent of moisture (wet basis), 25 per cent protein, 10-15 per cent oil and bulk amount of crude fibre (Van Der Riet *et al.*, 1980). According to Travaglini *et al.* (1980) the amino acid profile of okara is slightly superior to that of soymilk itself and Bowles and Demiate (2006) showed that approximately 1/3 of the isoflavones present in the soybean remains in the okara indicating that the okara protein is of extremely high quality suggesting that it is a good, low cost source of nutrients for human nutrition. The presence of 95 per cent of the solid grain solid components in okara makes it a very high nutritional value (Smith and Circle, 1978) and may be utilized as an ingredient in a variety of processed foods (Travaglini *et al*., 1980; O'Toole, 1999 and Wang and Calvins, 1989) because it reduces calorie intake and increases dietary fibre. The high quality protein fraction is responsible for water and fat binding, emulsifying and foaming properties and anti hypertension effects (Silva *et al.*, 2006 and Aplevicz and Demiate, 2007) and these non-nutritional properties influence the production and quality of a determined food. Due to high moisture content okara possesses high capacity of deterioration. It contains protein and fibre which have value and which can theoretically be used in food products that meet market demands and opportunities. Large amounts of soybean residue are generated as a byproduct from the manufacture of soybean milk and tofu, which are popular foods in Thailand. The soybean residue poses disposal problems in addition to existing pollution (Shurtleff and Aoyagi, 1979). It is a suitable dietary additive in biscuits and snacks because it reduces calorie intake and increases dietary fibre. The high-quality protein fraction has good water holding and emulsifying qualities and contains a peptide with anti-hypertension effects (O'Toole, 1999). Wet okara has approximately the nutrient composition as water 81.6 g, protein 3.2 g (moisture basis), carbohydrate 12.5g, fibre 4.1g, calcium 80mg, iron, 1.4mg, thiamine 0.02mg, and riboflavin 0.02mg. (USDA Human Nutrition Information Service- Agriculture Handbook No. 8-16). Grizotto and Aguirre (2011) reported that the drying of okara in a drum drier resulted in a better product than that dried in a tray drier as far as the protein quality was considered.

The disadvantage of this method was the elevated cost of the equipment. Wachiraphansaku and Devahastin (2005) used a spouted bed, Grizotto and Aguirre (2011) used a pneumatic flash dryer using Response Surface Methodology. Camila *et al.* (2009) dried okara pellets in a combined process consisting of a pneumatic tube and a rotational drum while Tatsummi *et al*. (2005) applied the electrohydro-dynamic technique. Considering the barriers for the use of okara such as its rapid degradation, high cost of drying and alternative protein sources to okara, it is more feasible to use as such fresh okara obtained from soymilk production to make the product protein rich.

METHODOLOGY

To prepare okara based dehydrated chunks, the 4 x 4 Factorial Design was employed with two independent variables at four levels of variation. The independent variables were process parameters *i.e.* proportion of okara (10, 20, 30, and 40 %); and drying temperature (50, 60, 70 and 80^{0}C). The dependent variables *i.e.* relevant physical properties of okara based chunks namely bulk density; cooking time, water absorption capacity, and hardness were determined by using standard methods in the laboratory.

Production of okara (soymilk residue) :

Well graded JS-335 soybean variety procured from Soybean Research Center, M. K. V., Parbhani. Soymilk plant was used for the preparation of soymilk. Soybean seeds were soaked in water 1:3 (w/v) for 6-7 hrs. After soaking, seeds were cleaned by using clean water. Soaked soybean were placed in grinder with water (1:6 w/v). The above mixture was cooked for 20 minutes and then slurry was collected in filter. After filtration of the slurry, soymilk and okara were collected separately. The care was taken to avoid the contamination for getting good quality of soy-okara for its utilization in preparation of dehydrated chunks. Black gram dhal and green gram dhal were procured from local market.

Preparation of batter and chunks :

Dhals (Blackgram and Greengram) were procured from the local market and soaked 4-5 hrs and drained before grinding. Chunks were prepared following the traditional method. Dhals were mixed in 50:50 proportion before grinding and then after ground for 20 min in wet grinder (home scale) with addition of little quantity of water (30ml/100g) to obtain the smooth paste. The obtained batter (initial mc 61%) was whisked thoroughly using a wooden spoon and okara was added in different proportion *i.e.* 10, 20, 30 and 40 per cent. Salt was added to this smooth paste (1g/100g of batter) and droppings of this batter dropped on a tray covered with aluminum foil. These were then dried in a hot air tray dryer at different temperatures up to its EMC. The product was also prepared using dhals (Blackgram and Greengram) only thereafter sun dried treated as control sample. Soaked dhals were kept for determination of initial moisture content (AOAC, 1990).

