Evaluation Of Physicochemical And Functional Properties Of Cereal Based Porridges Available In Indian Market

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Abstract- *Cereals are the major source of calories in the Indian diets. Traditionally products such as chapati, poori , paranth,a dalia and upma, are popular but with the advent of technology, modernization and more and more women working out, instant cereals i.e. porridge which are ready to eat are becoming popular. Different brands are available in the market. The information is available with respect to processing conditions however very little information is available with regard to physico-chemical and functional properties of the porridges. Research was undertaken to assess the physico-chemical properties of 10 market samples of porridge and it was found out that most of the porridges available are from single grain and only few were multigrain. Porridges were low in calories and instant porridges were more acceptable organoleptically.*

Keywords- Market survey; Cereal based porridges; Functional properties; Physico-chemical properties

I. INTRODUCTION

The total global output production of food grains has witnessed an overall rise of more than 3 times. In 1950 - 1951, it was just 631 million tons and by the year 2007 - 2008, it has touched a figure of 2,075 million tones. The total world production of cereals in 2006 – 2007 was 2012 million tons and this figure went up to a level of 2108 million tons in 2007 - 2008, that means an increase of 4.7% (Iqbal, 2010). The world wheat production in 2009-10 was 655.8 MMT (FAO), out of which the India accounts for 80.6 MMT following China with 114.5 MMT (marketskeptics.com). In the last two decades also wheat production witnessed a spectacular increase from 44.5 million tonnes in 1987-88 to 78.4 million tonnes in 2008. Wheat is the leading source of calories and protein for human nutrition as it provides more than 20 per cent of each in our diets. Only a small proportion of the world wheat production is used for industrial application .Wheat and rice are the major cereals of India and consumed mainly in the form of traditional products such as chapati, poori and parantha and breakfast food items such as upma, flakes and porridge (Arya, 1990). Porridge is one of the important processed foods made from grains. The health benefits of porridge have made it a popular food worldwide.Porridge, popular in many parts of northern India, is made by cooking wheat grits, known as dalia, with water or milk and adding sugar to taste. It is also consumed as a savory dish after cooking with water, vegetables and spices. In addition to wheat, cereal meals used for porridge include rice, oats, barley and corn. With the advent of technology, ready-to-eat type of porridges are available in the market where the grains have been precooked and is ready for consumption with no or little cooking.The wheat grits are prepared by coarse grinding of either polished or unpolished, cleaned wheat in a plate mill (BIS) to a particle size of 300–850 mm. Information is available with respect to processing wheat to grits (Arya, 1991; Rahim et al, 1986) which is the basic ingredient for porridge. Different brands of porridge are present in the market; however, little information is available on the physio-chemical and functional properties of these porridges. The present study was undertaken to assess the physio-chemical and functional properties of these porridges and summarize the information given by the manufacturer so as to provide an insight for further research in product development and value addition.

II. MATERIALS AND METHODS

1) Materials

Ten samples of porridge available in the market were bought from local grocery stores. The products were categorized as traditional and instant porridge. As per their manufacturer, they are Instant roasted porridge (SKB Food Products),MP wheat roasted dalia (Tip Top Food Tech), Paustic dalia (Tip Top Food Tech),Sprouted and pre-baked porridge (Adunik Ahaar Impex), Organic brown rice gluten free dalia (Green Fiesta Pvt Ltd), 100% natural oats(Quaker oats Australia Pvt Ltd), Heart to heart oats(Blue lake milling Pvt Ltd),Dalia (Shakti Bhog foods Ltd),Instant wheat porridge(KCL Ltd), white oats (Baggrys India Ltd). The packaging material varied from LDPE bags to laminated aluminium pouches placed in cardboard boxes. The processed porridge was packed in specialized packaging material while the milled grains were packed LDPE/HDPE bags.

2) Methods:-

Porridge sample were analysed for the following parameters.

a. Moisture Content

Products were ground in a laboratory mill (Model No.3303, Perten Instruments AB, Huddings, Sweden) to pass through an 80-mesh sieve. The moisture content of the ground products were determined using AACC method, 2000.

b. Bulk Density

A 50ml graduated measuring cylinder was tared and gently filled with porridge sample. The bottom of the cylinder was repeatedly tapped gently on a laboratory bench until there was no further reduction of sample volume. Bulk density was calculated as weight of the sample/volume (Hwang and Hayakawa, 1980). All measurements were done in triplicate and results reported as kg/m^3.

