The Pharma Innovation Journal 2021; 10(5): 1543-1547

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(5): 1543-1547

www.thepharmajournal.com
Received: 07-02-2021
Accepted: 16-03-2021

KV Sudha
Ph.D., Scholar, Department of Food Science and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad, Karnataka, India

Sarojani J Karakannavar
Professor and Head, Department of Food Science and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad, Karnataka, India

Nirmala B Yenagi
Professor, Department of Food Science and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad, Karnataka, India

Basavraj Inamdar
Assistant Professor, Department of Animal Genetics and Breeding, Veterinary College, KVAFSU, Hebbal, Bengaluru, Karnataka, India

Corresponding Author:
KV Sudha
PhD Scholar, Department of Food Science and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad, Karnataka, India

Effect of roasting on the physicochemical and nutritional properties of foxtail millet (*Setaria italica*) and Bengal gram dhal flours

KV Sudha, Sarojani J Karakannavar, Nirmala B Yenagi and Basavraj Inamdar

Abstract
The physicochemical and nutritional properties of flour is imperative to facilitate their efficient application, either into composite flours or by themselves. In the present study, the influence of roasting on physicochemical properties and nutritional composition of the Foxtail millet and Bengal gram dhal flours was studied. Bulk density and volume of the flours significantly decreased after roasting. However, water absorption index, oil absorption index, swelling power and percent solubility of flours significantly increased with roasting process. Nutritional analysis revealed that moisture, fat, protein, crude fibre, ash and carbohydrate of raw foxtail millet flour was 8.53, 4.29, 13.01, 7.92, 2.78 and 65 percent respectively. However, after roasting process, there was decrease in the moisture, fat, protein, crude fibre, ash and carbohydrate of foxtail millet flour *i.e.* by 0.81, 4.13, 11.46, 7.13, 2.64 and 72.28 percent respectively.

Keywords: Foxtail millet flour, Bengal gram dhal flour, physicochemical properties, water absorption index, oil absorption index, swelling power, percent solubility and nutritional composition

Introduction
Millets are a group of small seeded species of cereal crops, widely grown around the world for food and fodder. Millets are being adjudged as miracle grains and potential future crops. Millets are good source of vitamins, minerals, dietary fibre and sulphur containing amino acids. Compared to staple cereals, millets have more protein, fat, calcium and phosphorus and hence are termed as "Nutri-cereals". Foxtail millet (*Setaria italica*) is one such nutritious and important underutilized grain, grown in various parts of India. It grows well even under adverse agro climatic conditions. Foxtail millet is a good source of protein (12.3 g/100 g), dietary fibre (14 g/100 g) and carbohydrates (60.9 g/100 g). Besides, it is rich in minerals (3 g/100 g) and phytochemicals (Gopalan *et al.*, 2010) [9]. Foxtail millet is a good source of ß carotene (126-191 µg/100 g, Goudar *et al*., 2011) [10].
Bengal gram, which is also known as Chickpea (*Cicer arietinum* L.) is an important and cheap source of legume protein which can be used as a substitute for animal protein because their supply is limited and expensive (Pelletier, 1994) [19]. Chickpea contains between 14.9 and 30.6% crude protein (Chavan *et al*., 1986) [5] and is also good source of calories, certain minerals and vitamins (Deshpande, 1992) [8].
Understanding the physicochemical properties and nutritional components of flours is imperative to facilitate their efficient application, either into composite flours or by themselves. To verify the influence of roasting on physicochemical properties of the Foxtail millet and Bengal gram dhal flours. It was considered crucial to evaluate nutritional composition. Hence the present study was undertaken with aim to investigate effect of roasting on nutritional composition of foxtail millet, Bengal gram dhal and millet mix flours.

Materials and Methods
The present investigation was undertaken during the year 2015-2016 at the Department of Food Science and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad, Karnataka. The raw materials like foxtail millet, Bengal gram dhal flour, ghee and sugar powder were purchased from the local market. The millet grains were washed, rinsed, shade dried and milled at a local commercial milling machine.
The foxtail millet flour, Bengal gram dhal flour and millet mix were roasted separately i.e.

both raw and roasted flours were studied for physico-chemical and nutritional properties. Fifty gram of raw bengal gram dhal flour, raw foxtail millet and raw millet mix (25 g bengal gram dhal flour and 25 g foxtail millet flour) each were roasted till the roasted flavour and aroma developed. Bengal gram dhal flour took twelve minutes to get roasted and foxtail millet flour took 10 mins to get roasted. However the millet mix took nine minutes to get roasted.

