Effect of different processing techniques on nutritional characteristics of oat (*Avena sativa*) grains and formulated weaning mixes

Neha Tiwari · Pratima Awasthi

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Abstract One of the variety of oat, UPO 94 was processed by two simple processing techniques. One method is malting and other is roasting. Malted and roasted oat flour as well as weaning mixes prepared from these two processed flour were analyzed for their nutrient composition, alpha amylase activity and in-vitro protein digestibility. For making weaning mix, oat flour, wheat flour, green gram and skim milk powder were taken in a ratio of 30:30:25:15 respectively. Higher moisture, ash, crude fat, energy, amylase activity, and in-vitro protein digestibility were reported in malted oat flour and weaning mix prepared from malted flour. The minerals, calcium (180.0 mg/100 g) and iron (7.9 mg/100 g) were also higher in malted weaning mix as compared to roasted weaning mix. Both malted and roasted weaning gruels were evaluated for sensory quality characteristics and both were found acceptable by the panel members.

Keywords Oat · Nutrient composition · Amylase activity · In-vitro protein digestibility · Weaning mix

Oat is one of the most important Rabi crops of India and belongs to Poaceae family. It is an annual grass that is

believed to be Asiatic in origin. It is used both for human and animal nutrition. Oats are grown practically in every country in the world but Russia, United States, Canada, Australia and Poland are some leading oat producer countries. It is evidenced from various researches that oats contain higher amount of nutrients like protein, fat, dietary fiber than other staple cereals like wheat and rice.

Most infants are first fed with breast milk, a food supply that provides adequate nutrition and some resistance to disease. At 4–6 months of age, it becomes necessary to introduce other foods into the diet, because human milk alone is insufficient to meet the ever increasing nutrient needs of the infants Lutter et al. (1990). Before this age, the relatively high permeability of the young infants digestive tract contributes to the risk of penetration by foreign bodies, especially proteins, which can cause hypersensitivity reactions (Hendricks and Badruddin 1992), and therefore a child should be exclusively breast fed. Most studies have shown that, growth faltering in children coincides with commencement of the introduction of weaning foods, mainly due to their nutritional inferiority, improper feeding practices, and increased risk of gastrointestinal tract infections. Improving the nutritional value of traditional weaning foods by using simple processing techniques can therefore help to alleviate child malnutrition. To keep in view higher nutritive value and various beneficial health effects of oat, the present study was designed to analyze the nutritional composition, amylase activity and in-vitro protein digestibility of malted and roasted oat flour and the weaning mixes prepared from these two processed flour.

Materials and methods

Oat variety, UPO 94 was procured from the Department of Genetics and Plant Breeding, College of Agriculture, G.B

N. Tiwari (✉)
Msc. Foods and Nutrition, G.B.P.U.A. & T. Pantnagar,
Pantnagar, Uttarakhand, India
e-mail: nehatiwari41@gmail.com

N. Tiwari
D/o Mr. M. C. Tiwari. Village- Jawaharnagar. P.O- Dairy farm
Nagla. U.S. Nagar,
Pantnagar, Uttarakhand, 263149, India

P. Awasthi
Department of Foods and Nutrition, College of Home Science,
G.B.P.U.A & T. Pantnagar,
263145 Pantnagar, Uttarakhand, India

Pant University of Agriculture and Technology, Pantnagar. Other materials like green gram, skim milk powder and sugar were procured from the local market of Pantnagar.

Processing of oats

Oat grains were cleaned and malting of grains was done by the method given by Malleshi and Desikachar (1986) for obtaining maximum amylase activity. For roasting, oat kernels were roasted in iron skillet for about 10–15 min. Green gram and wheat flour were also roasted separately in iron skillet for 10–15 min. The roasted grains were dehusked and ground to pass through 100 mesh sieve.

Analytical procedure

Proximate composition of malted and roasted oat flour was determined by A.O.A.C. (1995) method. The alpha amylase activity was determined by the method given by Bernfeld (1955). The in-vitro protein digestibility of the samples was done by the modified procedure of Akesson and Stahman (1964). Iron was estimated calorimetrically by Wong's method as given by Raghuramulu et al. (2003). Calcium content was estimated by titrimetric method given by AOAC (1995).

Statistical analysis The results were analyzed statistically using one way -ANOVA technique to see the significant difference in nutrient composition and in-vitro protein digestibility of malted and roasted oat flour as well as formulated weaning-mixes (Snedecor and Cochran 1967). Three replicates experiments were carried out and an average of these three values was taken. Both the weaning gruels were evaluated for sensory quality characteristics using Nine Point Hedonic scale and score card method by a trained panel of 15 panel members from the department of Foods and Nutrition and Food Science and Technology. (Amerine et al. 1965).

Product formulation

Two types of weaning mixes were prepared by using malted and roasted oat flour. In one mix malted oat flour was used and in another roasted oat flour was used.