$\rho = W_p / V_c$

W_p =Weight of porridge (kg)

V_c =Volume of cylinder (m^3)

ρ=Density (kg/m^3)

c. Water Absorption Index

Water absorption index (WAI) was determined according to the method of Kaur and Singh(2006).A 2.0 g ± 0.005 g sample was placed in a tared centrifuge tube and 20 ml distilled water added. After standing for 15 min (with intermittent shaking every 5 min), the sample was centrifuged at 4000 rpm for 15 min. The supernatant was decanted into a tared aluminium pan and weight gain in the gel was noted. Water absorption index (WAI) **(**Kaur and Singh, 2006**)** was calculated as the increase in weight of sediment obtained after decanting the supernatant as:

WAI= Weight of wet sediment (gm)/weight of dried sediment (gm)

d. Water Solubility Index

The supernatant was evaporated to dryness at 105°C until constant weight. Water solubility index (WSI) was determined by the method given by Nyombaire et al, 2011 as:

WSI= [(weight of dried supernatant)/ (weight of dry sample) X 100].

e. Colour

Colour of raw porridge samples was measured using a Hunter Laboratory Instrument Model CIE 1996 (Hunter Associates Laboratory, Inc., Reston, Virginia, U.S.A.) and expressed in terms of the 'L' (lightness (100) or darkness (0)), 'a' (redness (+) or greenness (–)), and 'b' (yellowness (+) or blueness (–)). A white calibration plate (L = 91.08,a = –1.25 and b = 1.43) was used as a standard for the measurements. Ground and sieved samples (sieve #48 mesh) were taken. For each sample, three measurements were taken and averaged. ΔE, which signifies the total color difference(Matthey and Hanna,1997), was calculated as:

$$\Delta E = (\Delta L^2+\Delta a^2+\Delta b^2)^{1/2}$$

Where $\Delta L = L_{sample} - L_{standard}$

$\Delta a = a_{sample} - a_{standard}$

$\Delta b = b_{sample} - b_{standard}$

f. Cooking Time, Expansion Volume and Water Uptake

The initial volume of 10 g of porridge sample was noted, the cooking time required to prepare the porridge was determined by taking 200ml boiling water and adding 10 g of sample to it. The sample was taken every 30 s and pressed between two glass slides to check the appearance of chalky core indicating uncooked sample. Time required to thoroughly soften the sample was noted as cooking time. The water was drained from the porridge and the increase in volume and weight of the cooked sample was noted and reported as expansion volume (%) and water uptake (%) respectively.

g. Fineness Modulus and Particle Diameter

For determination of average particle size of the porridge sample, a set of Indian standard screens(No. 70, 50, 40, 30, 20, 15 and pan) were arranged serially and sample of 100 g porridge was placed in the topmost sieve and shaken for 2 minutes (Sahay and Singh,2001).The average particle size(D_p) and fineness modulus(F.M.) were calculated as follows.

F.M.= Cumulative percentage material retained above each sieve/100

$D_p=0.135(1.366)^{F.M}$

h. Pasting Characteristics

A Rapid Visco Analyser (RVA), Starch Master (Newport Scientific, Warrie-Wood, Australia) was used to determine the pasting properties of ground porridge samples. Ground porridge sample (3.5 g at 14% wb) was dispersed in 25 ml of distilled water and the 13 min profile given by Yadav et al (2011) was followed .The RVA Thermocline™ software (ver. 2.6) was used to obtain the pasting temperature, peak, trough and final viscosities of the samples (Yadav et al, 2011). All measurements were carried out in triplicate.

i. Sensory Evaluation

The porridge samples were cooked according to the instructions given on the label and evaluated organoleptically. A 9-point hedonic scale, where 9 was the highest score and 1 the lowest, was used to test sensory attributes like appearance, color, flavor, texture(mouth feel) and overall acceptability of the porridges (Nnam,2001). The extent to which a product was liked was expressed as like extremely (9 points), like very much (8 points), like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points), and dislike extremely (1 point). Ten experienced panelists evaluated the products. The product temperature during evaluation was maintained at about 30˚C.

j. Statistical analysis

Since the products surveyed were of different sources and manufactured by different processes tatistical analysis was not possible as influenced by processes, formulations and combinations. The sensory scores were however analyzed by as per one-factor analysis of variance using LSD of AgRes software statistical package. All the values were average of at least three determinations.

