Research Article

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ACCEPTABILITY AND NUTRITIONAL QUALITY OF CEREAL-PULSE-MILK BASED GLUTEN FREE WEANING MIXTURES

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ABSTRACT

Weaning food is the supplementary food which is introduced to the infant after 6 months of age others than mother's milk to meet the growing needs of infant. In the present study, gluten free weaning mixtures were developed using processed and unprocessed oat flour in combinations with rice flour, mung bean flour and linseed powder. The overall organoleptic acceptability of weaning mixture made from Type-I (unprocessed oat flour based), Type-II (malted oat flour based) and Type-III (flaked oat flour based) instant mixtures were 'liked moderately' whereas weaning mixtures made from Type-IV and Type-V instant mixtures (i.e. roasted and popped oat flour based) were 'liked slightly' to 'neither liked nor disliked' by the panelists. Hence, most acceptable weaning mixtures were selected for their physico-chemical, nutritional composition and shelf life. Malted oat flour based weaning mixture had significantly higher amount of protein, available Ca (58.10%), Fe (48.52%) and Zn (41.19%) and in vitro digestibility of protein (75.16%) and starch (59.32%) as compared to Type-I and Type-III weaning mixtures. All the three types of weaning mixtures made from 3 months stored instant mixes were found to be acceptable till 90 days of storage i.e. in the category of 'liked moderately'.

Key words: Weaning mixtures, organoleptic acceptability, nutritional composition, shelf life.

Celiac disease is a gluten induced, immune-mediated, inflammatory process affecting almost exclusively individuals carrying HLA DQ2 and DQ8 genes. Gluten intolerance cause a wide number of symptoms such as gastroenteritis, chronic diarrhea, weight loss, anaemia, abdominal distension, loss of appetite and among the children failure to grow normally (Lamacchia *et al*., 2014). It was also reported that the only dietary treatment for celiac disease is to follow a gluten free diet. Oats may also provide a useful substitute for wheat products in patients suffering from celiac disease. The enrichment of gluten free products with coarse cereals/millets rich in dietary fibres has proved to be necessary, since it has been reported that celiac patients generally have a low intake of fibres attributed to their gluten free diet (Padalino *et al*., 2011).

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 (Hamada *et al*. 2013). From the nutritional point of view, legumes are of particular interest in gluten free diet due to presence of high amount of protein. Among legumes, mung bean (*Vigna radiata L.*) is an excellent source of high quality protein and is one of the cheapest and richest sources of plant proteins (Olua *et al*. 2015). Similarly, flaxseed or linseed (*Linum usitatissimum L.*) has many health promoting properties and excellent nutritional profile. It is 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, in the present study five types of oat based value added gluten free weaning mixtures were prepared by using unprocessed and processed weaning mixes.

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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 good quality rice, mung bean and linseed 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.

Preparation of raw weaning mixes

The unprocessed and processed oat grains, rice and mung bean were subjected to milling to obtain flour. Linseed seeds were roasted and ground to obtain fine powder. For initial range finding trials, oat flour and rice flour were used in amounts ranging from 50:50, 60:40 and 70:30 whereas the amount of mung bean flour and linseed remained same i.e 20:5 for all trials. Final evaluations were performed on recipes containing oat flour, rice flour, mung bean flour and linseed powder in ratio of 60:40:20:5. Roasted oat flour, rice flour, mung bean flour and linseed powder separately in ratio of 60:40:20:5. All the ingredients were mixed well. Then packed and sealed in polyethylene pouches. Weaning mixes (100g) were put in a pan and milk (300ml) was added. It was cooked for at least 5-7 minutes until it becomes soft.

Organoleptic evaluation of oat based gluten free weaning mixtures

Organoleptic evaluation of stored weaning mixtures were done for a period of 3 months at an interval of one month

Processing of oat grains.