The chunks were dried at four temperature levels of 50, 60, 70^{0}C and 80^{0}C. A sample size of approximately 100 g out of the lot was kept separate in aluminium paper plate in the drying chamber and was used for accurate determination of moisture content. The moisture content of chunks at every stage of process was determined by hot air oven method (Ranganna, 1995). Chunks were dried up to two constant consecutive readings of weight loss (Equilibrium moisture content). Total drying time required to dry the chunks continuously from uniform initial moisture content 63-69% (wb) to its near equilibrium safe value about 12% (wb) at different temperature.

Quality assessment of chunks :

Bulk density :

Bulk density was determined by filling the sample gently in a container of known volume and weighed. The ratio between the weight and volume was calculated as bulk density and expressed as kg/m^3 (Bodhankar, 1992).

Optimum cooking time :

The cooking time is defined as the time required in cooking when the cooked sample does not contain any white core (uncooked part) in it (Battacharya and Sowbhagya, 1971). Eight to ten chunks were cooked in a boiling cooking medium (2% NaCl solution in distilled water). A chunk was withdrawn at a regular interval of 1 minute and then it was pressed in between two transparent colorless glass slides. The pressed chunk, which shows no visible white core in it, was identified and its time of cooking was noted.

Water absorption capacity (WAC) :

In a weighed centrifuge tube 5 g of sample and 30 ml of distilled water was added and material was suspended in water by mixing with a thin glass rod taking care to see that no sample adhered to the side of centrifuge tube. After holding periods of 30 min, 10 ml of distill water was used to wash the sample adhering to the stirring rod and centrifuge tube, if any. The suspension was then centrifuged at 3000 rpm for 15 min. The supernatant liquid was discarded and the tube kept mouth down at an angle of 15-20 in forced drought air oven at 50^{0}C. It was placed in desiccators at room temperature and subsequently weighed. Water absorption capacity was calculated as the amount of water retained by 100 g of sample and expressed in per cent (Bodhankar, 1992).

Hardness :

The textural properties (Hardness) of chunk samples

were evaluated using Texture Analyzer (TAX-II-TI).

Textural set up :

Textural analysis of the chunks was carried out under the following conditions: Pre test speed, 5 mm/s; test speed 0.5 mm/s; post test speed 10 mm/s; trigger force, 25g. The slotted insert is secured on the heavy duty platform. The knife edge is attached to the load cell carrier and lowered into the slotted insert. The heavy duty platform is repositioned so that there is no contact between the blade and slot surfaces and a 'blank' test run as a check. The blade is then raised to allow placement of the chunk sample. The chunk sample is then placed centrally under the knife edge. Textural property 'hardness' was computed using the data obtained from textural profile (Force-Time) curve as:

Hardness = Maximum force of the compression (F)

The effect of addition of okara and drying air temperature on the hardness of chunk samples was studied as hardness is the most dominating characteristic for better quality of chunks.

Optimization of variables :

Four level two variables factorial design was adopted to optimize the process variables for the production of chunks (Design Expert Ver.8.0.5.2). Optimization of process for okara based dehydrated chunks was performed based on its quality attributes such as bulk density, optimum cooking time, water absorption capacity and hardness value. Measured values of bulk density, optimum cooking time, water absorption capacity and hardness of market product were considered as standard values for optimization.

Sensory evaluation :

A panel of ten judges evaluated the chunks prepared with standard process and market product for quality attributes based on color and appearance, taste, flavour and overall acceptability. For attributes like taste and flavour the sample were served in cooked form. Data obtained were analyzed statistically.

Protein content of optimized product :

Total crude protein was determined by Micro Kjeldhal method (Ranganna, 1995).

Calculation :

$$\text{Per cent N} = \frac{\text{(Titrate value of sample – titrate value blank)} \times \text{Normality of HCl} \times 14 \times 100 \times \text{dilute factor}}{\text{Weight of sample (g)}}$$

Multiplying per cent nitrogen by factor 6.25 to calculate per cent protein.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of process variables on drying time :

Drying characteristics of the okara based chunks at varying process variables and also sun dried chunks (control) were analyzed. Fig. 1 represents the drying time required to attain EMC at different process variables. Results revealed that there was increased drying time with increase in per cent okara incorporation at particular temperature. Chunks prepared with 10 per cent okara incorporation required drying time of 450 min while chunks with 40 per cent okara incorporation required 480 min for its drying at temperature of 50°C. This might be due to that the okara incorporation increased from 10-40 per cent and thereby increased initial moisture content of the chunks. Increase in drying time with respect to temperature might be due to case hardening of product at lower drying air temperature.