III. RESULTS AND DISCUSSION

Physico-chemical properties

The composition of porridge products as reported by the manufacturers on the nutritional labels are summarized in Table 1. The various porridge products were categorized into traditionally cooked and instant porridges. The major ingredients of these products were mainly wheat, rice, pulses, oats and millets. Some of the products were having little sugar, salt, antioxidants and coloring agents also. The traditional porridges were without any added salt/sugar and required addition during or after cooking. The moisture content was clearly marked into 2 groups with the range of 4.10-4.76 % and 8.69-12.50 %.The products with lower moisture content were instant porridges which required no cooking while the samples with high moisture content were primarily milled grains. The calorific value of all the products ranged within 330-683.1 kcal. Maximum reported calorific value was for sample 6 (683.1 kcal) because it had the maximum amount of carbohydrate(143.65%) and protein content(19.16%) as it was based on ingredients such as brown rice granules, sorghum, little millet and finger millet which have high protein content. Porridges with oats as their major constituent had highest fat content falling in the range from 8.5-9 % while porridges made with other ingredients had fat content in range of 1-3.5%.Dietary fiber ranged from 3.0-11.1%, Iron 2.4-7.3 mg, whereas a lot of variation was recorded for sodium(0.29-8.0mg) and calcium(20-48.25mg). The price ranged from Rs 60-180 /Kg. The packaging material had a direct effect on the price as it increased with the specialized packaging.

The particle size analysis of the porridges (Table 2) shows that the Fineness Modulus (uniformity of the particles in the porridge sample) ranged from 2.90-3.82 which was directly proportional to the average particle size, Dp which fell in the in the range of 0.33-0.44mm.

The bulk density (Table 2) was least for instant porridges (210-300 kg/m3) that were manufactured by extrusion resulting in porous structure of the material hence increasing the volume and resulting in lower bulk densities. Highest bulk density (850 kg/m3) was reported for sample 9 which was based on wheat grits. Bulk density is an important parameter in the production of expanded and formed food products. Bulk density has been linked with the expansion ratio in describing the degree of puffing in extrudates (Asare, 2004). Low bulk densities are important in complementary foods because high bulk limits the caloric and nutrient intake per feed per child and infants are sometimes unable to consume enough to satisfy their energy and nutrient requirements (Ikujenlola and Fashakin, 2005). Apart from dietary bulk of the porridge made; the bulk density is also important in the packaging requirement and material handling of the porridges (karuna et al, 1996).

The porridge samples made with oats (Sample 1, 2, and 3) had highest L values (70.4-72.16) (Table 2). Sample 6 had the least value of L (53.56) signifying the sample to be the darkest among all due to the presence of multiple ingredients like cereal, pulses, oilseeds and carom seeds. The ‘a’ value was highest for Sample 2 followed by 9 and 7 in the order making it close to the redness which could have been due to browning reactions due to the heat treatment during extrusion or roasting. The ‘b’ value ranged from 14.15 to 20.63 and was highest again for Sample 2 which could have been due to sugar coating of the instant porridge.

Functional properties

The cooking time required to cook the porridges was in accordance with the time limit specified by the manufactures and is tabulated in Table 3. It varied from 3 minutes to more than half an hour. Maximum cooking time was required for sample 8 due to the presence of variety of ingredients like roasted wheat, rice, pulses, oilseed and carom seeds resulting in slower moisture diffusion and starch gelatinization during cooking (Gujral and Kumara, 2003).

Water absorption capacity is an important functional characteristic in the development of a ready-to-eat food for cereal grains, since a high water absorption capacity may assure product cohesiveness. The water absorption index (WAI) measures the volume occupied by the extrudate starch after swelling in excess water, which maintains the integrity of starch in aqueous dispersion (Ding et al, 2005). It gives an indication of the amount of water needed to form a gruel that results to gelatinization. The WAI for sample 2 and 10(Table 3) were 4.12 and 3.73 respectively which was comparatively high when compared to other samples. Water absorption has been generally attributed to the dispersion of starch in excess water and the dispersion is increased by the degree of starch damaged due to gelatinization and extrusion-induced fragmentation i.e. molecular weight reduction of amylose and amylopectin molecules(Rayas-Duarte et al, 1998). The relatively higher carbohydrate content might also have contributed to the higher water absorption capacity (Houssou and Ayernor, 2002). The WAI for Samples 1, 3-9 ranged from (0.842-1.55).Lower water absorption is desirable for making thinner gruels that will enhance more in-take of nutrients (Kulkani et al, 1991).

