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Sensory evaluation and nutritional composition of oat based value added gluten free muffins

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Oats provide a useful substitute for wheat products in patients suffering from celiac disease. The incorporation of oats into a gluten free diet diversifies the celiac diet and also provides many health and nutritional benefits. Keeping these facts in view, the present study was undertaken to develop gluten free muffins by utilizing processed (malted, flaked, roasted and popped) and unprocessed oat flour in combinations with rice flour, mung bean flour and linseed powder. It was found that overall organoleptic acceptability of Type-I (unprocessed oat flour based blend), Type-II (malted oat flour based blend) and Type-III (flaked oat flour based blend) muffins were 'liked moderately' by the judges whereas Type-IV and Type-V muffins (*i.e.* roasted and popped oat flour based blend) were 'liked slightly' by the panelists. Hence, most acceptable (Type-I, Type-II and Type-III) muffins were selected for their physico-chemical and nutritional composition. Water and oil absorption capacity was significantly higher (2.25 and 1.94 g/g) in Type-II muffins as compared to Type-III and Type-I muffins. Whereas, Type-I muffins exhibited higher (0.65 g/ml) bulk density. Muffins prepared from Type-II and Type-III blend contained higher albumin (4.48 and 4.32%), globulin (6.98 and 6.64%) and glutelin (3.92 and 3.76%) fractions. Nutritional composition revealed that muffins prepared from malted oat flour based blend had significantly higher amount of protein (16.82%), available Ca (57.78%), Fe (46.30%) and Zn (40.43%). Total minerals i.e calcium, phosphorus, magnesium, iron and zinc was found to be maximum in Type-I and Type-III muffins. Total and insoluble dietary fibre was higher in Type-I (11.40 and 3.21%) and Type-III (10.26 and 2.26%) muffins as compared to Type-II muffins. However, soluble dietary fibre was found to be maximum in muffins prepared Type-II (4.70%) and Type-III (4.61%) muffins. It may be concluded that oat based gluten free muffins could be suitable for patients suffering from celiac disease.

Key Words : Muffins, Sensory evaluation, Dietary fibre, Proximate composition, Minerals

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INTRODUCTION

Celiac disease is an autoimmune inflammatory disease of the small intestine that can occur in genetically predisposed people due to ingestion of gluten (a protein found in wheat, rye and barley (Zannini *et al.*, 2012 and Salehi and Sardarodiyan, 2016) which leads to damage in the small intestine villi (small finger like projections). It usually develops with in the first three years of life, however, it may occur even in adulthood. Currently this disease affects one in 100 individuals world wide or 1 to 2 per cent of the general population in developed and developing countries. Celiac disease can be treated by avoiding of gluten ingestion. It was also reported that the only dietary treatment for celiac disease is to follow a gluten free diet. Oats may provide a useful substitute for

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wheat products in patients suffering from celiac disease (Sharma and Chawla, 2012 and Comino *et al*., 2013). The incorporation of oats into α gluten free diet which diversifies the celiac diet and also provides many health and nutritional benefits (Padalino *et al*., 2011; Sharma and Chawla, 2012 and Comino *et al*., 2013). Oat is the only cereal containing a globulin or legume like protein avenalins, as the major (80%) storage proteins. It is currently a very popular coarse cereal in consumer demand due to its unique nutritional and health properties (Sharma *et al*., 2010 and Kaur *et al*., 2012) but long before this, it was used only for brewing and animal feed purposes and to some extent as human food. They are excellent source of different dietary fibre compound of mixed linkage (1→3), (1→4) β-D glucan, arabinoxylans and cellulose. Soluble fibre of oat has been reported to reduce elevated blood cholesterol, triglycerides and glucose levels and thereby reducing the risk of degenerative diseases (Anderson *et al.*, 2009 and Immerstrand, 2010), whereas insoluble dietary fibre helps in preventing the colorectal cancer (Ryan *et al.*, 2007). Therefore, keeping in consideration the importance and nutritional benefits of oats, the present study was carried out to use blends/mixtures of processed and unprocessed oat flour in combination with rice flour, mung bean flour and linseed powder for preparation of gluten free muffins suitable for patients with celiac disease. The developed muffins were assessed for their organoleptic acceptability and nutritional composition.

