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Antinutritional content of developed weaning foods as affected by domestic processing

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Four weaning foods were formulated using locally available cereals and pulses such as wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and green gram (*Vigna radiata*). Cereals and pulses were used in the ratio 7 : 3. The effects of domestic processing such as roasting and malting on antinutrients such as phytic acid, saponin and polyphenols of weaning foods were studied. Roasting of raw ingredients resulted in 38·9 to 40·8%, 44·8 to 48·6% and 48·4 to 51·0% decrease in phytic acid, saponin and polyphenols, respectively, whereas malting brought about 56·6 to 57·6%, 53·9 to 57·7% and 61·2 to 62·7% decrease in phytic acid, saponin and polyphenols, respectively. Thus the study indicated that malting has a pronounced effect in lowering the antinutrients, while roasting was relatively less effective.

INTRODUCTION

Infancy is considered to be a most critical period during which there is a high mortality rate. It is generally agreed that 'breast is best' and breast milk should preferably be the only food given to infants up to four to six months of age (Devadas *et al.*, 1984). It contains most of the nutrients in appropriate proportions required to maintain growth up to six months. After 6 months supplementary feeding has to be resorted to in order to maintain the expected rate of growth of infants and to bridge the gap of energy and protein requirements.

Weaning foods manufactured commercially by employing roller drying or extrusion cooking are still out of the reach of the majority of the Indian population, especially in rural areas (Chandrasekhara *et al.*, 1967; Desikachar, 1979). This greatly increases the need for the development of low-cost weaning foods. Thus, it becomes important that staples of the community should be the basis of these foods and the place of preparation should be the home. (Desikachar, 1982).

Cereals and pulses constitute an important source of dietary calories and protein for many segments of the world's population, especially in developing countries. Their utilisation in human nutrition is constrained due to their inherent antinutritional factors. Roasting is known to significantly reduce most of the antinutrients (Khan *et al.*, 1988). It also enhances the taste, flavour and nutritional quality of formulation. Malting has also been known to reduce the stress factor (Subbulakshmi *et al.*, 1976; Rao & Deosthale, 1982; Borade *et al.*, 1984; Ologhobo & Fetuga, 1984).

Bearing these facts in mind, four weaning foods were developed using locally available cereals and pulses in appropriate proportions. Roasting and malting were the two major processing methods employed in the formulation of weaning foods. They were evaluated nutritionally and for the extents to which processing effects the antinutritional content of weaning foods.

MATERIALS AND METHODS

Materials

The seeds of wheat (*Triticum aestivum*), dehusked barley (*Hordeum vulgare*) and green gram (*Vigna radiata*) were obtained from the Department of Plant Breeding, Haryana Agricultural University, Hisar, India. Jaggery (unrefined brown sugar) was procured from the market in a single lot. The seeds were freed from dust, broken seeds and other foreign materials.

Processing procedures

Wheat, barley and green gram were steeped in double amounts of water at ambient temperature for 12 h. The soaked cereals and pulses were wrapped in a damp muslin cloth allowed to sprout at room temperature (37°C) for 48 h (cereals) and for 24 h (pulses). Then the sprouts were fan-dried overnight. Sprouted cereals and pulses were roasted in an oven at 70°C for 2 h to develop malt aroma. Grains of wheat, barley and green gram were roasted in a skillet until a uniform light-brown colour was produced. The malted and roasted ingredients were ground in a cyclone mill (mesh size 0·5 mm) separately. The flour thus obtained and powdered jaggery were thoroughly blended.

Preparation of food blends

In addition to breast milk, an infant of six months should be provided with 268 kcal, 6·5 g protein and 6 mg iron per day to meet its growing requirements. So proportions of these ingredients (cereal, pulse and jaggery) were selected in such as way that each weaning food could provide 300 kcal, 6·9 mg iron per 100 g and also an amino acid makeup similar to that of an egg. The following weaning foods were developed.

- I Roasted wheat (70 g); roasted green gram (30 g); jaggery (25 g).
- II Malted wheat (70 g); malted green gram (30 g); jaggery (25 g).
- III Roasted barley (70 g); roasted green gram (30 g); jaggery (25 g).
- IV Malted barley (70 g); malted green gram (30 g); jaggery (25 g).

The developed weaning foods were in dry powder form. Before serving they were cooked in boiling water on a slow fire for five minutes.

Unprocessed formulations were prepared by mixing the untreated grains in the same proportions and these served as control samples for their respective weaning foods.