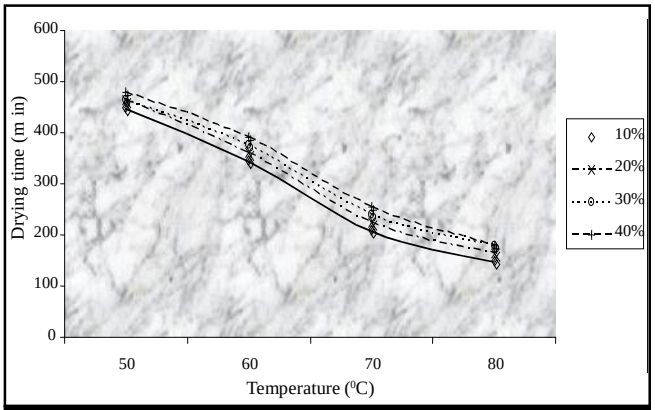

Fig. 1 : Drying time required to attain EMC at different process variables

However, the drying time for sample prepared under sun drying (control sample) was noted as 525 min. At the first day, the respective moisture content of control sample was 43.70 per cent (wb) and it took around 5 hrs. The drying was continued from 8:00 AM in the morning until the chunks were dried up to its EMC which was 11.56% (wb).

Effect of process variables on quality attributes of chunks :

Bulk density :

The bulk density of the chunks varied between 240-290 kg/m^3. From Table 1, it is clear that bulk density decreased with increase in level of okara incorporation and drying air temperature. Statistically the effect of okara was found non-significant however, the effect of drying air temperature was found significant. It was also noted that drying air temperature had negative effect on bulk density of the product (Fig. 2).

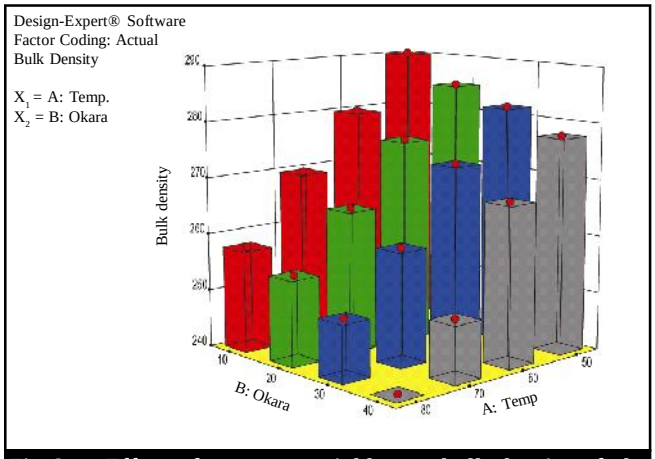

Fig. 2 : Effect of process variables on bulk density of the chunks

The first order polynomial model was fitted with the experimental data. Regression model was fitted adequately to the observed data with high co-efficient of co-relation (R=0.99).

$$\text{Bulk density (Bd)} = 352.92 - 1.12X_1 - 0.505X_2 \text{ (R=0.99)} \quad (1)$$

Equation (1) shows the predicted value of bulk density (Bd) as a function of drying temperature (X_1) and per cent okara (X_2). Inspection of the co-efficients variable in equation (1) suggested that drying air temperature (X_1) was the major factor contributing in decrease of bulk density followed by per cent okara (X_2). The negative co-efficient of these variables (X_1 and X_2) revealed that an increase in their variables decreased the bulk density. Similar results were reported by Khodke (2002).

Optimum cooking time :

The optimum cooking time of the chunks varied between 6 to 11 minutes within the combination of the variables studied. Statistically both the variables showed its significance within the combination of treatment studied. Results revealed that an increase in their variables decreased the optimum cooking time (Fig. 3).