METHODOLOGY

Procurement of selected oat varieties :

Sample of five oat varieties namely HJ-8, HFO-114, OS-6, OS-346 and Kent were procured from the Forage Section of the Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. The grain samples were cleaned and stored in plastic containers till further use.

Selection of best oat variety for product development :

Out of five (HJ-8, HFO-114, OS-6, OS-346 and Kent) oat varieties, OS-346 variety was found superior in terms of its physico-chemical and nutritional composition, hence selected for employing various processing techniques.

Different 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°C till constant weight and then root-lets were removed. 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°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. Flaked 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 they pressed by rollers and finally dried in hot air oven at 50 ± 5° C. Then the samples were ground to fine powder and stored in air tight containers.

Preparation of muffins :

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. The muffins prepared with unprocessed and processed oat flour with rice flour, mung bean flour and linseed powder in ratio of 60:40:20:5 (butter 100g, sugar 100g, baking powder 1 tsp and eggs 3 no.). The following baking schedule was adopted: Sieving, creaming (butter and egg then mix sugar), mixing (flour, baking powder), placed in greased baking tin, baking (160° C for 20 min).

Organoleptic acceptability :

Organoleptic acceptability of developed breads were determined by a panel of 10 judges using a nine point Hedonic Rating Scale ranging from like moderately (9) to dislike extremely (1) for each organoleptic characteristics.

Functional properties and nutritional evaluation of unprocessed and processed oat based gluten free muffins :

On the basis of organoleptic acceptability, the muffins prepared with unprocessed, malted and flaked oat flour based blends 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 as per method of 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). Total minerals *i.e.* calcium, iron, magnesium and zinc in acid digested samples were determined by Atomic Absorption Spectrophotometer according to the method of Lindsey and Norwell (1969). Whereas, phosphorus was determined colorimetrically by using the method of Chen *et al*. (1956). *In vitro* availablility of minerals, iron in the samples were extracted according to the procedure of Rao and Prabhavathi (1978). Calcium and zinc were extracted by the method of Kim and Zemel (1986). Total, soluble and insoluble dietary fibre constituents were determined by the enzymatic method given by Furda (1981).

Statistical analysis :

The data obtained were analyzed statistically using standard methods of analysis (Sheoran and Pannu, 1999).

OBSERVATIONS AND ASSESSMENT

Overall acceptability scores of muffins based on unprocessed (Type-I), malted (Type-II) and flaked (Type-III) oat flour based blends were 7.59, 7.69 and 7.52 which was 'liked moderately' by the judges. However, overall acceptability mean scores of muffins prepared using roasted (Type-IV) and popped (Type-V) oat flour based blends were 6.98 and 6.78, respectively, which were 'liked slightly' by panel of judges (Table 1). It might be due to the fact that roasting and popping of oat grains changed the aroma, appearance and taste of developed cookies and muffins which were not found highly acceptable by the panelists. These results are supported by other findings of Chappalwar *et al*. (2013) and Bornare (2015) who reported that incorporation of oat flour upto 40 and 50 per cent levels in gluten free cookies and biscuits found acceptable but further increase in incorporation level caused significant reduction in scores of texture and taste.

Muffins made from Type-II blend had maximum (2.25 g/g) water absorption capacity followed by Type-III (2.24 g/g) and Type-I (2.20 g/g) blends based muffins. Oil absorption capacity was 1.91 g/g, which was similar in Type-I and Type III (flaked oat flour based blend) muffins. However, the Type-II (malted oat flour based blend) muffins had significantly ($P \leq 0.05$) higher (1.94 g/g) oil absorption capacity. Highest bulk density (0.65 g/ml) was noted in Type-I (unprocessed oat flour based blend) and lowest (0.60 g/ml) in Type-II muffins (malted oat flour based blend) (Table 2). 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. 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. The results of bulk density of gluten free muffins made from malted oat flour based blends are also in close proximity with the previous results reported by Murugkar *et al.* (2013).It might be due to breakdown of complex compounds such as starch and proteins (Ocheme *et al*., 2015; Takhellambam and Chimmad, 2015).

Protein fractions :

Albumin content of all three types of muffins were 3.58, 4.48 and 4.32 per cent, respectively. Highest (4.48%) albumin content was found in muffins prepared with malted (Type-II) oat flour based blend and lowest (3.58%) in muffins prepared with unprocessed (Type-I) oat flour based blend. Globulin content was 5.72 per cent in Type-I (unprocessed oat flour based blend) muffins, which was significantly ($P \leq 0.05$) increased to 6.98 and 6.64 per cent in Type-II (malted oat flour based blend) and Type-III (flaked oat four based bend) muffins (Table 3).