Physico-chemical properties include colour, volume, bulk density, water absorption index, oil absorption index and swelling power and percent solubility. Chromatic component, L (lightness), a (redness) and b (yellowness) values of sample were measured using spectrophotometer (Colour lab + Premier colour scan). Twenty grams of flour was weighed on electronic balance and it was transferred to 100 ml measuring cylinder. Measuring cylinder was tapped 100 times and then volume was noted. For bulk density, 50 g flour sample was put into a 100 ml measuring cylinder and tapped to a constant volume. The bulk density (g/cm-3) was calculated as weight of flour (g) divided by flour volume (cm^3) (Okaka and Potter, 1979) [18]. Water absorption index (WAI) and Oil absorption index (OAI**)** were determined according to the methods of Niba *et al.* (2001) [16]. Flour samples (1g) were suspended in 5 ml of water (for WAI) or vegetable oil (for OAI) in a centrifuge tube. The slurry was shaken on a platform tube rocker for 1 min. at room temperature and centrifuged at 3000 rpm for 10 min. The supernatant was decanted and discarded. The adhering drops of water were removed and reweighed WAI and OAI were expressed as the weight of sediment/initial weight of flour sample (g/g). The swelling power and percent solubility was determined according to the method used by Scotch (1964) [21]. 500 mg (W_1) of sample was added to a centrifuge tube, weight of centrifuge tube and test sample was noted (W_2). After addition of 20 ml (V_E) distilled water, the centrifuge tube was placed in the water bath at 100 ºC for 20-30 min. till the contents were cooked. Then it was centrifuged at 5000 rpm for 10 min. The supernatant was transferred to a test tube and the inner side of the centrifuge tube was dried well and weighed (W_3). The swelling of flour was calculated as follows.

$$\text{Swelling power (g/g)} = \frac{W_3 - W_2}{W_1} \times 1$$

For percent solubility, weight of dried moisture dish was noted (W_4) and after pouring 10 ml aliquot (V_A) in a dish, dried at 110º C for 4-5 hour. The moisture dish was cooled and weighed (W_5).

$$\text{Solubility (\%)} = \frac{(W_5 - W_4)\ (V_E)}{(V_A)} \times \frac{100}{W_1}$$

The roasted and raw flours were analysed for proximate composition according to standard procedures of Association of Official Analytical Chemists (Anon., 2005) [3]. The carbohydrate content was calculated by deducting the sum of the value of moisture, protein, fat, ash and fiber from 100 (Anon., 2005) [3]. Analysis of variance was used to test the significance differences in physico-chemical parameters and nutritional composition of flours.