Different processing methods were used to process the oat grains:

Fig. 3.1: Flow diagram for malting process

Oat grains
↓
Cleaning
↓
Overnight soaking (oat: water:: 1:3)
↓
Germination (for 48 h)
↓
Drying in hot air oven(60°C for 6 hrs)
↓
Removal of root-lets by hand braising
↓
Ground to fine powder
↓
Stored in air tight containers

Fig. 3.1: Flow diagram for malting process

Oat grains
↓
Cleaning
↓
Soaking overnight
↓
Drying at room temperature
(in open for 12 h)
↓
Puffing in traditional furnace using sand
(at 200-250oC)
↓
Cooling
↓
Ground to fine powder
↓
Stored in air tight containers

Fig. 3.2: Flow diagram for roasting process

Oat grains
↓
Cleaning
↓
Roasting in a karahi till light brown
↓
Cooling
↓
Ground to fine powder
↓
Stored in air tight containers

Fig. 3.4: Flow diagram for flaking process

Oat grains
↓
Cleaning
↓
Soaking overnight
↓
Pressure cooking for 20 min.
↓
Pressing with rollers
↓
Drying in hot air oven at 60o C
↓
Ground to fine powder
↓
Stored in air tight containers

by a panel of ten semi trained judges for colour, appearance, aroma, texture, taste and overall acceptability using a nine-point Hedonic Scale. All the five types of weaning mixtures were stored in air tight polyethylene Pouches at room temperature.

Serving size - 250 g Serving time- 11A.M – 1 P.M

Serving temperature- 50-60°C

Functional and nutritional properties of oat based gluten free weaning mixtures

On the basis of organoleptic acceptability, weaning mixtures 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 (1991). Oil absorption capacity was done according to the method of Iyer and Singh (1997). 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 (2000).

Proximate composition such as moisture, protein, crude fat, crude fibre and ash was determined by employing the standard method of analysis (AOAC, 2000). 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 (1979).

In vitro availability of minerals in the samples *viz*., iron was extracted according to method of Rao & Prabhavathi (1978) and calcium and zinc were extracted by the method of Kim and Zemel (1986). Starch digestibility (*in vitro*) was assessed by employing pancreatic amylase and incubating at 37ºC for 2 hours. Liberated maltose was measured colorimetrically by using dinitrosalicyclic acid reagent (Singh *et al*., 1982). Protein digestibility (*in vitro*) was assessed by employing pepsin and pancreatin (Mertz *et al*., 1983). The nitrogen contents of the sample and the

Table 1
Mean scores of organoleptic acceptability of oat based gluten free weaning mixtures

Weaning mixtures	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
GFWM-I	7.80±0.14	7.83±0.11	7.82±0.10	8.27±0.21	7.80±0.07	7.90±0.14
GFWM-II	7.67±0.15	7.94±0.10	7.66±0.14	8.06±0.25	8.00±0.11	7.86±0.08
GFWM-III	7.55±0.29	7.85±0.13	7.58±0.27	7.80±0.12	7.87±0.25	7.69±0.09
GFWM-IV	6.44±0.15	6.61±0.20	6.50±0.16	6.72±0.20	6.44±0.15	6.54±0.11
GFWM-V	6.11±0.35	5.82±0.36	5.06±0.24	5.13±0.40	5.65±0.28	5.55±0.14
CD (P=0.05)	0.68	0.55	0.50	0.69	0.57	0.29

Values are mean ± SE of ten independent determinations GFWM- Gluten free weaning mixture
GFWM- I: Unprocessed oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5), GFWM-II: Malted oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5), GFWM-III: Roasted oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5), GFWM-IV: Popped oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5), GFWM-V: Flaked oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5)

undigested residue were determined using automatic KEL PLUS (AOAC, 2000). The digested protein of the sample was calculated by subtracting residual protein from the total protein of the sample.

