ELSEVIER

Food Chemistry 51 (1994) 433–436

0308-8146/94/$7.00

Evaluation of protein quality of brown and white ragi (*Eleusine coracana*) before and after malting

P. Udayasekhara Rao

National Institute of Nutrition, Indian Council of Medical Research, Jamai Osmania P.O., Hyderabad - 500 007, India

(Received 5 November 1993; revised version received and accepted 4 January 1994)

One brown and one white ragi (*Eleusine coracana*) were analysed for their protein, amino acid, tannin and mineral composition. White ragi had higher protein (12·3 g%) and iron (12 mg/100 g) than the brown ragi (8·7 g% protein and 4·4 mg/100 g of iron). White ragi was devoid of tannin while brown ragi had 2·4 g% of tannin. Malting decreased the tannin by 54% in brown ragi and phytin phosphorus by 58 and 65% in brown and white ragi, respectively. Ionisable iron (271 and 55%) and soluble zinc (81 and 25%) contents increased significantly after malting brown and white ragi. There were no significant differences in the amino acid compositions of brown and white ragi proteins.

Diets prepared from malted and unmalted brown or white ragi flour were fed to weanling rats for 28 days. The nutritional qualities of all four ragi diets was very much lower than that of the casein control diet. PER (1·40, 1·80), dry matter (91 and 88%) and protein digestibilities (76 and 70%) as well and NPU (35 and 36) of raw and malted white ragi diets were significantly higher than for the corresponding brown ragi diets. The better nutritional quality of white ragi over that of brown ragi observed in this study may be due to the absence of tannins in the white ragi variety.

INTRODUCTION

Ragi or finger millet is a staple food for some people belonging to a low socioeconomic group in certain parts of India. Ragi is cultivated over 22 lakh hectares producing 1·6 lakh tons of grain per year. Ragi starch is hydrolysed in the gastrointestinal tract more slowly than rice starch (Ramanathan & Gopalan, 1957) and is prescribed for diabetic patients. Malted ragi is used in the preparation of baby foods and weaning foods. Ragi was one of the grains tested at the Central Food Technological Research Institute, Mysore, for use in low-cost weaning foods from locally available sources (Narayanaswamy *et al.*, 1971). Traditional ragi varieties are coloured. Few white ragi varieties have been evolved by the breeders. In the present investigation, protein, tannin and mineral composition of one white and one brown ragi were analysed and their protein quality was evaluated before and after malting.

MATERIALS AND METHODS

One brown (Indaf-5) and one white (WR-9) ragi variety was obtained from the Associate Co-ordinator (Minor millets), All India Co-ordinate Millet Improvement Project, University of Agricultural Sciences, Bangalore. After cleaning, half the quantity of brown and white ragi was germinated for 72 h and dried. The seeds were ground after the removal of vegetative parts.

Chemical composition

Brown and white ragi, before and after malting, were analysed for their protein (N × 6·25), ash, phosphorus and iron by AOAC (1970) methods. Zinc was estimated in an atomic absorption spectrophotometer (Varian Techtron AAS 1000). Tannin content was determined by the modified vanillin method of Price *et al.* (1978). Catechin was used as a standard and the values were expressed as catechin equivalents. Phytate phosphorus was estimated according to the method of Makower (1970).

Ionisable iron and soluble zinc contents were determined according to the methods developed by Narasinga Rao and Prabhavathi (1978) and Mrinaline (1983), respectively.