Results and Discussion

Physico-chemical characteristics of raw and roasted flours are given in Table 1**.** The bengal gram dhal flour (raw) had the highest volume i.e. 43.33 ml followed by roasted bengal gram dhal flour (41.33 ml), millet mix (39.33 ml), roasted millet mix (37.33 ml), foxtail millet flour (35.33 ml) and roasted foxtail millet flour (33.33 ml). The volume of the flours decreased significantly (p<0.01) after roasting process. The foxtail millet flour had the highest bulk density i.e. 0.63 g/cm^3 then followed by the roasted foxtail millet flour (0.62), millet mix (0.62), roasted millet mix (0.61), bengal gram dhal flour (0.58) and roasted bengal gram dhal flour (0.56). Bulk density also decreased with the roasting process. These changes could be due to the chemical composition of flours. The volume and bulk density of the flours decreased with the roasting process may be due the loss of the moisture content in the flours. The low bulk density of foxtail millet flour was due to its lower particle density and the large particle size (Kamara *et al*., 2009) [11]. Water absorption index (WAI) of roasted foxtail millet flour was highest with 2.11 g/g whereas the raw foxtail millet flour had 1.57 g/g. WAI of bengal gram dhal flour was 1.08 which increased with roasting to 1.68 g/g. WAI of millet mix was 1.11 g/g which also increased with roasting to 1.62 g/g. Oil absorption index (OAI) of raw bengal gram dhal flour, foxtail millet flour and millet mix were 1.21, 1.02 and 1.01 g/g respectively. However, OAI increased with roasting i.e roasted bengal gram dhal flour (1.24 g/g), roasted foxtail millet flour (1.21 g/g) and roasted millet mix (1.21 g/g). Swelling power of bengal gram dhal flour was 3.74 g/g which increased with roasting to 5.85 g/g. Swelling power of millet mix was 5.34 g/g which increased with roasting to 5.58 g/g and swelling power of foxtail millet flour was 5.75 g/g which also increased with roasting to 6.17 g/g. Percent solubility of bengal gram dhal flour (0.08), foxtail millet flour (0.07) and millet mix (0.09) increased with the roasting process i.e. 0.10, 0.12 and 0.14 percent respectively. Statistical analysis showed that there was significant difference in volume, bulk density, WAI, OAI, swelling power and percent solubility (p<0.01). Water absorption index, oil absorption index, swelling power and percent solubility of flours increased with the roasting process may be due to the loss of the moisture content. The water absorption index was more in foxtail millet flour when compared to the bengal gram dhal flour. Swelling power and percent solubility of flours increased with the roasting process may be due to the loss of the moisture content, these changes may be due to starch content (amylose and amylopectin chains) (Coulibaly *et al.*, 2012) [7]. The water absorption index measures the volume occupied by the starch after swelling in excess water, which maintains the integrity of starch in aqueous dispersion. WAI was high in millet flour when compared to pulse flour (Thilagavathi *et al.*, 2015) [22]. Increased WAI of roasted flours could be due to partial gelatinization of starch due to dry heat processing (Njoki *et al.*, 2014) [17]. There was increase in the oil absorption capacity, water absorption capacity and swelling power of roasted millet flour. High swelling of millet flour could be due to high content of starch and low protein and fat content. It was also reported that roasting increased WAI and OAI in pearl millet (Sade *et al.*, 2009) [20]. Interactions of water and oil with protein are very important in the food systems because of their effects on the flavour and texture of foods. Intrinsic factors affecting water binding of food protein include amino acids composition, protein conformation and surface hydrophobicity/polarity (Barbut, 1999) [4]. The oil absorption index was more in bengal gram dhal flour when compared to the foxtail millet flour. The results show that

foxtail millet flour may be a lower retainer than raw winged bean (Narayana and Narasingha, 1982) [15]. The lower oil absorption capacity of foxtail millet flour might be due to low hydrophobic proteins which show superior binding of lipid (Kinsella, 1979) [12]. Abbey and Ibeh, (2006) [1] also reported that water and oil absorption capacities of raw cowpea flour increased with heat processing.

Table 2 shows the colour values of flours. The values of 'L' of raw bengal gram dhal flour, foxtail millet flour and millet mix were 91.74, 87.36 and 90.23 respectively. The values of 'L' decreased with roasting of flours i.e. bengal gram dhal flour (83.93), foxtail millet flour (79.85) and millet mix (83.31) which indicates lightness decreased and darkness increased. The values of 'a' of raw bengal gram dhal flour, foxtail millet flour and millet mix were 1.31, 1.41 and 1.20 respectively. The values of 'a' increased with roasting of flours i.e. bengal gram dhal flour (3.92), foxtail millet flour (3.85) and millet mix (3.51) which indicates redness of flour increased. The values of 'b' of raw bengal gram dhal flour, foxtail millet flour and millet mix were 18.61, 14.83, 17.80 respectively. The values of 'b' increased with roasting of flours i.e. bengal gram dhal flour (23.54), foxtail millet flour (18.44) and millet mix (20.54). Statistical analysis showed that there was significant difference in values for 'a' and 'b' ($p<0.01$). Colour (L) values of flour decreased after roasting indicated that the lightness of the flour decreased and darkness increased (Table 2). Darkness browning reactions such as maillard reaction and degree of cooking and pigment degradation that take place during the starch extraction process (Altan *et al.*, 2008) [2].