Protein digestibility (%) = Soluble protein N/ Total protein N×100

RESULTS AND DISCUSSION

Organoleptic evaluation of oat based gluten free weaning mixtures

Mean scores of colour (Table 1) of weaning mixtures made from unprocessed, malted and flaked oat flour based blends (GFWM-I, GFWM-II and GFWM-III) fell in the category of 'liked moderately'. Whereas, other weaning mixtures prepared from roasted and popped oat flour based blends (GFWM-IV and GFWM-V) were 'liked slightly' by the judges. Mean score of appearance (Table 1) of GFWM-I, GFWM-II and GFWM-III fell in the category of 'liked moderately'. However, GFWM-IV and GFWM-V fell in the category of 'liked slightly' to 'neither liked nor disliked'. It may be due to the fact that popping of oat grains caused dark brown colour to the popped oat grain flour which was not found acceptable by the panelists.

Aroma mean scores of all types of weaning mixtures were 7.82, 7.66, 7.58, 7.77 and 5.06, respectively, which fell in the category of 'liked moderately' except the weaning mixture prepared from popped oat flour based blend was 'neither liked or disliked' by the panelists (Table 1). Texture mean scores of GFWM-I GFWM-II, GFWM-III, GFWM-IV and GFWM-V varied from 5.13 to 8.27, respectively. Taste scores of weaning mixtures ranged from 5.65 to 8.00, respectively. Weaning mixture made from malted oat flour based blend scored 8.00 which fell in the category of 'liked very much'. However, weaning mixtures made from unprocessed and flaked oat flour based blends were 'liked moderately' by the judges. Other two types of weaning mixtures made from roasted and popped oat flour based blends fell in the category of 'liked slightly' to 'neither liked nor disliked'. Overall acceptability of GFWM-I, GFWM-2 and GFWM-3 was 'liked moderately' by the panelists whereas GFWM-IV and GFWM-V were 'liked slightly' and 'neither liked nor disliked' by the panelists. Sharma and Chawla (2012) reported that the products prepared with oat flour were 'liked moderately' by the judges which are in lines of present study. Moreover, oat based gluten free *kheer* developed by Tiwari *et al.* (2017) was also found to be acceptable by the panelist. In the present study, weaning mixtures based on malted oat flour had better acceptability than weaning mixtures based on roasted oat flour based mixes whereas, contrary to this, Tiwari and Awasthi (2014) reported that roasted oat flour weaning mixture had better acceptability than malted oat flour based weaning mixture.

Physico-chemical properties of oat based gluten free weaning mixtures (on dry matter basis)

Water absorption capacity of GFWM-I was 2.22 g/g, which was significantly increased (2.26 g/g) in GFWM-II. GFWM-III had almost similar (2.21g/g) water absorption capacity as of GFWM-I. GFWM-II had highest (2.26 g/g) water absorption capacity followed by GFWM-I (2.22 g/g) and GFWM-III (2.21g/g). These results are in accordance with Murugkar *et al*. (2013) who reported that water absorption index and water solubility index increased significantly in germinated mixes indicating the ability of flour to absorb more water. Pelembe *et al*. (2002) also reported that malting had a significant effect in increasing the water solubility index of multi nutrient mixes. Oil absorption capacity of weaning mixture prepared from Type-I blend (unprocessed oat flour based) was 1.95 g/g, which was significantly increased (1.99 g/g) in Type-II weaning mixtures. However, the Type-III had similar (1.95 g/g) oil absorption capacity as of Type-I weaning mixture. Deepali *et al*. (2013) 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. Bulk density varied from 0.67 to

Table 2
Proximate composition (%) and energy (Kcal/100g) of oat based gluten free weaning mixtures (on dry matter basis)