Amino acid composition

One hundred mg each of Indaf-5 and WR-9 were hydrolysed in 6 N constant boiling hydrochloric acid at 110°C for 20 h in evacuated sealed ampoules. After hy-

Table 1. Percent composition of experimental diets

	I Protein free	II Casein control	III Coloured ragi Raw	IV Coloured ragi Malted	V White ragi Raw	VI White ragi Malted
Vitamin mixture[a]	1	1	1	1	1	1
Salt mixture[b]	4	4	4	4	4	4
Oil	5	5	5	5	5	5
Casein	—	13	—	—	—	—
Coloured ragi, Raw	—	—	90	—	—	—
Coloured ragi, Malted	—	—	—	90	—	—
White ragi, Raw	—	—	—	—	65	—
White ragi, Malted	—	—	—	—	—	65
Starch	90	77	—	—	25	25

[a]Vitamin mixture according to Campbell (1963).
[b]Salt mixture according to USP XVII.

drolysis, excess acid was removed by flash evaporation under reduced pressure. Amino acid analyses were carried out by ion-exchange chromatography in an automatic amino acid analyser (Moore *et al.*, 1958).

Table 1 gives the composition of experimental diets. The diets were complete with respect to all the nutrients except that of protein. The protein content of the diets ranged between 6·4 and 6·6 g%. The diets were steamed in an autoclave for 15 min before feeding to experimental animals.

Thirty-six weanling male rats (Wistar/NIN) weighing around 42 g were divided randomly into six groups of six each. They were housed individually in bottom-raised cages. Food and water were given *ad lib*. Daily food intake and weekly changes in body weights of individual rats were recorded. During the last three days of the experiment, faeces of individual rats were collected and their nitrogen content was estimated by the Kjeldahl method. From the data, dry matter and protein digestibilities were calculated (Campbell, 1963). After 28 days, all the rats were sacrificed by exposure to ether atmosphere. The rat carcasses were hydrolysed in 6 N hydrochloric acid by autoclaving at 15 lbs pressure for 2 h. Nitrogen content of the hydrolysates was estimated by the Kjeldahl method to determine NPU (Miller, 1963).

The data were statistically analysed by using the analysis of variance procedure.

RESULTS AND DISCUSSION

Table 2 gives the chemical composition of brown and white ragi before and after malting. Protein (12·3 g%) and iron (12·0 mg/100 g) contents of white ragi were higher than those observed for brown ragi. White ragi was devoid of tannins while brown ragi had high amounts of tannins (2·4 g%). Phosphorus and zinc contents were not different between white and brown ragi. Ionisable iron (176%) and soluble zinc (56%) contents were higher in white ragi than in brown ragi.

Malting of ragi significantly decreased the content of two antinutritional factors, namely tannin and phytate phosphorus. Ionisable iron and soluble zinc contents, supposed to be bioavailable forms of iron and zinc in foods of plant origin, increased significantly during malting. Iron deficiency anaemia is prevalent among infants and children. Malted ragi supplements to infants and children may help in combating iron deficiency anaemia in these populations in developing countries.

As in any other cereal, lysine is the limiting amino acid of brown and white ragi (Table 3). There were no significant differences in the amino acid compositions of brown and white ragi.

Brown ragi protein contents were 8·7 and 8·2 g% before and after malting, respectively. Hence, the protein quality of ragi was evaluated in rats at the 6·6 g% level instead of the usual 10 g%.

All the parameters measured were significantly higher for the casein diet than for the brown or white ragi (before and after malting) (Table 4). Malting of coloured ragi brought about a marginal improvement

Table 2. Effect of malting on the chemical composition of brown and white ragi

	Brown ragi Before malting	Brown ragi After malting	White ragi Before malting	White ragi After malting
Protein (g%)	8·7	8·2	12·3	11·3
Ash (g%)	1·8	1·8	1·7	1·7
Tannins (mg/100 g)	2392	1102	Nil	Nil
Total phosphorus (mg/100 g)	202	193	197	174
Phytate phosphorus (mg/100 g)	149	63	150	52
Total iron (mg/100 g)	4·4	1·8	12·0	2·8
Ionisable iron (μg/100 g)	425	1578	1174	1825
Total zinc (mg/100 g)	2·1	2·0	2·4	2·0
Soluble zinc (μg/100 g)	903	1633	1407	1752

Values given are averages of triplicate analyses.