Prolamin content ranged from 1.15 to 1.29 per cent, respectively, with the highest in muffins prepared with Type-I blend followed by Type-III and lowest in muffins prepared with Type-II blend.

Glutelin content of muffins prepared with unprocessed (Type-I) oat flour based blend was 3.70 per cent, whereas other two types of muffins exhibited 3.92 and 3.76 per cent of glutelins, respectively. Other workers also reported similar results (Wu, 1983; Moneim *et al*., 2012 and Rasane *et al*., 2015) which are in agreement with the present results.

Moisture content of muffins prepared with Type-I blend was 20.93 per cent, which increased gradually in Type-II (22.89%) and Type-III (22.59%) muffins.Protein content ranged from 16.40 to 16.82 per cent, respectively. Processing treatments non- significantly ($P \leq 0.05$) increased the protein content in other two types of muffins. Crude fibre content of Type-I (unprocessed oat flour based blend) muffins was 7.89 per cent. Significantly ($P \leq 0.05$) lower crude fibre contents were found in Type-II and Type-III muffins.

Ash content of all three types of muffins were 1.93, 1.72 and 1.79 per cent, respectively. Ash content was significantly decreased in Type-II and type-III muffins. Fat content of muffins prepared with Type-I blend was 31.87 per cent, which decreased gradually in muffins

Table 1 : Mean scores of organoleptic acceptability of oat based gluten free muffins

Muffins	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Type-I	7.75±0.13	7.78±0.25	7.8±0.29	7.35±0.31	7.30±0.21	7.59±0.09
Type-II	7.50±0.16	7.80±0.23	7.98±0.26	7.63±0.14	7.55±0.18	7.69±0.09
Type-III	7.25±0.13	7.80±0.13	7.68±0.22	7.60±0.18	7.30±0.13	7.52±0.06
Type-IV	7.15±0.10	7.00±0.00	7.37±0.22	6.80±0.20	6.60±0.26	6.98±0.11
Type-V	6.93±0.13	6.90±0.10	7.00±0.21	6.65±0.15	6.45±0.28	6.78±0.08
C.D. ($P \leq 0.05$)	0.37	0.48	0.68	0.58	0.63	0.28

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

Table 2 : Physico-chemical properties of oat based gluten free muffins (on dry matter basis)

Muffins	Water absorption capacity(g/g)	Oil absorption capacity (g/g)	Bulk density (g/ml)	Gluten (g/100g)
Type-I	2.20±0.01	1.91±0.03	0.65± 0.01	ND
Type-II	2.25±0.00	1.94±0.00	0.60±0.02	ND
Type-III	2.24±0.03	1.91±0.04	0.64±0.00	ND
C.D.($P \leq 0.05$)	0.02	0.03	0.01	-

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

prepared from Type-II and Type-III muffins. Gupta and Brar (2015) 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. The increase in protein content could be due to a compensatory increase in free amino acids, peptides and non-protein nitrogenous constituents during germination. 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). Carbohydrate content of three types of muffins ranged from 41.91 to 44.46 per cent, respectively, being highest (44.46%) in muffins made from Type-III blend and lowest (41.91%) in muffins made from Type-I blend. Energy content of all three types of muffins ranged from 519.75 to 523.59 Kcal/100g, respectively. Type-II muffins exhibited highest (523.59 Kcal/100g) energy content followed by Type-I (520.07 Kcal/100g) and Type-III (519.75 Kcal/100g) muffins (Table 4).