Weaning mixtures	Moisture	Crude protein	Crude fibre	Ash	Crude fat	Carbohydrates	Energy
GFWM-I	15.26±1.14	20.12±1.14	8.60±0.15	2.90±0.05	6.52±0.02	61.20± 1.46	387.00±3.71
GFWM-II	16.53±0.93	20.78±1.46	7.43±0.06	2.56±0.08	5.16±0.02	64.40± 1.56	386.00±2.78
GFWM-III	16.16±1.08	20.45±1.20	7.46±0.08	2.40±0.04	5.87±0.04	64.15± 1.09	390.00±3.33
CD (P=0.05)	0.47	NS	0.38	0.31	0.15	1.87	1.98

Values are mean ± SE of three independent determinations   GFWM- gluten free weaning mixture
GFWM-I: Unprocessed oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5)
GFWM-II: Malted oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5)
GFWM-III: Flaked oat flour: Rice flour: Mung bean flour: Linseed powder (60:40:20:5)

0.72, which was highest (0.72 g/ml) in Type-I weaning mixture and lowest (0.67 g/ml) in Type-II weaning mixture. Imtiaz and Burhan (2012) also reported that products made from malted and flaked millet/pulses flour mixes had lower bulk density than products made from unprocessed millet/pulses mixes. It might be due to breakdown of complex compounds such as starch and proteins (Takhellambam and Chimmad 2015). Gluten protein was not detected in any of these weaning mixtures.

Protein fractions

Albumin content of gluten free weaning mixture-I (GFWM-I) prepared from unprocessed oat based blend was 3.75 per cent which increased significantly by processing treatments like malting and flaking. Malting significantly (P≤0.05) increased albumin content of GFWM-II and GFWM-III i.e. 4.67 and 4.50 per cent, respectively. Globulin contents of GFWM-II and GFWM-III increased significantly (P≤0.05) as compared to GFWM-I. The globulin content was highest in GFWM-II (7.57%) followed by GFWM-III (7.12%) and GFWM-I (6.18%). Prolamin content of GFWM-II and GFWM-III decreased significantly (1.85 to 1.69%) as a result of malting and flaking. On mean basis, the prolamin content was significantly (P≤0.05) higher (1.85%) in GFWM-I, whereas, GFWM-II (1.69%) and GFWM-III (1.75%) had lower content of prolamins.

Results indicated that the glutelin content of weaning mixture prepared from unprocessed oat flour based blend was lowest i.e. 3.33 per cent, and it increased gradually as a result of processing treatment. GFWM-II had highest (3.48%) content of glutelin content followed by GFWM-III (3.40%). Moneim *et al*. (2012) also reported that malting process increased the albumin, globulin and glutelin and decreased prolamins content in oat flour.

Proximate composition and energy

Maximum moisture content was observed in GFWM-II followed by GFWM-III and GFWM-I (Table 2). Non-significant differences were observed in protein content of all the three types of weaning mixtures. The different processing treatments like malting and flaking significantly decreased the crude fibre content in GFWM-II and GFWM-III containing malted and flaked oat flour. Maximum ash content was observed in GFWM-I and minimum in GFWM-III (Table 2). Significant differences were observed among the fat values. Similar results were also reported by other workers in products made from malted and unprocessed mixes (Murugkar *et al*., 2013; Tiwari and Awasthi 2014). Fat and crude fibre degraded during malting/sprouting process as also reported by Bau *et al*. (1997).The decrease in oil content on sprouting may be attributed to their utilization in the sprouting process as energy source (Kumar *et al*., 2006). Giridhar and Sathisha (2016) reported that there was significant decrease in protein, crude fibre and fat content after flaking of millet grains which are similar as reported in flaked products in the present study.

Total carbohydrate content of weaning mixtures ranged from 61.20 to 64.40 per cent (Table 2). GFWM-III had highest energy content 390 Kcal/100g, followed by GFWM-I and GFWM-II i.e. 387 Kcal/100g and 386 Kcal/100g, respectively. Laxmi *et al*. (2015) reported that malted instant mixes/products contained higher carbohydrate content as compared to unprocessed mixes/products which are in lines of present study.