Chemical analysis

The weaning foods were analysed for moisture, total nitrogen, ash, fat, crude fibre and calories employing standard methods (AOAC, 1980). Iron was determined by atomic absorption spectrophotometer (Lindsey & Norwell, 1969). A factor of 6·25 was applied to convert N into crude protein.

Phytic acid extracted in 0·3 M nitric acid and determined colorimetrically by the method described by Davies and Reid (1979). The method of Gestetner *et al.*, (1966) was employed for extraction and colorimetric determination of saponins. Total polyphenols were extracted by the method of Singh and Jambunathan (1981) and estimated as tannic acid equivalent according to the Folin Denis procedure (Swain & Hills, 1959).

Statistical analysis

Data thus obtained were subjected to analysis of variance according to standard method of statistical analysis (Snedecor & Cochran, 1967).

RESULTS AND DISCUSSION

Nutritional value

The moisture, protein, ash, fat, iron, crude fibre and calorie contents of the weaning foods varied from 5·45 to 6·15%, 13·9 to 14·2%, 4·20 to 4·61%, 1·27 to 1·60%, 13·9 to 16·0 mg/100 g, 1·33 to 1·89% and 323 to 364 kcal, respectively (Table 1). All the values of these weaning foods were within the ranged prescribed by ISI for processed weaning foods (ISI, 1969). A weaning mixture made from malted ragi, horse gram and roasted groundnuts contributed 13 g protein (Chandrasekhara *et al.*, 1988). On the other hand, a higher amount of protein (18 g per 100 g) has been reported in weaning foods formulated from germinated food grains (Nattress *et al.*, 1987). Likewise, 19·2 g protein was reported from a weaning food developed using maize, cow pea, sorghum and blanched groundnuts (Odum *et al.*, 1981).

Effect of processing methods

A marked decrease of 38–40% (I & III) and 56–57% (II & IV) in phytic acid content of weaning foods was observed upon roasting and malting, respectively (Table 2). Khan *et al.* (1988) reported destruction of phytic acid in roasted bengal gram (*Cicer arietinum*). However, some of the decrease in phytic acid in roasted samples might have resulted from the formation of complexes of phytic acid with protein and minerals that were not extractable in dilute HNO_3 and therefore not measurable by the method used. The greater decrease in phytic acid content by malting can be attributed to leaching of phytate ions into the soaking medium

Table 1. Chemical composition of developed weaning foods[a] (expressed per 100 g on dry matter basis)

Weaning foods	Moisture (g)	Protein (g)	Ash (g)	Fat (g)	Iron (mg)	Crude fibre (g)	Calories (kcal)
I	5·51 ± 0·11	14·2 ± 0·32	4·49 ± 0·08	1·60 ± 0·09	16·0 ± 0·35	1·89 ± 0·02	364 ± 2·0
II	6·13 ± 0·07	13·9 ± 0·36	4·20 ± 0·03	1·48 ± 0·07	15·5 ± 2·07	1·78 ± 0·06	362 ± 3·5
III	5·45 ± 0·08	14·1 ± 0·32	4·61 ± 0·08	1·43 ± 0·08	13·9 ± 0·78	1·46 ± 0·02	323 ± 3·5
IV	6·15 ± 0·04	14·0 ± 0·39	4·36 ± 0·03	1·27 ± 0·09	13·9 ± 0·36	1·33 ± 0·05	348 ± 4·5
SE(m)[b]	0·0006	0·15	0·06	0·03	1·37	0·05	2·47
CD[c] ($P < 0·05$)	0·002	0·44	0·18	0·10	4·04	0·15	7·51

[a] Values are mean ± SD of six independent determinations.
[b] Standard error of means.
[c] Critical difference between two treatments.

Table 2. Effect of domestic processing on antinutritional content of weaning foods[a]

	Weaning foods	Phytic acid	Saponins	Polyphenols
I	Processed [roasted]	429 ± 5·48 (38·87)	1234 ± 21·26 (48·62)	368 ± 15·36 (48·41)
	Unprocessed (raw)	703 ± 3·53	2402 ± 34·92	712 ± 16·25
II	Processed [malted]	305+2·04 (56·58)	1017 ± 36·16 (57·65)	277 ± 11·41 (61·20)
	Unprocessed (raw)	703 ± 3·53	2402 ± 34·92	712 ± 16·25
III	Processed [roasted]	419 ± 3·43 (40·75)	116 ± 24·65 (44·75)	350 ± 13·36 (50·97)
	Unprocessed (raw)	708 ± 2·04	2093 ± 29·06	714 ± 13·46
IV	Processed [malted]	300 ± 4·01 (57·56)	964 ± 23·66 (53·94)	266 ± 16·01 (62·71)
	Unprocessed (raw)	708 ± 2·04	2093 ± 29·06	714 ± 13·46
SE (m)		1·59	17·0	6·7
CD ($P < 0{\cdot}05$)		4·59	49·2	19·4

