Research Article

Sensory Evaluation, Nutritional Characteristics and Shelf Life of Oat Based Gluten Free Instant *Porridge*

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Abstract

Instant mixes are packaged food products that can be prepared easily and quickly by thawing or heating. Keeping these facts in view, in the present study efforts were made to develop five types of gluten free instant *porridge* by using instant mixes i.e rice grits (40%), mung bean grits (20%) and linseed powder (5%) in 60 per cent processed (malted, flaked, roasted and popped) and unprocessed oat grits. The developed *porridge* was subjected to sensory evaluation. The results showed that Type-I (unprocessed oat grits based mix), Type-II (malted oat grits based mix) and Type-III (flaked oat grits based mix) *porridge* were found acceptable whereas Type-IV (roasted oat grits based mix) and Type-V (popped oat grits based mix) *porridge* was least acceptable by the judges. The highly acceptable *porridge* was selected for their nutritional properties and shelf life. Water and oil absorption capacity was significantly higher (2.31 and 2.02 g/g) in Type-II *porridge* as compared to Type-III and Type-I *porridge*. Whereas, Type-I *porridge* exhibited higher bulk density. Type-II and Type-III *porridge* contained higher albumin (4.81 and 4.68%), globulin (8.05 and 7.89%) and glutelin (3.93 and 3.86%) fractions. Nutritional properties showed that Type-II (malted oat flour based blend) *porridge* had maximum protein (20.56 %), *in vitro* digestibility of protein (77.65%) and starch (62.26%). Storage studies showed that all the three types of *porridge* prepared from 3 months stored instant mixes were found in the category of 'liked moderately' and remained acceptable up to 90 days of storage.

Keywords: Instant mixes, sensory evaluation, functional properties, nutritional composition, shelf life

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Introduction

The increasing consumer demand for foods that combine additional benefits in addition to common nutrients imposes on the food industry a need for advances in ingredients and formulations, particularly for the production of gluten free foods. Celiac Disease (CD), an autoimmune response to foods containing gluten presents itself in genetically susceptible individuals resulting in lesions or total flattening of intestinal villi [9, 18]. Gluten intolerance presents a large variety of symptoms including gastrointestinal and extra-intestinal manifestations, though in some patients, particularly of paediatric age, the disease is completely symptomless

Oat is an important cereal crop in the developing world and the most popularly cultivated. Oats have received considerable attention for their high content of dietary fibres, phytochemicals and nutritional value. Oat products are consumed as ingredients in baked foods or in *porridge* and considered as source of low cost protein with a protein content of 15 to 20% (dry matter basis) in de-hulled oat grain [10, 22].Oats are an excellent food for lowering cholesterol and reducing risk of heart disease because of the high soluble fiber content. Owing to their high nutritional value, oat-based food products like breads, biscuits, cookies, breakfast cereals, flakes and infant food are gaining increasing consideration [16, 19].

Rice is also naturally gluten-free and contains proteins which are known to be nutritious and hypoallergenic. As rice possess unique nutritional, hypoallergenic and bland taste, therefore, consumption of rice by celiac patients has been increasing as rice is used to prepare gluten free bakery and pasta products which are traditionally made with wheat flour [32]. From the nutritional point of view, legumes are of particular interest in gluten free diet due to presence of high amount of protein. In addition to providing a source of essential amino acids and bioactive peptides, pulse proteins possess functional properties that boost up their potential use in wide variety of gluten free food products [28]. Similarly, flaxseed or linseed (*Linum usitatissimum L.*) has many health promoting properties and excellent nutritional profile. It has been becoming a popular functional ingredient for incorporation in human diet. However, little information is available on the use of oat flour, rice flour, mung bean flour and linseed powder for development of gluten free products. Keeping these facts in view, the present study was carried out to use blends/mixtures of processed and unprocessed oat grits in combination with rice grits, mung bean grits and coarsely ground linseed powder for preparation of gluten free instant *porridge* suitable for patients with celiac disease.

Material and Methods

Procurement of selected oat variety

One oat variety (OS-346) was procured from the Forage Section of the Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, whereas rice, mung bean and linseed samples were purchased from local market. All the samples were cleaned and stored in plastic containers till further use. The oat grain samples were processed by using various processing techniques.