The water solubility index (WSI) describes the rate and extent to which the component of powder material or particles dissolves in water. It depends mainly on the chemical composition of the powder and its physical state. The WSI often is used as an indicator of degradation of molecular components (Kirby et al, 1988), measures the degree of starch conversion during extrusion which is the amount of soluble polysaccharide released from the starch component after extrusion. The Water Solubility Index for sample 2 and 10 was 14.08 and 16.48(Table 3). The observed increase in WSI indicates that dextrinization appears to have played an important role (Ding et al, 2006).The WSI of other porridge samples made of grits is falling in the range of 1.48-4.12. These samples comprised of milled multi-grains with minimum degradation of fiber, resulting in lower WSI when compared to the instant porridge samples.

The water uptake percent was maximum for sample 3(constituted of oats) and least for extruded porridge samples as tabulated in Table 3. The hydrophilic nature of the crude fibre might have contributed to the increase in water absorption. The percent volume increase was maximum for sample 8(216.6). Akapunam et al(1996) reported that fats may complex with starch and limit swelling . This is in line with the result obtained in this study since the swelling power increased as the fat content was least for this sample. There was decrease in the volume of extruded porridges after cooking as seen by the negative values of percent volume increase.

The viscosity of a fluid reflects its resistance to flow and influence acceptability of liquid foods. Viscosity depends on solubility and water holding capacity as well as the structure of components in food. Viscosity profile can be thought of as a reflection of the granular changes in the starch granule that occur during gelatinization (Thomas and Atwell,1997).

Paste temperature-The temperature required for a paste of different porridges to attain the maximum viscosity. Pasting temperature of 4 samples out of 10 was in the range of 900C.

Peak Viscosity- Peak viscosity occurred at the equilibrium point between swelling and polymer leaching which caused an increase in viscosity. It also indicates the water binding capacity of starch or mixture. Among the traditionally cooked porridges the one having oats as their major ingredient exhibited highest peak viscosity (1277-1401 cp).Amongst the other traditional porridges Sample 8 had the least peak viscosity (222cp) as sample 8 was constituted of ingredients high in protein and the reduction in peak viscosity might have been due to reduced starch content which resulted in the reduced degree of starch granule swelling (Symons and Brennan, 2004). Moreover, the starch granules with the high swelling capacity resulted in higher peak viscosity (Ragee and Abdel-Aal, 2006).Sample 5 and 6 showed lower peak viscosities which might have been due to heat treatment as they were prepared from roasted grains. This might be associated with the formation of resistant starch and starch based complex like starch-protein (Manohar et al, 2011). The least viscosities were exhibited by sample 2 and 10 extruded porridges where the starch was already gelatinized and hence show least peak viscosities. More over, the presence of other components such as sugar and salt in starch–water systems had been found to inhibit gelatinization (Perry and Donald, 2002).The low peak viscosity exhibited by sample 8 might have been due to high fibrous portion which might have retarded starch swelling (Srikaeo and Sopade, 2010) as this porridge constituted of multi grains.

Hold Viscosity-During the holding period the material slurries were subjected to high temperature and mechanical shear stress which further disrupted starch granules in the grains resulting in amylase leaching out leading to lower viscosity values when compared to the peak viscosity. Hold viscosity was maximum for sample 1 and minimum for sample 10which correlated with the cooking time required in porridge making.