Table 3 shows the Nutritional composition of flours. Moisture content of flours ranged from 8.74 to 0.77 percent i.e. bengal gram dhal flour (8.74), roasted bengal gram dhal flour (1.20), foxtail millet flour (8.53), roasted foxtail millet flour (0.81), millet mix (8.59) and roasted millet mix (0.77). There was decrease in the moisture content after roasting of flours because of evaporation of moisture during heating process. The fat content of bengal gram dhal flour, roasted bengal gram dhal flour, foxtail millet flour, roasted foxtail millet flour, millet mix and roasted millet mix were 4.80, 4.46, 4.29, 4.13, 4.59 and 4.19 g/100g respectively. Fat content decreased with the roasting of flours. Protein content of flours ranged from 11.46 to 20.90 g/100g i.e. bengal gram dhal flour (19.56), roasted bengal gram dhal flour (20.90), foxtail millet flour (13.01), roasted foxtail millet flour (11.46), millet mix (14.03) and roasted millet mix (12.58). Protein content of bengal gram dhal flour increased after roasting of the flour due to break down of complex protein to simpler protein increasing the protein availability. However, roasting technology resulted in the decrease in the protein content of the foxtail millet flour. The change in the protein content of roasted flour could be due to loss of amino acids (Mauron, 1982 and Sade *et al.* 2009) [14, 20]. Crude fibre content of flours decreased with the roasting process in bengal gram dhal flour, roasted bengal gram dhal flour, foxtail millet flour, roasted foxtail millet flour, millet mix and roasted millet mix i.e. 1.79, 0.93, 7.92, 7.13, 4.67 and 3.07 respectively. There was decrease in the ash content of flours after roasting i.e. bengal gram dhal flour (2.54), roasted bengal gram dhal flour (2.35), foxtail millet flour (2.78), roasted foxtail millet flour (2.64), millet mix (2.60) and roasted millet mix (2.16). Carbohydrate content also increased with the roasting in bengal gram dhal flour, roasted bengal gram dhal flour, foxtail millet flour, roasted foxtail millet flour, millet mix and roasted millet mix i.e. 62.54, 70.15, 65.00, 72.28, 66.49 and 75.21 respectively. The energy also increased with roasting process i.e. bengal gram dhal flour (371.68), roasted bengal gram dhal flour (404.38), foxtail millet flour (344.50), roasted foxtail millet flour (378.41), millet mix (357.46) and roasted millet mix (394.92). Statistical analysis showed that there was significant difference in moisture, fat, protein, crude fibre, ash, carbohydrate and energy ($p<0.01$) between the different flours. Moisture, fat, protein, crude fibre and ash content decreased in foxtail millet flour in the present study. It has been reported that moisture, protein, fat, ash and fibre contents decreased in foxtail and barnyard millet by the effect of milling and roasting (Choudhury *et al.*, 2011 and Lohani *et al.*, 2012) [6, 13].

From the study it is concluded that the physicochemical properties i.e. bulk density and volume of flours significantly reduced and WAI, OAI, swelling power and percent solubility of flours significantly increased with roasting process. After the roasting process, nutritional composition also decreased. These findings would facilitate and can be substituted in development of novel healthy food products.

Table 1: Physico-chemical characteristics of raw and roasted flours

Flour	Volume# (ml)	Bulk density (g/cm^3)	Water absorption index (g/g)	Oil absorption index (g/g)	Swelling power (g/g)	Percent solubility (%)
A. Bengal gram dhal						
Raw	$43.33^{a} \pm 0.57$	$0.58^{d} \pm 0.03$	$1.08^{f} \pm 0.02$	$1.21^{b} \pm 0.18$	$3.74^{e} \pm 0.17$	$0.08^{c} \pm 0.01$
Roasted	$41.33^{b} \pm 0.57$	$0.56^{d} \pm 0.04$	$1.68^{b} \pm 0.05$	$1.24^{a} \pm 0.21$	$5.85^{b} \pm 0.12$	$0.10^{b} \pm 0.01$
B. Foxtail millet						
Raw	$35.33^{e} \pm 0.57$	$0.63^{a} \pm 0.05$	$1.57^{d} \pm 0.02$	$1.02^{d} \pm 0.02$	$5.75^{bc} \pm 0.05$	$0.07^{c} \pm 0.02$
Roasted	$33.33^{f} \pm 0.57$	$0.62^{b} \pm 0.05$	$2.11^{a} \pm 0.04$	$1.21^{c} \pm 0.02$	$6.17^{a} \pm 0.02$	$0.12^{a} \pm 0.05$
C. Millet mix						
Raw	$39.33^{c} \pm 0.57$	$0.62^{b} \pm 0.06$	$1.11^{e} \pm 0.01$	$1.01^{d} \pm 0.02$	$5.34^{d} \pm 0.30$	$0.09^{c} \pm 0.01$
Roasted	$37.33^{d} \pm 0.57$	$0.61^{c} \pm 0.04$	$1.62^{c} \pm 0.02$	$1.21^{b} \pm 0.19$	$5.58^{cd} \pm 0.10$	$0.14^{ab} \pm 0.05$
F	126.00**	55.46**	771.06**	126.47**	99.56**	21.33**
S.Em	0.39	0.11	0.09	0.19	0.20	0.09
CD	1.02	0.07	0.05	0.25	0.28	0.05

****** Significant at 0.01%.

For volume 50 g of flours (Bengal gram dhal and foxtail millet), millet mix (Bengal gram dhal 25 g and foxtail millet 25 g) was taken.