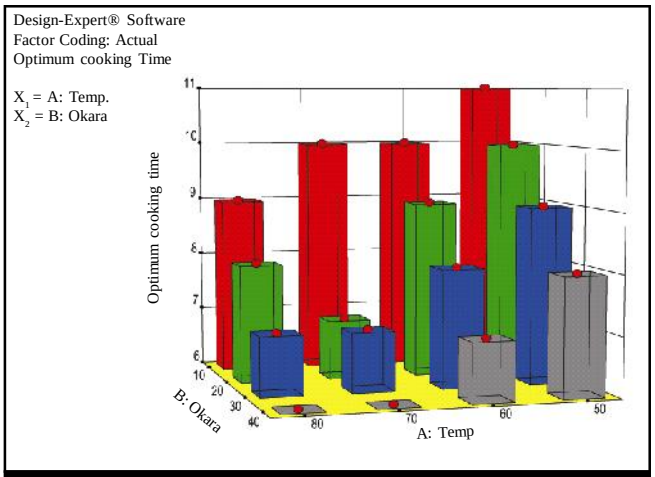

Fig. 3 : Effect of process variables on optimum cooking time of the chunks

The first order polynomial model was fitted with the experimental data.

Table 1 : Effect of process variables on quality attributes of chunks

Temperature (^{0}C)	Okara incorporation (%)	Bulk density (kg/m^3)	Cooking time (min)	Water absorption capacity (%)	Hardness (N)
50	10	290	11	70	13.82
	20	285	10	90	16.8
	30	282	9	107.76	18.63
	40	278	8	162.24	21.02
60	10	280	10	77	11.37
	20	276	9	94	12.48
	30	273	8	116.8	15.32
	40	268	7	180	19.84
70	10	270	10	82	9.25
	20	265	7	100	11.03
	30	260	7	130	14.93
	40	250	6	197.58	16.47
80	10	258	9	87	7.01
	20	255	8	104	9.63
	30	250	7	150.35	12.41
	40	240	6	210.4	14.75
Control sample (Sundried)	–	370	12	68.53	8.10
Market sample (Sundried)	–	325	9	95	12.45

Optimum cooking time (CT) = 15.42 – 0.07X_1 – 0.105X_2 (R=0.95) **(2)**

Equation (2) shows the predicted value of optimum cooking time (CT) as a function of drying temperature (X_1) and per cent okara (X_2). Inspection of the co-efficients variable in equation (2) revealed that per cent okara (X_2) was the major factor contributing in decrease of optimum cooking time followed by drying air temperature (X_1). The negative co-efficient of these variables (X_1 and X_2) revealed that an increase in their variables decreased the optimum cooking time. Sosulski and Wu (1988) observed similar results while incorporating the fibre ingredients into wheat flour.

Water absorption capacity :

Water absorption capacity (WAC) of chunks with different combinations of process parameters varied in the range of 70 to 210.4 per cent within the combination of variable studied. Results revealed that water absorption capacity varied significantly with per cent okara incorporation and drying air temperature (Fig. 4).

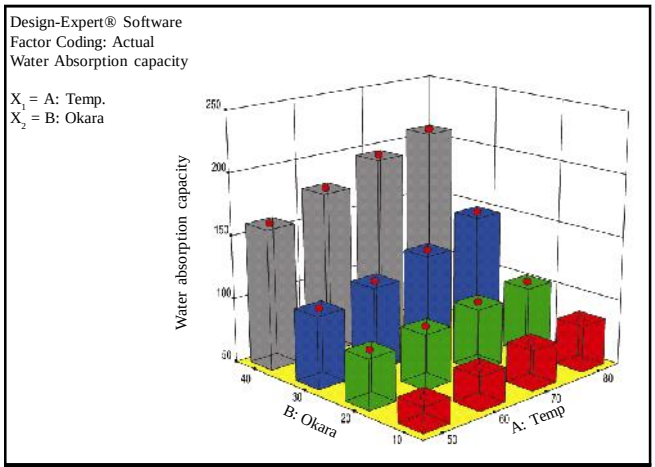

Fig. 4 : Effect of process variables on water absorption capacity of the chunks

The relationship was obtained with values of drying temperature (X_1) and per cent okara (X_2). The relationship developed with independent variables was as follows :

Water absorption capacity (WAC) = 1.01X_1+3.54X_2 - 32.41 (R=0.95) **(3)**

The positive co-efficient of drying temperature (X_1) and per cent okara incorporation (X_2) indicated that water absorption capacity increased with increase in both the variables. Increasing water absorption might be due to the fact that okara contains more fibre and protein, which retained more water. Yaseen *et al.* (2009) reported similar observation for okara-based bread. Chen *et al.* (1988) stated that the increasing water absorption might be caused by the strong water binding ability of fibres.