Final Viscosity-Indicated the ability of material to form viscous paste or gel after cooking and cooling .The gel formed at the end of RVA cycle is essentially a three dimensional network of intertwined amylase molecules incorporating dispersed swollen and ruptured starch granules(Langton and Hemansson, 1989). Amongst the traditional porridges the least final viscosity was of Sample 8 (719cp) which contained legumes and oilseeds which are non-newtonian and affected the viscosity. This might have been due to the high fibre content of the sample where the three-dimensional network was weakened by the presence of large sized fibre particle in the matrix with high water insolubility and dilution of wheat starch (Yadav et al, 2010). Sample 7 contained germinated cereals in which enzymes played a major role in altering the composition of the grains which affected the viscosity (Sathe et al, 1983). Germination might have led to increased production of alpha-amylase, and corresponded to reduced viscosity (Helland et al, 2002). Low final viscosity of the porridge implied that it would form a low viscous paste rather than a thick gel on cooking and cooling (Otegbayo et al, 2006) hence it would be a high caloric density food per unit volume (Desikachar, 1980) rather than a dietary bulk (high volume /high viscosity) (Ikujenlola and Fashakin,2005).

Break Down-The lower values of the break down indicated lesser paste capacity to hold water. Break down of viscosity is caused by rupture of swollen granules (Sandhya and Bhattacharrya, 1995).The breakdown viscosities were highest for the oat porridges which might be due to the high amount of dietary fibre. The higher values of breakdown are associated with peak viscosities which in turn are related to the degree of swelling of the starch granules during heating.

Set back- During set back, the mixture is subsequently cooled and re-association between starch molecules especially amylose occurred. In sufficient concentrations the formation of gel and viscosity normally increased and the phase is generally regarded as set back region and related to retro gradation and reordering of starch molecules. Sample 8 shows the lowest value for the set back. Effect of fiber content on the parameters characterizing the gelling process were particularly significant for total set back on cooling (Collar et al, 2006).The low set back values indicated low rate of starch retrogradation or syneresis. The low set back value of the porridge indicates that on cooking it will not be a cohesive gruel.

Sensory evaluation

The sensory scores for all parameters (color, appearance, flavor and overall acceptability) except texture showed non-significant difference ($p \leq 0.05$).Sample 12 showed highest scores (8.35) for texture which were at par with sample 1,4,10 and 11. It was observed that lighter colored porridges were more acceptable when compared to dark colored porridges (Ocheme and Chinma, 2008) even though the scores for porridge color and appearance were non-significant ($p \leq 0.05$).The overall acceptability values were also non-significant which showed that all the porridges were acceptable to the consumers.

IV. CONCLUSION

It was found that the majority of porridges available in the market were made from grits of single cereal, though a few multi grain porridges were also available. Most of the porridges were low in calories in the range of 330-395 cal/100 gm, exception being sample 6 due to presence of brown rice, little millet, finger millet granules and sorghum. The protein content varied from 10-19 % with sample 10 having minimum protein content of 4 % and least dietary fibre of 3 gm. The particle size increased with fineness modulus. The instant porridge showed maximum acceptance due to the convenience of consumption and good organoleptic properties. Efforts should be made to provide such a product at an affordable price to the masses thus supplying wholesome food which is nutritious and easy to consume..

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Table 1: Information* as listed on the nutrient label on package of the porridges (*except moisture and ash)

Porridge Sample	Ingredients	Moisture Content (%)	Ash %	Calories (k cal)	Protein (g)	Total CHO	Total Fat (g)	Dietary Fiber (g)	Fe (mg)	Ca (mg)	Na (mg)	Price Rs/kg
1	Oats	9.5	1.5	397	14.2	66.0	8.5	10.2	4.4	NA	NA	132
2	Whole-wheat Flour(90%),Sugar, salt, Antioxidant Ins-320	4.1	1.4	384.8	10	84	1	10.2	5	46	0.29	180
3	Oats	4.5	1.5	354	11.6	67.8	9	11.1	2.4	48.25	7.0	138
4	Oats	9.09	1.4	390	15.2	62.9	8.6	10	4.5	-	3.7	150
5	Wheat	8.69	1.5	352	10	78	-	9.5	2.8	-	8.0	70
6	Brown rice, Little millet, Finger millet Granules, Sorghum.	12.5	1.2	683.1	19.16	143.65	3.53	10.3	7.33	28	-	140
7	Germinated wheat	9.09	1.5	NA	NA	NA	NA	NA	NA	NA	NA	75
8	Whole roasted wheat, Broken rice, Moong dal, White til, Azwain.	4.76	1.1	330	11	70.5	1	7.5	4	20	6.0	105
9	Wheat	9.09	0.43	NA	NA	NA	NA	NA	NA	NA	NA	60
10	Whole wheat (hard MP variety, sucrose, invert syrup, malt extract, sugar, sodium and potassium salts, minerals and vitamins	3.05	1.5	391	4	90	3	3	3	82	124	150