Each value is mean of three replications.

Values with same superscript are not significantly different.

Table 2: Colour values of raw and roasted flours

Flour	L (Lightness or darkness)	a (Redness or yellow)	b (Blue or green)
A. Bengal gram dhal			
Raw	91.74^{a} ± 0.56	1.31^{d} ± 0.03	18.61^{c} ± 0.03
Roasted	83.93^{a} ± 0.05	3.92^{a} ± 0.03	23.54^{a} ± 0.05
B. Foxtail millet			
Raw	87.36^{a} ± 0.06	1.41^{c} ± 0.03	14.83^{f} ± 0.04
Roasted	79.85^{a} ± 0.05	3.85^{a} ± 0.05	18.44^{d} ± 0.05
C. Millet mix$^{\#}$			
Raw	90.23^{a} ± 0.05	1.20^{e} ± 0.05	17.80^{e} ± 0.04
Roasted	83.31^{a} ± 0.03	3.51^{b} ± 0.07	20.54^{b} ± 0.09
F	1.34	2368.41**	8079.11**
S.Em	2.32	0.16	0.16
CD	35.19	0.17	0.17

****** Significant at 0.01%.
$^{\#}$ Millet mix (Bengal gram dhal 25 g and foxtail millet 25 g).
Each value is mean of three replications.
Values with same superscript are not significantly different.

Table 3: Nutritional composition of raw and roasted flours

Flours	Moisture (%)	Fat (g/100g)	Protein (g/100g)	Crude fibre (g/100g)	Ash (g/100g)	Carbohydrate (g/100g)	Energy (Kcal)
A. Bengal gram dhal							
Raw	8.74^{a} ± 0.05	4.80^{a} ± 0.18	19.56^{b} ± 0.70	1.79^{e} ± 0.47	2.54^{c} ± 0.02	62.54^{e} ± 0.93	371.68^{d} ± 1.89
Roasted	1.20^{b} ± 0.26	4.46^{bc} ± 0.04	20.90^{a} ± 0.40	0.93^{f} ± 0.05	2.35^{d} ± 0.04	70.15^{c} ± 0.48	404.38^{a} ± 0.60
B. Foxtail millet							
Raw	8.53^{a} ± 0.24	4.29^{cd} ± 0.01	13.01^{cd} ± 0.58	7.92^{a} ± 0.06	2.78^{a} ± 0.02	65.00^{d} ± 0.64	344.50^{f} ± 0.74
Roasted	0.81^{c} ± 0.08	4.13^{d} ± 0.15	11.46^{e} ± 0.55	7.13^{b} ± 0.04	2.64^{b} ± 0.03	72.28^{b} ± 0.50	378.41^{c} ± 0.55
C. Millet mix$^{\#}$							
Raw	8.59^{a} ± 0.06	4.59^{ab} ± 0.20	12.58^{d} ± 0.59	4.67^{c} ± 0.12	2.60^{b} ± 0.02	66.49^{d} ± 0.71	357.46^{e} ± 0.70
Roasted	0.77^{c} ± 0.02	4.19^{d} ± 0.01	14.03^{c} ± 0.61	3.07^{d} ± 0.11	2.16^{e} ± 0.04	75.21^{a} ± 0.74	394.92^{b} ± 0.65
F	2261.15**	11.88**	139.406**	558.91**	129.32**	188.513**	1584.97**
S.Em	0.19	0.16	0.39	0.23	0.16	0.43	0.51
CD	0.25	0.17	1.02	0.35	0.17	1.21	1.73

****** Significant at 0.01%.
$^{\#}$ Millet mix was taken in the ratio of 1:1 (Bengal gram dhal flour: foxtail millet flour).
Each value is mean of three replications.
Values with same superscript are not significantly different.