Hardness :

The measured values for hardness (N) of chunks with different combinations of process parameters varied between 8.1 to 27.02 N within the combination of variable studied. Results revealed that, the hardness of chunks decreased with increase drying temperature but increased with increase in per cent okara incorporation (Fig. 5).

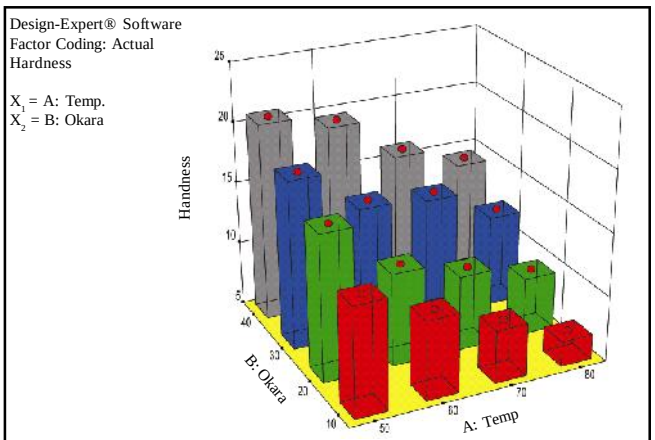

Fig. 5 : Effect of process variables on hardness of the chunks

Good fit was obtained with co-efficient of correlation (R=0.98) which showed that the model developed was adequate for the experimental data. The relationship was developed with the process variables given below :

Hardness (Hd) = 21.69–0.2169 X_1 + 0.2581 X_2 (R=0.98) **(4)**

where, X_1 and X_2 are the values of drying temperature and per cent okara, respectively. Inspection of the Eq. 4 revealed that, the hardness of chunks decreased with increase drying temperature (X_1) but increased with increase in per cent okara incorporation (X_2). Similar results were observed by Brennan (2008) while studying the effect of dietary fibres on quality of breakfast cereals. He observed that the use of bran in the base recipe significantly increased the product hardness compared to control sample (increase in relation to fibre concentration). Shi *et al.* (2011) reported that okara fibre usually imparts gritty texture in product, which may cause reduced hardness value for increased temperatures. They observed similar results in okara-maize snack foods.

Optimization of variables :

It was noted through sensory evaluation that chunks prepared by incorporation of 40 per cent okara and dried at temperature 80^{0}C were not acceptable with respect to its quality attributes. These chunks were having gritty texture and after cooking did not retain good texture. Structure of these chunks was collapsed after cooking. This may be due to the fact of increased fibre concentration (40% okara). Therefore, higher

level of okara incorporation (40%) and drying air temperature (80^0C) were not considered while optimizing the process variables. The optimum values of process variables were obtained for the chunks prepared with 20% okara incorporation and dried at 60^0C. Experimental and predicted values represented in Table 2.

Table 2 : Experimental and predicted values of variables

	Predicted values	Experimental values
Bulk density	275.62	276
Optimum cooking time	9.12	9
Water absorption capacity	95	94
Hardness	14.19	12.481

Sensory evaluation :

T-test for score of quality attributes revealed that there was no significant difference in sample prepared with optimized process variables (S_1) and market sample (S_2) as regard to all quality attributes *viz.*, color, flavour, texture, taste and overall acceptability.

Protein content of developed okara based dehydrated chunks:

Total crude protein was determined by Micro-Kjeldhal method**.** It was found that protein content in okara-based chunks was higher than control sample and market sample. This may be due to the fact that the okara is rich in proteins. Wet okara contains 24-40 per cent proteins on dry basis (Gopalan *et al.*, 1987). Results revealed that chunks prepared with optimized process variables was about 1.5 times protein rich as compared to the control sample (blackgram: greengram in 50:50 proportion) and commercially available market sample.

Conclusion :

Incorporation of 20 per cent okara and hot air drying at 60^0C was found to be the most effective treatment to obtain better quality protein rich dehydrated chunks. It is evident that total drying time decreased with increase in drying air temperature. Mechanical drying of chunks offers promising alternative to maintain uniformity of the product and to reduce the drying time. The chunks prepared by the optimum process variable were consumer acceptable. The use of soybean residue also reduce disposal problems in addition to existing pollution.

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REFERENCES

A.O.A.C. (1990). *Official methods of analysis*. Association of official analytical chemists, (12th Edn). Washington D.C., U.S.A.

Aplevicz, K.S. and Demiate, I.M. (2007). Physicochemical analyses of commercial samples of cheese bread premix and production of cheese breads with addition of okara. *J. Sci. & Agro-technol.*, **31**(5): 1416-1422.