Total and available minerals :

Muffins prepared with Type-I blend exhibited non significantly higher amount of total calcium, phosphorus, magnesium, iron and zinc as compared to muffins prepared with Type II and Type-III blend 176.45, 532.56, 146.32, 5.52 and 4.69 per cent, respectively (Table 5). It might be due to leaching out of minerals in soaking medium during germination and flaking process. Chitra *et al*. (1996); Hooda (2002); Magdi and Osman (2007) also reported similar results which are in agreement with the present results. *In vitro* calcium, iron and zinc availability was significantly higher in Type-II and Type-III muffins as compared to Type-I muffins 57.78, 46.30 and 40.43 per cent, respectively, Type II 53.60, 44.52 and 38.56 per cent, respectively in Type III (Table 6). Arora *et al*. (2009) reported that germination and flaking significantly

Table 3 : Protein fractions (%) of oat based gluten free muffins (on dry matter basis)

Muffins	Albumin	Globulin	Prolamins	Glutelin
Type-I	3.58±0.01	5.72±0.17	1.29±0.02	3.70± 0.00
Type-II	4.48±0.00	6.98±0.25	1.15±0.00	3.92±0.05
Type-III	4.32±0.02	6.64±0.30	1.22±0.01	3.76±0.06
C.D. (P≤0.05)	0.04	0.18	0.02	0.05

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

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

Muffins	Moisture	Crude protein	Crude fibre	Ash	Crude fat	Carbohydrates	Energy
Type-I	20.93±0.99	16.40±0.29	7.89±0.10	1.93±0.01	31.87±1.16	41.91± 0.85	520.07±3.59
Type-II	22.89± 0.28	16.82±0.59	6.42±0.11	1.72±0.01	31.23±1.45	43.81± 0.78	523.59±2.98
Type-III	22.59±0.37	16.56±1.28	6.56±0.09	1.79±0.02	30.63±0.87	44.46± 0.49	519.75± 2.43
C.D. (P≤0.05)	0.67	NS	0.15	0.03	0.23	1.34	1.26

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

Table 5 : Total minerals (mg/100g) of oat based gluten free muffins (on dry matter basis)

Muffins	Calcium	Phosphorus	Magnesium	Iron	Zinc
Type-I	176.45±2.26	532.56±1.58	146.32±1.67	5.52± 0.01	4.69± 0.03
Type-II	174.94±1.78	530.71±1.80	144.69±2.24	4.85±0.02	3.92±0.01
Type-II	173.89± 1.54	529.54±1.28	143.28±1.28	4.70± 0.08	3.78± 0.00
C.D. (P≤0.05)	NS	NS	NS	NS	NS

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

Table 6 : Available minerals (%) of oat based gluten free muffins (on dry matter basis)

Muffins	Calcium	Iron	Zinc
Type-I	49.71±0.46	40.07±0.23	35.37±0.77
Type-II	57.78±0.64	46.30± 0.54	40.43±0.62
Type-III	53.60±0.59	44.52±0.64	38.56± 0.86
C.D. (P≤0.05)	4.20	2.87	1.52

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

Table 7: Total dietary fibre (%) content of oat based gluten free muffins (on dry matter basis)

Muffins	Total dietary fibre	Soluble dietary fibre	Insoluble dietary fibre
Type-I	11.40±0.27	3.17±0.34	3.21±0.01
Type-II	8.97±0.34	4.70±0.26	2.23±0.06
Type-III	10.26±0.12	4.61±0.26	2.26±0.08
C.D. (P≤0.05)	0.54	0.15	0.07

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

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.

Total dietary fibre content of all three types of muffins were 11.40, 8.97 and 10.26, per cent, respectively. Maximum (11.40%) was noted in muffins made from Type-1 blend (unproceesed oat flour based blend) and minimum (8.97%) in muffins made from Type-II blend (malted oat flour based blend).

Soluble dietary fibre content ranged from 3.17 to 4.70 per cent, respectively. Highest was observed in muffins prepared from Type-II blend (malted oat flour based blend) and lowest in muffins prepared from Type-I blend (unprocessed oat flour based blend). Type-II and Type-III muffins had significantly (P≤0.05) higher content of soluble dietary fibre. Insoluble dietary fibre content was 3.21 per cent in muffins prepared from Type-I blend, which was significantly decreased in muffins prepared from Type-II and Type-III blend. The values were 2.23 and 2.26 per cent, respectively in Type-II and type-III muffins (Table 7). It might be due to that increased alpha-galactosidase activity during germination has been reported to cause a decrease in oligosaccharides content leading to reduced level of dietary fibre during germination (Chitra *et al*., 1996 and Anita, 2002).

On the other hand, the decrease in TDF and IDF contents and increase in SDF content during flaking may be due to leaching out of soluble dietary fibre in to soaking medium and conversion of some of IDF in to SDF contents (Takhellambam and Chimmad, 2015). The increase in soluble dietary fibre could have been the result of depolymerization and/or solubilization of non-starch polysaccharides during steam gelatinization under pressure (Patil *et al*., 2014).