References

1. Abbey BW, Ibeh GO. Functional properties of raw and heat processed cowpea (*Vigna unguiculata*, Walp) flour. J Food Sci 2006;53(6):1775-1777.
2. Altan A, Mccathy KL, Maskan M. Twin-screw extrusion of barley-grape pomace blends: extrudate characteristics and determination of optimum processing conditions. J Food Eng 2008;89(1):24-32.
3. Anonymous. Official methods of analysis, Association of Official Analytical Chemists 18th ed., Washington, DC, USA. AVI Publishing Co. Inc. Westport, CN 2005.
4. Barbut S. Determining water and fat holding, in methods of testing protein functionality. Hall. G. M. (Ed.). Blackie Academic and Professional, New York. ISBN-13:978-0751400533 1999, 186-225.
5. Chavan J, Kadam S, Salunke D. Biochemistry and technology of chickpea (*Cicer arietinum* L.) seeds. CRC Critical Reviews of Food Sci. and Nutrition 1986;25:107-158.
6. Choudhury M, Das P, Baroova B. Nutritional evaluation of popped and malted indigenous millet of Assam. J Food Sci. Technol 2011;48(6):706-711.
7. Coulibaly A, Kouakou B, Chen J. Extruded adult breakfast based on millet and soybean: nutritional and functional qualities, source of low glycemic food. J Nutr. Food Sci 2012;2(1):151-155.
8. Deshpande SS. Food legumes in human nutrition: a personal perspective. Reviews in Food Sci. and Nutrition 1992;32:333–363.
9. Gopalan C, Ramasastri BV, Balasubramanium SC. Nutritive value of Indian foods, National Institute of Nutrition, ICMR, Hyderabad 2010.
10. Goudar G, Hemalatha S, Naik RK, Kamatar MY. Evaluation of nutritional composition of foxtail millet (*Setaria italic)* grains cultivated in agro climatic zones of Karnataka by NIR. Paper presented in: National Symp. Recapturing Nutritious millets for Health and Management of Diseases, UAS, Dharwad 2011;17:37.
11. Kamara MT, Huiming Z, Kexue Z, Amadou I, Tarawalie F. Comparative study of chemical composition and physicochemical properties of two varieties of defatted foxtail millet flour grown in China. American J Food Tech 2009;4(6):255-267.
12. Kinsella JE. Functional properties of soy proteins. J American Oil Chem. Soc 1979;56(1):242-258.
13. Lohani UC, Pandey JP, Shahi NC. Effect of degree of polishing on milling characteristics and proximate compositions of barnyard millet (*Echinochloa frumentacea*). Food Bioprocess Technol 2012;5(1):1113-1119.
14. Mauron J. Effect of processing on nutritive value of food protein. In: Rechagl, M. (Ed.), Handbook of Nutritive Value Processed Foods, CRC Press, Boca Raton, Florida 1982;1:429-471.

15. Narayana K, Narasingha RMS. Functional properties of raw and heat processed winged bean flour. J Food Sci 1982;47(1):1534-1538.
16. Niba LL, Bokonga MM, Jackson EL, Schlimme DS, Li BW. Physicochemical properties and starch granular characteristics of flour from various *Manihot esculenta* (cassava) genotypes. J Food Sci 2001;67(5):1701-1705.
17. Njoki JW, Sila DN, Onyango AN. Impact of processing techniques on nutrient and anti-nutrient content of grain amaranth (*A. albus*). Food Sci. Quality Mgt 2014;25(1):10-17.
18. Okaka JC, Potter NN. Physicochemical and functional properties of cowpea flour. J Food Sci 1979;44(1):1235-1237.
19. Pelletier DL. The potentiating effects of malnutrition on child mortality: epidemiologic evidence and policy implications. Nutrition Review 1994;52:409–415.
20. Sade FO. Proximate, anti-nutritional factors and functional properties of processed pearl millet (*Pennisetum glaucum)*. J Food Technol 2009;7(3):92-97.
21. Scotch TJ. Swelling power and solubility of granular starches. In: Carbohydrate Chemistry Ed. Whistler, R. J., Miller, N. J. and Wolform, M. I., Academic Press, New York 1964, 106-108.
22. Thilagavathi T, Kanchana S, Banumathi P, Hemalatha G, Vanniarajan C, Sundar M. Physical-chemical and functional characteristics of selected millets and pulses. Indian J Sci. Technol 2015;8(57):147-155.