Processing of oat grains

Different processing methods were used to process the oat grains:

Malting

The seeds were manually cleaned and steeped in tap water in ratio of 1:3 (w/v) grains for 12 h at room temperature. At the end of the period, the seeds were drained, spread separately and were allowed to germinate for 48 h covered with damp cotton cloth to optimize most suitable time for germination for maximum nutrient availability and digestibility. Water was sprinkled at 12 h interval to facilitate the germination process. The seed samples were dried in hot air oven at 60^{o}C till constant weight and then root-lets were removed by hand braising. The dried samples were ground into fine powder and stored in air tight containers for further analysis.

Roasting

Roasting invariably improves the flavour and shelf life of the product. The seeds were manually cleaned and roasted in a *karahi* until they become brown and then kept for cooling. Then the samples were ground to fine powder and stored in air tight polythene bags for further analysis.

Popping

Popped grain is a crunchy, porous and precooked product. Popping invariably improves texture and flavour. Popping was done first by soaking the grains in tap water in a ratio of 1:3 for 12 h. Then dried at room temperature in open for 12 h and puffed in traditional iron *karai* using sand at 200-250^{o}C and then kept for cooling. The samples were ground to fine powder and stored in air tight containers.

Flaking

Flaking is done to prepare instant foods for Breakfast. Flakes were prepared by soaking the grains in tap water in a ratio of 1:5 for 12 h. Then pressure cooked the oat grains for 20 min and then pressed by rollers and finally dried in hot air oven at 50 ± 5^{o} C. Then the samples were ground to fine powder and stored in air tight containers.

Preparation of Instant porridge mix

The unprocessed and processed oat grains, rice and mung bean were subjected to milling to obtain grits. Linseed seeds were roasted and ground to obtain coarse powder. Roasted oat grits, rice grits, mung bean grits and coarsely ground linseed separately in ratio of 60:40:20:5 and then added sugar and ghee. Mixed all the ingredients well. Then packed and sealed in polyethylene pouches. Reconstituted *porridge* mix (100g) with milk (400ml) and pressure cooked for 5 minutes.

Organoleptic evaluation of oat based gluten free instant porridge

Instant *porridge* were subjected to sensory evaluation with respect to color, appearance, aroma, texture, taste and overall acceptability by a panel of 10 semi trained judges, using 9 point hedonic scale.

Functional and nutritional properties of oat based gluten free instant porridge

On the basis of organoleptic acceptability instant *porridge* prepared with unprocessed, malted and flaked oat flour based mix were selected for further nutritional analysis. Water absorption capacity of flours was measured by the method described by Singh and Singh [33]. Oil absorption capacity was done according to the method of Iyer and Singh [20]. For measuring the bulk density, grains were gently filled in a 100 ml graduated cylinder. The bottom of

cylinder was gently tapped several times until there was no further diminution of the sample level either filling to the 100 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/100 ml). The different protein fractions viz., albumin (water soluble), globulin (salt soluble), prolamin (alcohol soluble) and glutelin (alkali soluble) were determined according to the method of AACC [6]. Proximate composition such as moisture, protein, crude fat, crude fibre and ash was determined by employing the standard method of analysis [8]. Total carbohydrates were estimated by the following calculation method: Total carbohydrates (%) = 100 – (Crude protein+crude fat+crude fibre+ash). Total energy was calculated theoretically by using the following conversion factors 4.0, 4.0 and 9.0 Kcal/ g for protein, carbohydrates and fat, respectively, according to the method described by Paul and Southgate [3].

Shelf life of most acceptable developed oat based gluten free instant idli

Sensory evaluation

Organoleptic evaluation of stored products were done for period of 3 months at interval of one month by a panel of ten semi trained judges for colour, appearance, aroma, texture, taste and overall acceptability using a nine-point Hedonic Scale.

Fat acidity

The fat acidity was determined by the standard method of analysis [8].

Statistical analysis

Mean, standard error and CD (critical difference) were calculated for analysis of data [26].