Digestibility and available minerals

In vitro protein digestibility of GFWM-I based on unprocessed oat flour was 60.00 per cent, which improved significantly (P≤0.05) in malted and flaked oat flour based weaning mixtures. *In vitro* protein digestibility of GFWM-II and GFWM-III based on malted and flaked oat flour was 75.16 and 71.46 per cent, respectively. Significant differences were observed among the values. *In vitro* starch digestibility of GFWM-I was 49.27 mg maltose released/g meal which increased significantly in GFWM-II (59.32) and GFWM-III (57.91) based on malted and flaked oat flour. Improved protein digestibility on germination may be due to decrease in anti-nutritional factors like phytic acid and polyphenols and degradation of storage proteins and complex carbohydrates due to action of hydrolytic enzymes (Suma and Urooj, 2017).

Heat treatment makes starch granules more available to digestive enzymes by causing their gelatinization. Additionally, heat treatment also destroys anti-nutritional factors which hinder the activity of hydrolytic enzymes such as amylase and protease (Takhellambam and Chimmad, 2015).

GFWM-I contained 51.11 per cent calcium availability. Malting and flaking processing methods significantly (P≤0.05) increased the calcium per cent availability of GFWM-II (58.10 %) and GFWM-III (54.92 %). Iron availability of GFWM-I was 42.76 per cent, which increased significantly with the use of malting and flaking treatments. Iron availability of GFWM-II and GFWM-III was 48.52 and 46.78 per cent, respectively. Zinc availability of all three types of weaning mixtures was 37.26, 41.19 and 39.85 per cent, respectively. Significant (P≤0.05) differences were observed among the values. Germination and flaking significantly improved the *in vitro* availability of minerals as germination and pressure cooking cause hydrolysis in anti-nutrient contents as they are known to form insoluble complexes with minerals and lowering their bio-availability (Tiwari and Awasthi, 2014).

All the three types of weaning mixtures made from fresh (0 day) and stored unprocessed and processed (malted and flaked) oat flour based mixtures (GFWM-I, GFWM-II and GFWM-III) were organoleptically evaluated. Mean scores of colour of GFWM-I, II and III on 0 day was 7.80, 7.67 and 7.65, respectively, which were found in the category of 'liked moderately' up to 90 days of storage**.** Appearance score of GFWM-I on 0 day was 7.83, which declined non-significantly on increasing the storage period and remained in the category of 'liked moderately'. Similarly, the appearance scores of weaning mixtures prepared from malted and flaked mixtures on 0 day were 7.94 and 7.66, respectively and remained acceptable up to storage period of 90 days and fell in the category of 'liked moderately'**.** Aroma scores of weaning mixtures made from all the three types of mixtures on 0 day were 7.82, 7.66 and 7.58, respectively which were 'liked moderately' by the judges. On 30th day and onwards, the aroma scores decreased but still fell in the category of 'liked moderately'.

Texture mean scores of GFWM-I and GFWM-II were 8.27, and 8.06, which was 'liked very much' by the judges. Whereas, GFWM-III scored 7.80, which fell under the category of 'liked moderately'. However, the texture of all three types of weaning mixtures up to 90 days of storage were 7.00, 7.22 and 7.16, respectively which were 'liked moderately' by the judges. Taste scores of all three types of weaning mixtures were 'liked moderately' from 0 to 90 days of storage. Overall acceptability scores of all the three types of weaning mixtures on 0 day were 7.94, 7.88 and 7.69, respectively, which fell under the category of 'liked moderately'. All three types of weaning mixtures found acceptable up to 90 days of storage in their organoleptic characteristics were 'liked moderately' by the judges. The results are in conformity with the previous findings of 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.

It may be concluded that there is great scope for utilization of unprocessed and processed (malted and flaked oat flour based mix) oat flour to develop value added gluten free weaning mixtures having good shelf life for children suffering from celiac disease.

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