Conclusion :

It may be concluded from the present results that the muffns prepared from malted and flaked oat flour/grits based blends were found organoleptically acceptable and nutritionally superior. Whereas muffins prepared from roasted and popped oat flour/grits based blends were found organoleptically unacceptable by the panelists. Processing treatments (malting and flaking) can be used for improving the protein, soluble dietary fibre, availability of nutrients in oat based gluten free products. These types of muffins may be useful in the gluten free diets and also helpful for improving the nutritional status of celiac patients.

LITERATURE CITED

AACC (2000). Approved Methods of Analysis. The American Association of Cereal Chemists, *St. Paul, MN.*

Anderson, J.W., Baird, P., Davis, R.H., Ferreri, S., Knudtson, M., Koraym, A., Waters, V. and Williams, C.L. (2009). Health benefits of dietary fibre. *Nutrition Revolution*,

67,188-205.

Anita (2002). Development and nutritional evaluation of breakfast foods. Ph.D Thesis, CCS Haryana Agricultural University, Hisar, India.

AOAC (2000) Approved Methods of Analysis. 16th Ed. Association of Official Analytical Chemists. Arlyngton, Verginia, USA.

Arora, S., Jood, S., Khetarpaul, N. and Goyal, R. (2009). Effect of germination and probiotic fermentation on anti-nutrients and *in vitro* digestibility of starch and protein and availability of minerals from barley based food mixtures. *Food Chem.*, **119** : 746-752.

Bau, H., Villaume, C., Nicolas, J. and Mejean, L. (1997). Effect of germination on chemical composition, biochemical constituents and antinutritional factors of soyabean seeds. *J. Sci. Food & Agric.*, **73**(1) : 1-9.

Bornare, D.T. (2015). Physical and sensory evaluation of cookies incorporated with oats and honey. *Internat. J. Engg. Res. & Technol.*, **4**(8) : 407-411.

Chappalwar, V.M., Peter, D., Bobde, H. and Steffi, M.J. (2013) Quality characteristics of cookies prepared from oats and finger millet based composite flour. *Intenat. J. Engg. Sci. & Technol.*, **3**(4) : 677-683.

Chen, P.S., Toriuaka, T.Y. and Warner, H. (1956). Microdetermination of phosphorus. *Anal. Chew.*, **28** : 1756-1758.

Chitra, U., Singh, U. and Rao (1996). Phytic acid, *in vitro* protein digestibility, dietary fibre, and minerals of pulses as influenced by processing methods. *Plant Foods for Human Nutrition*, **49**(4) : 307-316.

Comino, I., Lourdes, M., Alfonso, R., Francisco, B., and Carolina, S. (2013). The gluten-free diet: Testing alternative cereals tolerated by celiac patients. *Nutrients*, **5** : 4250-4268.

Deepali, A., Anubha, U., Preeti, S.N. and Krishi, V.K.D. (2013). Functional characteristics of malted flour of foxtail, barnyard and little millets. *Ann. Food Sci. & Technol.*, **14**(1) : 44-49.

Furda, I. (1981). Simultaneous analysis of soluble and insoluble dietary fibre. In W.P.T. James, and O. Theander (Eds.), The Analysis of Dietary Fibre in Food. Marcel Dekker, New York. pp. 163-172.

Gupta, S. and Brar, J. (2015). Formulation and evaluation of malted ingredient mixes. *International J. Food & Nutri. Sci.*, **5** (3) : 182-190.

Hooda, S. (2002). Nutritional evaluation of fenugreek supplemented wheat products. M.Sc. Thesis, Haryana Agricultural University, Hisar (Haryana) India.

Immerstrand, T. (2010). Cholesterol-lowering properties of oats: Effects of processing and the role of oat components. Ph.D. Thesis, Lund University, Sweden.

Iyer, L. and Singh, U. (1997). Functional properties of wheat and chickpea composite flours. *Food Australia*, **49** : 27-31.

Kaur, G., Sharma, S., Nagi, H.B.S. and Dar, B.N. (2012). Functional properties of pasta enriched with variable cereal brans. *J. Food Sci. & Technol.*, **49** : 467–474.