[a] Values are means ± SD of three independent determinations.
Figures in parentheses indicate per cent decrease over control values.

under the influence of a concentration gradient. Similar losses have been reported after soaking of different legume seeds (Deshpande & Cheryan, 1983; Ologhobo & Fetuga, 1984; Sharma & Sehgal, 1992). Such losses may be taken as a function of the changed permeability of the seed coat. The loss of phytic acid during sprouting may be attributed to the development of phytase activity. Phytase has been shown to be active in seeds like faba beans during germination (Michael & Wiebe, 1983) and was reported to reduce the phytic acid content in cowpea, soybean and lima bean (Ologhobo & Fetuga, 1984) and horse gram and moth bean (Borade *et al.*, 1984).

There was a 44–57% reduction in saponin content of weaning foods brought about by processing. Malted weaning foods had lower saponin contents than roasted ones. Roasting and germination have been reported to reduce the saponin content of the moth bean (Khokhar & Chauhan, 1986), chick pea and black gram (Jood *et al.*, 1986) black gram and green gram (Kataria *et al.*, 1988). The loss of saponin content of the seeds during soaking may be attributed to the leaching of saponins into the soaking medium through simple diffusion.

A significant loss varying from 48–62% in polyphenol content of weaning foods was brought about by processing. Malting resulted in significantly higher reduction of polyphenol content as compared to roasting.

Phenols react with protein forming poorly extractable protein phenolic complexes. Such reactions lead to enzymic inhibition and consequently lower protein digestibility. A marked decrease in polyphenols of dry beans (Deshpande & Cheryan, 1983), mung beans (Barroga *et al.*, 1985) and winged beans (Sathe & Salunkhe, 1981) during soaking has been reported. The loss of polyphenols during sprouting may be ascribed to the presence of polyphenol oxidase and enzymic hydrolysis (Rao & Deosthale, 1982). Leaching of polyphenols into water during sprouting may also partially account for the loss. Sprouting has been reported to decrease the polyphenol content of various food legumes (Jood *et al.*, 1987).

Thus phytates, saponins and polyphenols, which constitute an important group of antinutritional components in cereals and pulses, could be appreciably reduced by following common methods of domestic processing. Malting was found to be more effective in lowering the antinutritional content of weaning foods. The feeding of such locally developed weaning mixtures, if adopted, could be instrumental in raising the nutritional status of children in the developing nations.

REFERENCES

AOAC (1980). Official Methods of Analysis of the Association of Official Agricultural Chemists, 13th edn. Association of Official Agricultural Chemists, Washington DC, USA, pp. 125–39, 746.

Barroga, C. F., Laurena, A. C. & Mendona, C. M. T. (1985). Polyphenols in mung bean (*Vigna radiata* (L.) Wilezek). Determination and removal. *J. Agric. Food Chem.*, **33**, 1006–9.

Borade, V. P., Kadam, S. S. & Salunkhe, D. K. (1984). Changes in phytic phosphorus and minerals during germination and cooking of horse gram and moth beans. *Plant Foods Hum. Nutr.*, **34**, 151–7.

Chandrasekhara, M. R., Krishanaiah, M. M., Chandrasekhara, H. N. & Sheepalekhar, S. R. (1967). Preparative trials on roller dried weaning foods. *J. Food. Sci. Technol.*, **4**, 115.

Chandrasekhara, U., Bhooma, N. & Redday, S. (1988). Evaluation of malted weaning food based on low cost locally available foods. *Ind. J. Nutr. Dietet.*, **25**, 37–43.

Davies, N. T. & Reid, H. (1979). An evaluation of phytate, zinc, copper, iron and manganese content of soybean and availability from soya based textural vegetables meat substitute or meat extrudes. *Brit. J. Nutr.*, **41**, 579.

Deshpande, S. S. & Cheryan, M. (1983). Changes in phytic acid, tannins and trypsin inhibitor activity on soaking of dry beans (*Phaseolus vulgaris* L.). *Nutr. Rep. Int.*, **27**, 371–7.