Results and Discussion

Table 1 Mean scores of organoleptic acceptability of oat based gluten free instant *porridge*

Instant *porridge*	**Colour**	**Appearance**	**Aroma**	**Texture**	**Taste**	**Overall Acceptability**
Type-I	7.83±0.13	8.05±0.10	7.91±0.15	8.03±0.09	7.55±0.21	7.80±0.05
Type-II	7.61±0.14	7.96±0.17	7.76±0.15	7.70±0.18	7.21±0.21	7.64±0.04
Type-III	7.60±0.22	7.58±0.20	7.49±0.15	7.62±0.24	7.62±0.24	7.61±0.10
Type-IV	6.70±0.14	6.55±0.20	6.61±0.21	6.25±0.13	6.46±0.19	6.53±0.10
Type-V	6.35±0.37	5.96±0.35	5.46±0.41	5.18±0.41	5.29±0.34	5.55±0.21
CD (P≤0.05)	0.68	0.67	0.70	0.74	0.70	0.36

Values are mean ± SE of ten independent determinations
Type-I : Unprocessed oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-II : Malted oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-III : Roasted oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-IV : Popped oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-V : Flaked oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)

Colour mean score of *porridge* prepared from Type-I instant mix (based on unprocessed oat grits) was 7.83, which fell in the category of 'liked moderately' However, the colour of *porridge* prepared from mixes based on processed oat grits changes from creamish white to brownish colour. Mean scores of colour of *porridge* prepared from Type-II, Type-III, Type-IV and Type-V instant mixes (based on malted, flaked, roasted and popped oat grits) were 7.61, 7.60, 6.70 and 6.35 respectively. Type-I, Type-II and Type-III *porridge* (mixes based on unprocessed, malted and flaked oat grits) was 'liked moderately' by the judges whereas Type-IV and Type-V *porridge* (based on roasted and popped oat grits) was 'liked slightly' by the panelists.

Appearance mean scores of Type-I, Type-II, Type-III, Type-IV and Type-V *porridge* were 8.05, 7.96, 7.58, 5.96 and 6.55, respectively. *Porridge* prepared from Type-1 mix (based on unprocessed oat grits) scored highest (8.05) which was 'liked very much' whereas *porridge* prepared using Type II and Type-III mixes (based on malted and flaked oat grits) obtained scores i.e 7.96 and 7.58, fell in the category of 'liked moderately'. On the other hand, *porridge* prepared from Type-IV and Type-V mixes (based on roasted and popped oat grits) scored lowest (6.55 and 5.96) which was found in the category of 'liked slightly' to 'neither liked nor disliked'.

Aroma scores of *porridge* prepared from Type-I, Type-II and Type-III instant mixes (based on unprocessed, malted and flaked oat grits) were 7.91, 7.76 and 7.49, respectively, which was 'liked moderately' by the judges. However, *porridge* prepared from Type-IV and Type-V mixes (based on roasted and popped oat grits) scored 6.61

and 5.46, which fell in the category of 'liked slightly' to 'neither liked nor disliked'. It might be due to its burnt flavor during roasting and popping of oat grains.

Texture mean score of Type-I *porridge* (based on unprocessed oat grits) was 8.03, which fell in the category of 'liked very much'. Whereas, *porridge* prepared from Type–II and Type-III mixes (based on malted and flaked oat grits) exhibited 7.70 and 7.62 mean scores of taste which were 'liked moderately' by the judges. However, Type-IV and Type-V *porridge* (based on roasted and popped oat grits) got scores i.e 6.25 and 5.18, which fell in the category of 'liked moderately' to 'liked slightly'.

Taste scores of *porridge* prepared from Type-I, Type-II and Type-III mixes (based on unprocessed, malted and flaked oat grits) were 7.55, 7.21 and 7.62, respectively, which was liked moderately by the judges. Whereas, *porridge* prepared from Type-IV and Type-V mixes based on roasted and popped oat grits got minimum scores i.e 6.46 and 5.29, which was found in the category of 'liked slightly' to 'neither liked nor disliked'.

It might be due to the fact that popping of oat grains caused burnt taste. Overall acceptability scores of *porridge* prepared from instant *porridge* mixes based on unprocessed, malted and flaked oat grits (Type-I, Type-II and Type-III) were 7.80, 7.64 and 7.61, respectively, which were 'liked moderately' by the judges. Whereas, *porridge* prepared from instant mixes based on roasted and popped oat grits (Type-IV and Type-V) were found in the category of 'liked slightly' to 'neither liked nor disliked'. These results are in conformity with those obtained by various workers regarding acceptability of instant *porridge*, *kheer*, breakfast cereals and *poha* for celiac patients [34, 2 and 29].