- Weaning mix 1-** Malted oat flour was mixed thoroughly with roasted wheat flour, roasted green gram flour and skimmed milk powder in the ratio of 6:6:5:3 (30 % oat flour, 30 % wheat flour, 25 % green gram flour and 15 % skimmed milk powder) and stored in air tight container for future use.
- Weaning mix 2-** Roasted oat flour was thoroughly mixed with roasted wheat flour, roasted green

gram flour and skimmed milk powder in the ratio of 6:6:5:3 (30 % oat flour, 30 % wheat flour, 25 % green gram flour and 15 % skimmed milk powder). It was stored in air tight container for future use.

To 25 g of each weaning mix, 60 ml of lukewarm water (70 °C) and 10 g of sugar were added and mixed thoroughly to prepare weaning gruel.

Results and discussion

One of the varieties of oat, UPO 94 was processed by two processing techniques, i.e. malting and roasting. These two processed flours were used for the formulation of low cost weaning mix. Malted and roasted oat flour as well as formulated weaning mixes were analyzed for their nutrient composition, alpha amylase activity and in-vitro protein digestibility (Table 1). Results revealed that the moisture content of malted and roasted oat flour was 6.4 and 5.2 % respectively while for malted and roasted weaning-mix it was 5.0 and 4.0 % respectively. There was significant difference in moisture content of malted and roasted oat flours as well as in both malted and roasted weaning mixes. In weaning mixes the difference was due to high dry matter content within the gruel of roasted weaning mix. According to Butt et al. (2008) moisture content of unprocessed oat flour was 13.3 %, while Gopalan et al. (2000) reported the moisture content of oatmeal as 10.7 %, which is higher than the values obtained in present study. Ash content of malted and roasted oat flour was 4.2 and 3.4 % respectively and for malted and roasted weaning mix it was 3.5 and 2.5 % respectively which represents total mineral content. There was significant difference in total ash content of two types of oat flour and weaning mixes. Germination significantly increased percent ash over other processing methods. Roasting did not produce a significant change in percent ash. The crude fat content of malted, roasted oat flour, malted and roasted weaning mix were 8.6, 7.5, 9.0 and 6.2 % respectively. There was significant difference in crude fat content of these two types of oat flour. Gopalan et al. (2000) reported the crude fat content of oatmeal as 7.6 %, which is somewhat higher than the obtained value but lower than the values obtained for processed oat flour. Malting significantly increase the fat over other processing method. The apparent increase observed with germination was from the decrease in carbohydrate fractions resulting in a redistribution of nutrient percentages (Lorenz 1980). The percent crude protein content of malted and roasted oat flour was 16.2 and 17.0 respectively, which were quite higher than the value reported by Baker (1994) i.e. 11.0 %. Butt et al. (2008) reported the crude protein content of oat flour as 13.0 %. According to Gopalan et al. (2000) the crude protein content of oatmeal was 13.6 %. Values obtained by them were

Table 1 Nutrient composition, Alpha amylase activity and In-vitro protein digestibility of malted and roasted oat Flour and weaning mixes

Nutrient composition	Oat flour			Weaning mixes		
	Malted (<i>n</i> =3)	Roasted (<i>n</i> =3)	CD at 5 %	Malted (<i>n</i> =3)	Roasted (<i>n</i> =3)	CD at 5 %
Moisture (%)	6.4±0.00	5.2±0.00	0.23	5.0±0.00	4.0±0.00	0.94
Crude Protein (%)	16.2±0.02	17.0±0.01	0.43	19.6±0.02	20.0±0.02	0.27
Total ash (%)	4.2±0.00	3.4±0.00	0.22	3.5±0.00	2.5±0.00	0.36
Crude Fat (%)	8.6±0.02	7.5±0.02	0.47	9.0±0.20	6.2±0.02	0.18
Carbohydrate (%)	64.5±0.04	66.8±0.05	0.11	63.8±0.21	67.1±0.04	0.24
Physiological energy(Kcal/100 g)	400.7±0.10	403.01±0.02	1.31	411.0±1.00	405.3±0.10	1.1
Alpha amylase activity (units)	720.0±0.01	340.0±0.03	–	730.0±0.02	350.0±0.02	–
In- vitro protein digestibility (%)	76.6±0.03	55.2±0.20	0.32	78.4±0.20	57.6±0.20	1.80
Calcium (mg/100 g)	–	–	–	180.0±2.00	164.0±2.00	2.66
Iron (mg/100 g)	–	–	–	7.9±0.20	8.5±0.20	0.26

All values are derived on dry matter basis and all values are mean of three observations

lower than the values obtained in present study. There was significant difference in crude protein content of malted and roasted oat flour. The crude protein of the malted weaning mix and roasted weaning mix was estimated to be 19.6 % and 20.0 % respectively. Hwang and Bushuk (1993) observed a decrease in protein content after malting of wheat. A decrease in protein content after malting can be due to loss of low molecular weight nitrogen compounds during soaking and rinsing of the grain. Also, during germination a substantial proportion of the total nitrogen moves into the roots, so that they act as a ‘nitrogen drain’ (Hough et al. 1971).