Kim, H. and Zemel, M.B. (1986). *In vitro* estimation of the potential bioavailability of calcium from sea mustard milk and spinach under stimulated normal and reduced gastric acid conditions. *J. Food Sci.*, **51** : 957-963.

Kumar, V., Rani, A. and Chauhan, G.S. (2006). Influence of germination temperature on oil content and fatty acid composition of soy sprouts. *J. Food Sci. & Technol.*, **43** :325-326.

Lindsey, W.L. and Norwell, M.A. (1969). A new DPTA-TEA soil test for zinc and iron. *Agron. Abstr.*, **61** : 84–90

Magdi, A. and Osman, A.M. (2007). Effect of different processing method on nutrient composition, anti nutritional factors, and *in vitro* protein digestibility of *Dolicus lublub* bean. *Pakistan J. Food Sci. & Nutri.*, **4** : 299-303.

Moneim, A.E., Afify, M.R., El-Beltagi, H.S., Samiha, M., Salam, A.E. and Omran, A.A. (2012). Protein solubility, digestibility and fractionation after germination of sorghum varieties. *Plos One*, **7**(2) : 1-5.

Murugkar, D.A., Gulati, P. and Gupta, C. (2013). Effect of sprouting on physical properties and functional and nutritional components of multi-nutrient mixes. *International J. Food & Nutri. Sci.*, **2** : 8-15.

Ocheme, O.B., Adedeji, O.E., Lawal, G. and Zakari, U.M. (2015). Effect of germination on functional properties and degree of starch gelatinization of sorghum flour. *J. Food Res.*, **4**(2) : 159-65.

Padalino, L., Mastromatteo, M., Sepielli, G. and Alessandro, M. (2011). Formulation optimization of gluten-free functional sphaghetti based on maize flour and oat bran enriched in β-glucans. *Open Access Materials*, **4**: 2119-2135.

Patil, K.B., Chimmad, B.V. and Itagi, S. (2014). Glycemic index and quality evaluation of little millet (*Panicum miliare*) flakes with enhanced shelf life. *J. Food Sci. & Technol.*, **52**(9) : 6078-6082.

Paul, A. and Southgate, A.D. (1979). *The composition of food*. 4th Ed., Elsevier North, Holland Biomedical Press, Amestrdam. pp, 5-11.

Rao, B.S.N. and Prabhavati, T. (1978). An *in vitro* method of predicting the bioavailability of iron from food. *American J. Clinical Nutri.*, **31** : 169-172.

Rasane, P., Jha, A., Sabikhi, L., Kumar, A. and Unnkrishnan, V.S. (2015). Nutritional advantages of oats and opportunities for its processing as value added foods – a review. *J. Food Sci. & Technol*., **52** : 662-675.

Ryan, D., Kendall, M. and Robards, K. (2007). Bioactivity of oats as it relates to cardiovascular disease. *Nutri. Res. Review*, **20** : 147-162.

Salehi, E.A. and Sardarodiyan, M. (2016). Celiac disease and role of a gluten-free diet. *Res. & Rev. Bio-Sci.*, **11**(2) : 1-10.

Sharma, V., Chawla, P. and Grover, K. (2010) Organoleptic characteristics and nutrient composition of oats supplemented products. *J. Res.*, Punjab Agricultural University, **47** : 173-175.

Sharma, Vidisha and Chawla, Paramjit (2012). Development and nutritive evaluation of OAT supplemented products for celiac disease. *J. Dairying Foods & H.S.*, **31** (2) : 112-116.

Sheoran, O.P. and Pannu, R.S. (1999). Statistical package for agricultural works. "O.P. Stat" Collage of Agriculture, Kaul, CCS HAU, Hisar.

Singh, U. and Singh, B. (1991). Functional properties of sorghum-peanut composite flour. *Cereal Chem.*, **68**(5) : 460-463.

Takhellambam, R.D. and Chimmad, B.V. (2015). Study on physico-functional and nutrient composition of ready-to-cook (RTC) millet flakes. *Asian J. Home Sci.*, **10**(2) : 327-331

Wu, Y.V. (1983). Effect of germination on oats and oat protein. *Cereal Chem.*, **60**(6) : 418-420.

Zannini, E., Pontonio, E., Waters, DM. and Arendt, E.K. (2012). Applications of microbial fermentations for production of gluten-free products and perspectives. *Applied Microbiol. Biotechnol.*, **93** : 473-485.

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