Table 3. Amino acid composition of brown and white ragi

Amino acid	WR-9	Indaf-5
Lysine	1·49	1·62
Histidine	1·70	1·72
Arginine	2·19	2·49
Aspartic acid	3·63	6·63
Threonine	2·72	3·73
Serine	3·83	5·18
Glutamic acid	16·78	16·33
Proline	5·57	4·99
Glycine	2·17	2·56
Alanine	4·10	4·61
Valine	2·50	2·32
Methionine	2·49	2·64
Iso-leucine	1·36	1·45
Leucine	5·28	5·28
Tyrosine	2·60	2·30
Ph.Alanine	3·22	3·15

Values given are g/16 g N.

in the food intake, gain in body weight and PER but the differences were not significant. Rats receiving malted white ragi diet consumed significantly more food than those fed the unmalted white ragi, with a concomitant higher gain in body weight and PER, indicating the improvement in the nutritional quality of white ragi after malting. Hemanalini *et al.* (1980) observed no improvement in PER of sprouted brown ragi diet over that of unmalted ragi diet.

Malting decreased the dry matter and protein digestibilities of both coloured and white ragi diets. However, dry matter and protein digestibilities of white ragi diets, before and after malting, were significantly higher than those of the corresponding coloured ragi diets. This may be due to the absence of tannins in the white ragi variety. Tannins are known to bind to proteins, including digestive enzymes, thereby causing decrease in the protein and dry matter digestibilities. Geeta *et al.* (1977) observed a negative correlation between tannin and *in-vitro* protein digestibility of ragi. Brandtzaeg *et al.* (1981) reported significant decrease in biological value and NPU of ragi diets after malting. This they ascribed to loss of some amino acids during the heat treatment involved during malting. Malting had no effect on NPU of ragi diets, but NPU of white ragi diet, raw and malted, was significantly higher than for the corresponding coloured ragi diet.

There were no significant differences in amino acid compositions of brown and white ragi varieties. Hence, the differences observed in protein and dry matter digestibilities, as well as in NPU, between brown and white ragi diets may be due to the differences in their antinutritional factor content only.

White ragi varieties had higher protein contents (Kamalanathan *et al.*, 1971; Virupaksha *et al.*, 1975). Germination of ragi has been shown to decrease the antinutritional factors such as trypsin inhibitor, chymotrypsin inhibitor (Veerabhadrappa *et al.*, 1978; Chandrasekhar *et al.*, 1981) phytate and tannin (Rao & Deosthale, 1988) and increase riboflavin and niacin contents (Brandzaeg *et al.*, 1981). An increase in bioavailable forms of iron and zinc, namely ionisable iron and soluble zinc, have also been observed during germination (Rao & Deosthale, 1988). The viscosity of malted ragi flour was found to be lower with higher energy content (Brandzaeg *et al.*, 1981).

The data presented here indicate that the nutritional quality of white ragi is better than that of coloured ragi and malting of white ragi improved its protein quality further as judged by PER. Malted white ragi is ideal as an ingredient of weaning food.

ACKNOWLEDGEMENTS

The author thanks Dr Vinodini Reddy, Director, National Institute of Nutrition, Hyderabad, for her interest in the work and Mr P. Ramulu for his technical assistance.

REFERENCES

AOAC (1970). *Official methods of analysis.* 11th edn. Association of Official Analytical Chemists. Washington, DC.

Brandtzaeg, B., Malleshi, N. G., Svanberg, U. & Desikachar, H. S. B. (1981). Dietary built as a limiting factor for nutrient intake with special reference to the feeding of preschool children. III studies on malted flour from ragi, sorghum and green gram. *J. Trop. Praedi.*, **27**, 184–9.