The carbohydrate by difference for the malted and roasted oat flour was 64.5 and 66.8 % respectively and for malted weaning mix and roasted weaning mix it was 63.8 and 67.1 % respectively. Patwardhan and Ranganaathan (1975) reported carbohydrate content in oat meal as 62.8 % which is lower than the obtained values. According to Gopalan et al. (2000) the carbohydrate content of oatmeal was 62.8 %, which is lower than the values obtained in present investigation. The physiological energy value was found to be 400.7 Kcal/100 g, 403.0 Kcal/100 g, 411.0 Kcal/100 g and 405.3 Kcal/100 g respectively for the malted oat flour, roasted oat flour, malted weaning mix and roasted weaning mix respectively. Significant difference was found between two types of oat flours and weaning mixes. Gopalan et al. (2000) reported the energy content of oatmeal as 374.0 kcal/100 g, which is lower than the obtained values.

The calcium (mg/100 g) content for malted and roasted weaning mixes was estimated as 180.0 and 164.0 respectively. An increase in calcium content occurs during malting and roasting because of the decrease in phytic acid content. Phytic acid is responsible for binding of calcium and thus rendering calcium unavailable (Hough et al.

1971; Gopalan et al. 2000). Similar results have been found by Ranhotra et al. 1977. They observed that sprouting of wheat for five days resulted in an increase in calcium from 34.9 mg per 100 g to 39.6 mg per 100 g. An increase from 259 µg/g to 692 µg/g in barley sprouts was observed by Lorenz (1980). The iron content of malted and roasted weaning mixes was estimated to be 7.9 and 8.5 mg per 100 g respectively. Iron decreased significantly during malting because of leaching loss during steeping and devegetating (Hough et al. 1971 and Chavan and Kadam 1989). Similar results have been found by Ranhotra et al. (1977). They observed a decrease in iron content of wheat sprouts from 4.12 mg per 100 g to 4.02 mg per 100 g on sprouting for five days.

The biological changes during germination was caused by the various enzymes which are present in dry seeds and become active as the seed imbibes water during steeping in malting process (Lorenz 1980). On germination, the level of alpha amylase increases several folds with the rate of development Dronzek et al. (1972). In the present experiment, alpha amylase activity is defined as microgram of maltose liberated in 1 min at 22 °C by 1 ml of enzyme extract. The alpha amylase activity of malted and roasted oat flour was found to be 720.0 and 340.0 units (µg/ml) respectively. For malted weaning mix and roasted weaning mix it was found to be 730.0 and 350.0 units (µg/ml) respectively (Table 1).

The in- vitro protein digestibility of malted and roasted oat flour was 76.6 and 55.2 % respectively and for malted weaning mix and roasted weaning mix it was found to be 78.4 and 57.6 respectively (Table 1). Significant difference was found in malted and roasted oat flour with respect to in- vitro protein digestibility. Malting appreciably improved the in-vitro protein digestibility of oat flour

Table 2 Sensory scores of weaning mixes using Score Card Method

Sensory attributes	Malted weaning gruel	Roasted weaning gruel	t-value
Colour	6.0±0.10	8.5±0.03	11.76
Flavour	6.0±0.01	7.8±0.20	6.42
Texture	5.9±0.20	7.9±0.02	14.49
After taste	6.1±0.02	8.2±0.20	13.48
Consistency	6.0±0.01	8.0±0.01	11.80
Overall acceptability	6.0±0.10	8.1±0.01 [*]	17.40

*values reports are mean of fifteen observations

*Tabulate t- value- 2.145

and the improvement by malting was significantly higher than roasting.

Sensory evaluation of formulated weaning gruels was done using Nine Point Hedonic Scale and Score Card methods (Amerine et al. 1965) by the trained panel members of the department of Foods and nutrition and Food Science and Technology. Data on sensory evaluation revealed that out of 15 panelists 20 % liked very much, 66.6 % liked moderately and 13.3 % liked slightly the malted weaning gruel.

In case of roasted weaning gruel 13.3 % liked extremely, 66.6 % liked very much, 20 % liked moderately the gruel (Table 2).

The results on score card revealed that the sensory scores of malted weaning gruel for colour was 6.0 as compared to 8.5 for roasted weaning gruel. The mean sensory scores for flavour in malted and roasted weaning gruel were 6.0 and 7.8 respectively. The mean sensory scores for malted weaning gruel with respect to consistency were 6.0 and that of roasted weaning gruel was 8.0. The mean sensory scores for texture in malted weaning gruel were 5.9 and that of roasted weaning gruel was 7.9. For overall acceptability, the mean sensory scores of malted and roasted weaning gruel were 6.0 and 8.1 respectively. Both weaning gruels were found acceptable by the panel members (Table 2). Significant differences in all the sensory characteristic was observed in malted and roasted weaning- mixes when compared with the tabulated t- value.

Conclusion

It can be concluded from the study that both malting and roasting are simple techniques and helpful in increasing the nutritional value of staple cereals, useful in formulating nutritious weaning- mixes.

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