Desikachar, H. S. R. (1979). Weaning food formulation with low hot paste viscosity suitable for home or village level applications. *Proc. Symp. Food Needs of Infants and Preschool Children*, CRTRI, Madras, p. 54.

Desikachar, H. S. R. (1982). Technology options for formulating weaning foods for the economically weaker segments of populations in developing countries. *Food Nutr. Bull.*, **4**, 51–9.

Devadas, R. P., Chandrasekhara, U. & Bhooma, N. (1984). Nutritional outcomes of a rural diet supplemented with low cost locally available foods. IV. Impact on children studied from birth to preschool age. *Ind. J. Nutr. Dietet.*, **21**, 115–22.

Gestetner, B., Birk, Y., Bondi, A. & Tancer, Y. (1966). Methods for the determination of sapogenin and saponin contents of soybeans. *Phytochem.*, **5**, 803–6.

ISI (1969). Indian standard specifications for processed cereal weaning foods, Indian Standard Institute, New Delhi, India, p. 5.

Jood, S., Chauhan, B. M. & Kapoor, A. C. (1986). Saponin content of chick pea and blackgram: Varietal differences and effects of processing and cooking methods. *J. Sci. Food Agric.*, **37**, 1121–4.

Jood, S., Chauhan, B. M. & Kapoor, A. C. (1987). Polyphenols of chick pea and blackgram as affected by domestic processing and cooking methods. *J. Sci. Food Agric.*, **39**, 145–50.

Kataria, A., Chauhan, B. M. & Gandhi, S. (1988). Effect of domestic processing and cooking on antinutrients of black gram. *Food Chem.*, **30**, 149–56.

Khan, M., Zaman, R. & Elahi, M. (1988). Effect of processing on the phytic acid content of Bengal gram (*Cicer arietinum*) products. *J. Agric. Food Chem.*, **36**, 1274–6.

Khokhar, S. & Chauhan, B. M. (1986). Antinutritional factors in moth bean (*Vigna aconifolia*): Varietal differences and effects of methods of domestic processing and cooking. *J. Food Sci.*, **51**, 591–4.

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

Michael, E. N. A. & Wiebe, S. (1983). Changes in phytase activity and phytate during germination of two faba bean cultivars. *J. Food Sci.*, **48**, 270–1.

Nattress, L. A., Mehta, T., Mitchell, M. E. & Finney, P. L. (1987). Formulation and nutritive value of weaning food from germinated food grains. *Nutr. Res.*, **7**, 1309–20.

Odum, P. K., Adamson, L. A., Maragne, L. & Edwards, C. H. (1981). A weaning food from locally grown grains in Nigeria: Formulation and organoleptic evaluation. *Nutr. Rep. Int.*, **23**, 1005–19.

Ologhobo, A. D. & Fetuga, B. L. (1984). Distribution of phosphorus and phytate in some Nigerian varieties of legumes and some effects of processing. *J. Food Sci.*, **49**, 199–201.

Rao, P. U. & Deosthale, Y. G. (1982). Tannin content of pulses: Varietal differences and effect of germination and cooking. *J. Sci. Food Agric.*, **33**, 1013–6.

Sathe, S. & Salunkhe, D. K. (1981). Investigation on winged bean (*Psophocarpus tetragonolobus*) proteins and antinutritional factors. *J. Food Sci.*, **46**, 1389–93.

Sharma, A. & Sehgal, S. (1992). Effect of processing and cooking on the antinutritional factors in faba bean (*Vicia faba*). *Food chem.*, **43**, 383–5.

Singh, U. & Jambunathan, R. (1981). Studies on Desi and Kabuli Chick pea (*Cicer arietinum*) cultivars; levels of protease inhibitor, level of polyphenolic compounds and in-vitro protein digestibility. *J. Food Sci.*, **46**, 1364–7.

Snedecor, G. W. & Cochran, W. G. (1967). *Statistical Methods*. Oxford IBH Publishing Co., New Delhi, India.

Subbulakshmi, G., Kumar, K. G. & Venkataraman, L. V. (1976). Effect of germination on the carbohydrates, protein, trypsin inhibitor and haemagglutinin in horse gram and moth bean. *Nutr. Rep. Int.*, **13**, 19–31.

Swain, J. & Hills, W. E. (1959). The qualitative analysis of phenolic constituents. *J. Sci. Food Agric.*, **10**, 63–68.