Table 4. Effect of malting on the protein quality of white ragi

Group	II	III	IV	V	VI		
Diet	Casein	Raw coloured ragi	Malted coloured ragi	Raw white ragi	Malted white ragi	Critical difference at	
						5%	0·1%
Protein content of the diet (g%)	6·4	6·6	6·6	6·6	6·6		
Food intake (g/28 days)	349±7·1	229±8·9	245±3·3	232±6·0	262±4·8	18·4	33·5
Gain in body weight (g/28 days)	98±3·8	18±2·2	20±1·3	22±1·8	31±1·4	6·7	12·1
PER	3·98±0·78	1·18±103	1·24±0·074	1·40±0·90	1·80±0·058	0·24	0·43
Adjusted PER	2·5	0·7	0·8	0·9	1·1		
Dry matter digestibility (%)	96±0·2	87±1·3	85±0·7	91±0·4	88±0·3	2·1	3·9
Protein digestibility (%)	83±0·6	60±4·9	58±2·4	76±1·3	70±1·0	7·5	13·6
NPU	79±1·4	31±1·1	30±0·7	35±0·5	36±1·3	3·1	5·6

Campbell, J. A. (1963). In *Evaluation of protein quality*. National Academy of Sciences — National Research Council Publication, Washington, DC, p. 31.

Chandrasekhar, G., Raju, D. S. & Pattabiraman, T. N. (1981). Natural plant enzyme inhibitors. α-Amylase inhibitors in millets. *J. Sci. Food Agric.*, **32**, 9–16.

Geeta, R., Virupaksha, T. K. & Sadaksharaswamy, M. (1977). Relationship between tannins and *in-vitro* protein digestibility of protein in finger millets (*Eleusine coracana*). *J. Agric. Food Chem.*, **25**, 1101–4.

Hemanalini, G., Padma, K. V., Jamuna Rani, R. & Saraswathi, G. (1980). Nutritional evaluation of sprouted ragi. *Nutr. Rept Intern.*, **22**, 271–7.

Kamalanathan, G., Girija, K. A. & Devadas, R. P. (1971). Possibilities of white ragi E.C. Co. 9 in human dietary. *I. J. Nutr. Dietet.*, **8**, 315–18.

Makower, R. V. (1970). Extraction and determination of phytic acid in beans (*Phaseolus Vulgaris*). *Cereal chem.*, **47**, 288–95.

Miller, D. S. (1963). In *Evaluation of protein quality*. National Academy of Sciences, National Research Council. Publication, Washington, DC. p. 31.

Moore, S., Speckman, D. H. & Stein, W. H. (1958). Chromatography of amino acids on sulphonated polystyrene resins. An improved system. *Anal. Chem.*, **30**, 1185–90.

Mrinalini Devi Puar (1983). Essential trace element profile and zinc availability in Indian foods and diets. PhD thesis, M.S. University of Baroda, India.

Narasinga Rao, B. S. & Prabhavathi, T. (1978). An *in-vitro* method for predicting the bioavailability of iron from foods. *Am. J. Clin. Nutr.*, **31**, 169–75.

Narayanaswamy, D., Soma Kurien, Kurien, V. A., Rajalakshmi, D., Swamynathan, M. & Parpia, H. A. B. (1971). Supplementary value of a low cost protein food based on a blend of wheat and soyabean flours to poor rice and ragi diets. *Nutr. Rept Intern.*, **4**, 109–16.

Price, M. L., Scoyoc, S. V. & Butler, L. G. (1978). A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *J. Agric. Food Chem.*, **26**, 1214–18.

Ramanathan, M. K. & Gopalan, C. (1957). Effect of different cereals on blood sugar levels. *Indian. J. Med. Res.*, **45**, 255–62.

Udayasekhara Rao, P. & Deosthale, Y. G. (1988). *In-vitro* availability of iron and zinc in white and coloured ragi (*Eleusine coracana*): Role of tannin and phytate. *Plant Food Hum. Nutr.*, **38**, 35–41.

Veerabhadrappa, P. S., Munjunath, H. M. & Virupaksha, T. K. (1978). Protinase inhibitors of finger millet (*E. Coracana*). *J. Sci. Food Agric.*, **29**, 353–8.

Virupaksha, T. K., Geeta, R. & Nagaraju, D. (1975). Seed proteins of finger millet and their amino acid composition. *J. Sci. Food Agric.*, **26**, 1237–46.