Bhattacharya, K.A. and Soubhagya, C.M. (1971). Water uptake by rice during its cooking. *Ceraeal Sci. Today*, **16** : 420-424.

Bodhankar, S.S. (1992). Preparation and qualities of weaning food. M.Tech. Thesis, Marathwada Agricultural University, Parbhani, M.S. (INDIA).

Bowles S. and Demiate, I.M. (2006). Physicochemical characterization of the soymilk by product okara and application in French type breads. *J. Food Sci.& Technol.*, **26**(3): 652-659.

Brennan, M.A. (2008). Dietary fibres and their properties-The possibilities of fibres lowering the glyceamic index of foods post extrusion, M. Phil Thesis, Massey University, Palmerston North Campus, New-Zealand.

Camila Augusto Perussello (2009). A convective drying kinetics and darkening of okara. *Drying Technol.*, **27** : 1132–1141.

Chen, H., Rubenthaler, L., Leung, H.K. and Baranowski, J.D. (1988). Chemical, physical and baking properties of apple fibre compared with wheat and oat bran. *Cereal Chem.*, **65**(3) : 244-247.

Gopalan, C., Ramasastri, B.V. and Balsubramaniam, S.C. (1987). *Nutritional value of Indian Foods*. Published by National Institute of Nutrition, Indian Council for Medical Research, NEW DELHI (INDIA).

Grizottoi R.K. and Aguirre J.M. (2011). Study of the flash drying of the residue from soymilk processing - okara Ciênc. *Tecnol. Aliment., Campinas*, **31**(3): 645-653.

Khodke, S.U. (2002). Freeze-Thaw-Dehydration technology for the production of instant potato cubes. Ph.D. Thesis, Department of Agriculture and Food Engineering, Indian Institute of Technology Kharagpur, W.B. (INDIA).

O'Toole, D.K. (1999). Characteristics and use of okara, the soybean residue from soymilk production. A review. *J. Agric. & Food Chem.*, **47** : 363-371.

Ranganna, S. (1995). *Handbook of analysis and quality control for fruits and vegetable products* (2nd Ed.), Tata McGraw Hill, NEW DELHI (INDIA).

Shi, C., Wang, L., Wu, M., Adhikari, B. and Li, L. (2011). Optimization of twin-screw extrusion process to produce okara-maize snack foods using response surface methodology. *Internat. J. Food Engg.*, **7**(2) : 1-14.

Silva, L.G., Silva, J.B., Costa, V.S. and Neto, F.D.G. (2006). Utilization of okara, an agroindustrial residue of soy, in the manufacturing process of sandwich loaf; Paper presented at the 20th Brazilian Congress of Food Science and Technology, Curitiba, BRAZIL.

Shurtleff, W. and Aoyagi, A. (1979). Tofu and soymilk production Volume 2: The Book of Tofu. New Age Food Study Center, Lafayette, CA, USA.

Smith, A.K. and Circle, S.J. (1978). Soybeans: Chemistry and technology; AVI: Westport.

Sosulski, F.W. and Wu, K.K. (1988). High fibre breads containing field pea hulls, wheat, corn and oat brans.*CerealChem.*,**65**:186-191.

Tatsumi, E., Li, F.D. Li, L.T. and Sun, J.F. (2005). Electrohydrodynamic (EHD) drying characteristic of okara cake. *Drying Technol.,* **23** (3) : 565–580, 2005.

Travaglini, D. A. *et al*. (1980). The processing of soy milk residue mixed with cron grits. *Boletim do Instituto de Tecnologia de Alimentos,* **17**(3) : 275-296.

USDA. Human Nutrition Information Service Agriculture Handbook No. 8-16.

Van Der Riet, W.B., Wight, A.W., Cilliers, J.J.L. and Datel, J.M. (1989). Food chemical investigation of Tofu and its by product okara. *Food Chem.,* **34** : 193–202.

Wachiraphansakul, S., Devahastin, S. (2005). Drying kinetics and quality of soy residue (okara) dried in a jet spouted-bed dryer. *Drying Technol.,* **23** (6) : 1229–1242.

Wang, H.L. and Calvins, J.F. (1989). Yield and amino acid composition of fractions obtained during tofu production. *Cereal Chem.,* **66** (1) : 359–361.

Yaseen, A.A., Shouk, A.A. and Abousalem, Ferial M. (2009). Effect of okara addition on bread quality. *J. Agric. Sci. Mansoura Univ.,* **34**(12) : 11147-11155.