Table 2 Physico-chemical properties of oat based gluten free instant *porridge* (on dry matter basis)

Instant *porridge*	Water absorption Capacity (g/g)	Oil absorption Capacity (g/g)	Bulk density (g/ml)	Gluten (g/100g)
Type-I	2.26±0.01	1.97±0.01	0.75± 0.01	ND
Type-II	2.31±0.06	2.02±0.02	0.70±0.02	ND
Type-III	2.25±0.01	1.98±0.04	0.72±0.03	ND
CD(P≤0.05)	0.02	0.01	0.03	-

Values are mean ± SE of three independent determinations ND=Not detected
Type-I : Unprocessed oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-II : Malted oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-III : Flaked oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)

Water absorption capacity of *porridge* made from *porridge* mix based on Type-I blend was 2.26 g/g. Malting treatment significantly (P≤ 0.05) increased the water absorption capacity as compared to flaking. Water absorption capacity was maximum (2.31g/g) in *porridge* based on Type-II mix followed by Type-I (2.26 g/g) and minimum in *porridge* (2.25 g/g) prepared from Type-III mix.

Others workers reported that water absorption index and water solubility index increased significantly in germinated mixes indicating the ability of flour. Malting had a significant effect in increasing the water solubility index of multi nutrient mixes [2, 21].

Oil absorption capacity of all three types of *porridge* varied from 1.97 to 2.02 g/g, respectively. Maximum (2.02 g/g) was noted in *porridge* prepared from Type-II *porridge* mix and minimum (1.97 g/g) in *porridge* prepared from Type-I *porridge* mix. Type-I *porridge* differed significantly from Type-II *porridge*. Deepali *et al.* [1] reported that germination promote/induced oil absorption capacity may be due to solubilization and dissociation of proteins leading to exposure of non-polar constituents from within the protein molecule. Other workers also reported similar results which are in agreement of present study [12, 25].

Bulk density ranged from 0.70 to 0.75 g/ml, with maximum in Type-I *porridge* prepared from (0.75 g/ml) Type-I *porridge* mix followed by Type-III (0.72 g/ml) and minimum in Type-II (0.70 g/ml) *porridg*e based on Type-II *porridge* mix. Type-I *porridg*e differed significantly (P≤ 0.05) in the bulk density from the Type-2 *porridge*. Gluten content was not detected in any of three types of instant *porridge*. Other workers [5, 24, 17] also reported that bulk density of products made from malted and flaked millet/pulses flour mixes had lower bulk density than products made from unprocessed millet/pulses mixes.

Protein fractions

Water soluble albumin fraction ranged from 3.92 to 4.81 per cent among three different types of *porridge*. Per cent distribution of albumin was the highest (4.81%) in Type-II *porridge* (malted oat grits based mix) followed by Type-III (4.68%) and lowest (3.92%) in Type-I *porridge* (unprocessed oat grits based mix).

Table 3 Protein fractions (%) of oat based gluten free instant *porridge*

Instant *Porridge*	Albumin	Globulin	Prolamin	Glutelin
Type-I	3.92±0.02	6.96±0.22	1.95±0.01	3.78± 0.02
Type-II	4.81±0.01	8.05±0.41	1.78±0.00	3.93±0.03
Type-III	4.68±0.01	7.89±0.33	1.84±0.02	3.86±0.01
CD(P≤0.05)	0.07	0.36	0.06	0.09

Values are mean ± SE of three independent determinations
Type-I : Unprocessed oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-II : Malted oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-II : Flaked oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)

Globulin fraction was also maximum (8.05%) in Type-II *porridge* (malted oat grits based mix) followed by Type-III (7.89%) and minimum (6.96%) in Type-I *porridge* (unprocessed oat grits based mix). Type-II *Porridge* had significantly (P≤0.05) higher globulin fraction than Type-III and Type-I.

Malting and flaking treatments significantly (P≤0.05) decreased the prolamin contents in *porridge* prepared from mix based on malted and flaked oat grits. Prolamin content was highest (1.95%) in *porridge* prepared from unprocessed (Type-I) oat grits followed by flaked (Type-III) (1.84%) and lowest (1.78%) in *porridge* prepared from mix based on malted (Type-II) oat grits.