Table 2: Comparative study of the physical properties of different porridges

Porridge	Fineness modulus	Average particle size(mm)	Bulk Density (kg/m^3)	Color			
				L	a	b	ΔE
Sample 1	3.82	0.44	330	70.4	3.36	16.66	26.09
Sample 2	3.02	0.35	210	57.19	5.92	20.63	39.61
Sample 3	3.47	0.40	430	71.06	3.37	17.9	26.33
Sample 4	3.59	0.42	430	72.16	3.17	16.48	24.58
Sample 5	2.90	0.33	740	57.59	5.21	19.18	38.45
Sample 6	2.97	0.34	830	53.56	2.08	14.15	39.75
Sample 7	3.09	0.35	760	59.86	5.17	19.00	36.40
Sample 8	3.45	0.40	820	56.61	3.30	17.68	38.37
Sample 9	3.21	0.37	850	59.14	5.89	19.78	37.52
Sample10	3.75	0.43	300	64.96	5.38	18.83	32.08

Table 3: Functional properties of the porridge samples

Porridge	Method of Preparation	Cooking time(min)	W.A.I	W. S. I (%)	Water uptake (%)	Expansion Volume (%)
Sample 1	Needs cooking(5-7 min)	04:24:69	1.54	2.52	260.01	15.09
Sample 2	Instant (RTE)	00:14:12	4.12	14.08	88.3	-51.4
Sample 3	Needs cooking(3 min)	03:07:32	1.39	1.88	325.16	101.97
Sample 4	Needs cooking(3 min)	02:41:66	1.55	1.88	268.5	28.81
Sample 5	Needs cooking(10 or more min)	07:12:58	1.22	3.36	289.54	174
Sample 6	Needs cooking(20-25 min)	22:42:50	1.25	1.48	261.00	169.23
Sample 7	Needs cooking(10 min)	08:18:01	1.14	2.56	273.32	157.14
Sample 8	Needs cooking (soak before cooking)	20:03:68	1.34	3.08	276.54	216.67
Sample 9	Needs cooking	11:23:69	0.842	4.12	205.90	140
Sample 10	Instant (RTE)	00:43:21	3.73	16.48	4.80	-69.23

Table 4: Viscosity Studies of different porridges available in the market

Porridge	Paste Temperature	Peak Viscocity	Hold Viscosity	Final Viscosity	Breakdown	Setback	Paste Temperature
Sample 1	94.0	1277	1104	2391	172	1287	94.0
Sample 2	-	77	1	28	76	27	-
Sample 3	93.5	1319	1121	2408	198	1287	93.5
Sample 4	94.3	1401	1159	2802	242	1643	94.3
Sample 5	-	438	429	1332	9	903	-
Sample 6	-	658	648	2093	10	1445	-
Sample 7	-	528	523	1408	5	885	-
Sample 8	-	222	213	719	9	506	-
Sample 9	92.0	649	642	1638	7	996	92.0
Sample10	-	0	-48577	-9	48577	48568	-

Table 5: Sensory scores of the porridge samples

Porridge	Appearance	Color	Texture	Flavor	Overall Acceptability
Sample 1	7.35	7.65	7.55^{abc}	7.6	7.54
Sample 2	7.75	7.95	8.35^{a}	8.45	8.13
Sample 3	7.15	7.5	7.3^{a}	7.1	7.27
Sample 4	7.55	7.65	7.5^{a}	7.45	7.54
Sample 5	7.7	7.7	$7.4b^{c}$	7.25	7.51
Sample 6	7.25	7.45	6.8^{c}	6.75	7.06
Sample 7	7.05	7.15	6.75^{c}	6.7	6.91
Sample 8	7.55	7.45	$7.3b^{c}$	7.3	7.4
Sample 9	6.9	6.9	7.1^{c}	7.25	7.04
Sample10	7.65	7.75	7.55^{abc}	7.5	7.61

means in the same column with different superscripts were significantly ($p \leq 0.05$) different