Porridge made from mix based on unprocessed (Type-I) oat grits contained 3.78 per cent of glutelin content. Processing treatments (malting and flaking) significantly (P≤0.05) increased the glutelin content. Highest (3.93%) glutelin content was found in Type-II *porridge* (malted oat grits based mix) and lowest (3.78%) in Type-I *porridge* (unprocessed oat grits based mix). Other workers also reported similar results [35, 4, 27] which are in agreement with the present results

Table 4 Proximate composition (%) and energy (Kcal/100g) of oat based gluten free instant *porridge* (on dry matter basis)

Instant *porridge*	Moisture	Crude protein	Crude fibre	Ash	Crude fat	Carbohydrates	Energy
Type-I	18.63±0.42	20.00±1.29	9.86±0.17	2.47±0.01	7.52±0.22	60.15± 1.14	388.28±2.63
Type-II	20.60± 0.43	20.56±1.63	8.37±0.10	2.35±0.04	6.19±0.23	62.53± 1.27	388.07±2.16
Type-III	19.34±0.52	20.40±1.63	8.50±0.07	2.25±0.02	5.51±0.25	63.34± 1.20	384.55± 2.73
CD(P≤0.05)	0.52	NS	0.15	0.05	0.19	0.92	1.20

Values are mean ± SE of three independent determinations NS=Non-significant
Type-I : Unprocessed oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-II : Malted oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-III : Flaked oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)

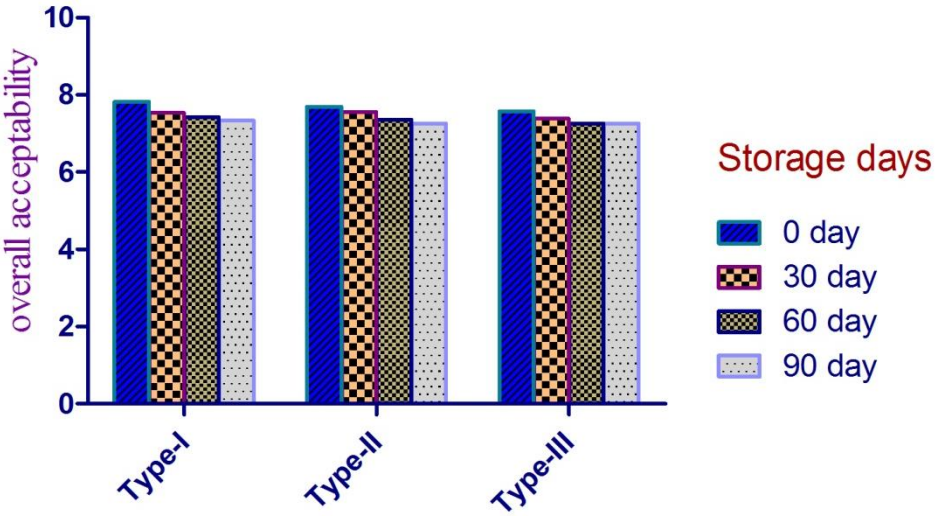
Moisture content of Type-I *porridge* (unprocessed oat grits based mix) was observed as 18.63 per cent. Significantly (P≤0.05) higher moisture content was found in Type-II and Type-III *porridge*. The values were 20.60 and 19.34 per cent, respectively in *porridge* prepared from Type-I and Type-II mix. Significant differences were observed among the values. Other workers also reported higher moisture content in products made from malted mixes as compared to flaked and unprocessed mixes [28, 4, 15].

Protein content Type-I *porridge* was 20.00 per cent, followed by Type-II *porridge* (20.56%) and Type-III *porridge* (20.40%). Non-significant (P≤0.05) differences were observed among the three values. Crude fibre content of Type-I *porridge* (unprocessed oat grits based mix) had 9.86 per cent of crude fibre. Whereas, Type-II and Type-III *porridge* (malted and flaked oat grits based mixes) had significantly (P≤ 0.05) lower range of crude fibre as compared to Type-I *porridge* (unprocessed oat grits based mixture). The values of were 8.37 and 8.50 per cent, respectively in Type-II and Type-III *porridge*. Highest (9.86%) crude fibre content was found in Type-I *porridge* and lowest in Type-II *porridge*.

Ash content was 2.47 per cent in Type-I *porridge*, which was significantly decreased in other two types of *porridge*. Maximum (2.47%) ash content was observed in Type-I *porridge* followed by Type-II (2.35%) and minimum (2.25%) in Type-III *porridge*. *Porridge* prepared from Type-I mix contained 7.52 per cent fat. The fat content of Type-II and Type-III *porridge* (malted and flaked oat grits based mix) were 6.19 and 5.51 per cent, respectively.

Significant difference was observed in fat content in all three types of Instant *porridge*. Similar results were also reported by other workers in products made from malted and unprocessed mixes [13, 11, 23, 31] who reported that

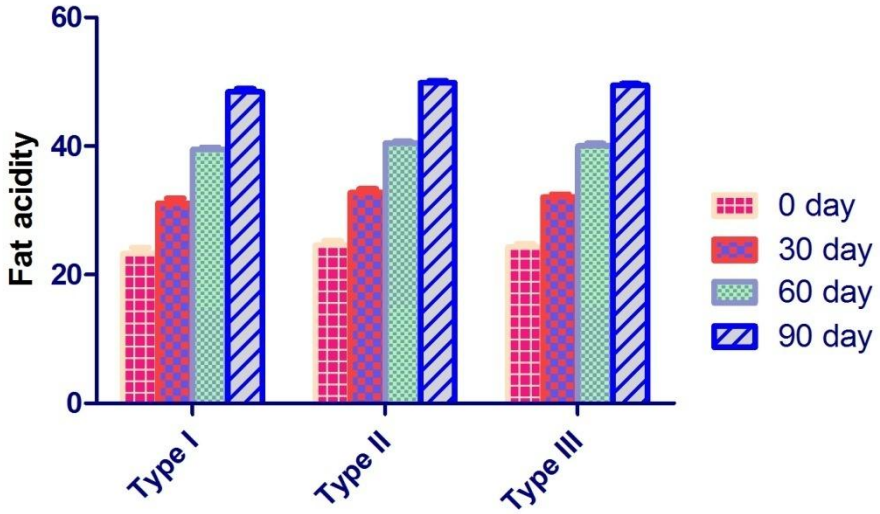
sprouted mixes had significantly higher amount of protein but lower amount of crude fat, crude fibre and ash contents as compared to unprocessed mixes. Type-II and Type-III *porridge* had significantly (P≤0.05) higher carbohydrate content than Type-I *porridge.* The values were 60.15, 62.53 and 63.34 per cent, respectively in three types of *porridge*. Type-I and Type-II *porridge* exhibited highest and similar (388.00 Kcal/100g) energy content and lowest (384.55 Kcal/100g) in Type-III *porridge*. Similar results were also reported by earlier workers [15, 14] in processed and unprocessed instant mixes/products.



Bars are mean ± SE of ten independent determinations
Type-I: Unprocessed oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-II: Malted oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-III: Flaked oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)

Figure 1 Effect of storage period on organoleptic characteristics of oat based gluten free instant *porridge*

Overall acceptability mean scores of *porridge* prepared from three types of fresh (0 day) *porridge* mixes (based on unprocessed, malted and flaked oat grits) were 7.82, 7.70 and 7.58, respectively which decreased with increase in storage period i.e 30, 60 and 90 days. Moreover, overall acceptability scores of *porridge* developed from *porridge* mixes based on unprocessed, malted and flaked oat grits (7.34, 7.26 and 7.26) were also found in the category of 'liked moderately' up to 90 days of storage. The results are in conformity with the previous findings of Anita (2002) and Roopa (2015) who reported that ready to eat breakfast cereals and instant *porridge* mix were found organoleptically acceptable from 3 months to 6 months of storage.



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Type-I : Unprocessed oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-II : Malted oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)
Type-III : Flaked oat grits: Rice grits: Mung bean grits: Linseed powder (60:40:20:5)

Figure 2 Effect of storage on fat acidity (mg KOH/100g) of oat based gluten free instant *porridge* (dry matter basis)

Fat acidity content of *porridge* prepared from 0 day Type-I stored mix (based on unprocessed oat grits) were 23.30 mg KOH/100g, which significantly increased on increasing the storage period. The values were 31.11, 39.53 and 48.41 mg KOH/100g on 30, 60 and 90 days of storage, respectively. Similarly, fat acidity in other two types of *porridge* developed from stored Type-II and Type-III mixes showed an increasing trend with increase in the storage period. Fat acidity of fresh (0 day) *porridge* prepared from Type-II and Type-III mixes were observed as 24.56 and 24.34 mg KOH/100g, respectively. The contents were found to be increased with increased in storage period. The values were in the range of 32.78 to 49.89 and 32.06 to 49.45 mg KOH/100g, respectively on 30, 60 and 90 days of storage.

Conclusion

It may be concluded from the present results that instant *porridge* can be recommended for patients suffering from celiac disease. Instant *porridge* mixes could be stored up to 3 months successfully without any significant change in their sensory attributes.

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