Qual Plant Plant Foods Hum Nutr 36: 223–230 (1986)

Protein quality evaluation of a weaning food based on malted ragi and green gram

N.G. MALLESHI, H.S.R. DESIKACHAR and S. VENKAT RAO

Discipline of Grain Science and Technology, Central Food Technological Research Institute, Mysore 570 013, India

(*Received September 25, 1985; in revised form May 28, 1986*)

Key words: Ragi, green gram, malted weaning food, protein quality

Abstract. The nutritional quality of a malted weaning food developed using malted ragi (*Eleusine coracana*) and green gram (*Phaseolus radiatus*) was evaluated by rat feeding trials. The protein score of the weaning food was 70 calculated according to FAO/WHO (1973) pattern. The protein efficiency ratio (PER), net protein utilization (NPU), biological value (BV) and true digestibility (TD) values for the weaning food proteins at 10% level of protein intake were 2.2, 51.6, 73.8 and 82.8, respectively and the relative protein value (RPV), determined at 5, 8 and 11% levels of protein intake was 84. Supplementation of the weaning food with 10% skim milk powder enhanced the PER to 2.7 and NPU to 63.0. The nutritional quality of a roller dried proprietary weaning food was also evaluated along with malted weaning food for comparison and it was observed that the nutritional quality of the two products were comparable.

Introduction

A large number of weaning foods, based on cereals and legumes have been developed to meet the need of young children, especially of developing countries [4, 6, 8]. Most of the weaning foods marketed in India are prepared by pre-cooking and roller-drying the slurry of cereal and legume blends. Such foods absorb a large amount of water and increase the 'dietary bulk' and reduce the calorie density of the foods [12]. Recently, a weaning food of low hot-paste viscosity and high calorie density has been developed using malted ragi and green gram [14]. The present study was undertaken to evaluate the protein quality of this malted weaning food by various standard rat bioassay procedures [16].

Materials and methods

Malted weaning food

Ragi or finger millet (*Eleusine coracana*) and green gram (*Phaseolus radiatus*) were steeped in water for 16 h and germinated for 2 d and 1 d respectively and then sun-dried. The rootlets from ragi and husk from green gram were removed by gentle abrasion in a rice huller mill. The devegetated ragi and dehusked green gram were kilned in a cake roaster at 70 °C for 45 min. Ragi

Table 1. Composition of diets for rat feeding trials

Diet	Test material (g)	Corn starch (g)	Protein level (%)
MWF	79.3	5.7	$10^{a,b}$
	39.1	45.9	5^{c}
	65.5	19.5	8^{c}
	83.0	2.0	11^{c}
MWFM	71.5	13.5	$10^{a,b}$
PWF	79.3	5.7	$10^{a,b}$
	39.1	45.9	5^{c}
	65.5	19.5	8^{c}
	83.0	2.0	11^{c}
SMP	28.8	56.2	$10^{a,b}$
	15.5	69.5	5^{c}
	24.8	60.2	8^{c}
	39.3	45.7	11^{c}
Non-protein diet	–	85.0	–

WMF – Malted weaning food; MWFM – Malted weaning food with 10% skim milk powder; PWF – Proprietary weaning food; SMP – Skim milk powder
^{a,b} Denote diets for PER, NPU, BV and TD
^{c} for RPV studies

was moistened with 7% extra water, tempered for 15 min, pulverised in a plate mill and sieved through 60 mesh (BSS) to remove coarse bran [13]. Malted ragi flour and green gram flour were mixed in the ratio of 70:30 to obtain the weaning food (MWF) [14]. A proprietary brand of weaning food (PWF) containing cereal flours and milk proteins having 12% protein, and skim milk powder (SMP) were obtained from a local market. A blend of the malted weaning food with 10% skim milk powder (MWFM) was also used in the study.

Essential amino acid content

Lysine, tryptophan, threonine, methionine and cystine contents of the weaning foods were assayed by microbiological procedures [1] and the available lysine content was estimated by the method of Carpenter [2].

Animal experiments

The diets using MWF, MWFM and PWF for rat feeding trials were prepared to contain 5, 8, 10 and 11% protein levels as shown in Table 1. The protein levels were adjusted by dilution of weaning foods with corn starch. All the diets contained refined peanut oil (10%), salt mixture 4% [10] and vitaminised mixture 2% [5]. Diet prepared similarly using spray-dried skim milk powder served as reference protein.

For PER, NPU and RPV determinations, male weaning rats of Wistar strain (10 rats for PER and 8 rats for NPU and RPV experiments, in each group)

Table 2. Some essential amino acids and available lysine content of the weaning foods (g/16 gN)

Amino acid	PWF		MWF		MWFM		SMP	FAO/WHO (1973) ref. pattern [18]
	Content	Chemical score	Content	Chemical score	Content	Chemical score		
Lysine	5.6	102	5.3	98	5.6	102	8.4	5.5
Tryptophan	1.4	142	1.3	134	1.3	134	1.7	1.0
Threonine	3.1	78	2.8	70	3.0	75	4.4	4.0
Methionine + Cystine	3.8	107	4.2	121	4.1	118	3.4	3.5
Available lysine	4.3	–	4.5	–	4.9	–	–	–

Table 3. Protein efficiency ratio of weaning foods

Diets	Average food intake (g)	Average protein intake (g)	Average weight gain (g)	PER
MWF	168.9	17.4	38.5	2.2(1)
MWFM	191.1	19.5	52.3	2.7(2)
PWF	196.6	19.1	43.4	2.3(3)
SMP	193.1	20.1	65.2	3.2(4)
SEM				± 0.09 (27df)

Test of significance: 1,3, 2,4.
Any means of the column underscored by the same line are not significantly different, ($P < 0.05$) according to Duncan's new multiple range test

were housed individually, in wire-mesh cages of galvanised iron. The temperature of the animal rooms varied from 73–86 °F during the experimental period. For BV and TD determinations, adult male rats (Wistar strain) weighing about 80 g (8 rats in each group) were used. The cages were rested on glass funnels provided with perforated discs to facilitate collection of faeces and urine separately. Ferric oxide was used as a marker for faeces. The diets were wetted with hot water prior to feeding. Feed and water were given daily *ad libitum* in all experiments. The left-over diet was collected daily and dried at about 95 °C and the food intake was calculated. After a feeding period of 28 d PER was determined [11], whereas NPU was determined after 10 d of feeding period [15]. The actual, faeces and urine collection period for BV and TD determination was 5 d after 3 d of adaptation period [7]. For RPV determination, the rats were fed the diets containing 5, 8 and 11% protein levels. The food intake and weight gain were recorded for each rat on alternate days during the experimental period of 21 d and the RPV was determined according to Hegsted and Chang [9].

Results and discussion

The composition of MWF and PWF were almost similar. The protein, fat and carbohydrate contents were 12, 2.5 and 76% respectively. The proteins of the MWF and PWF had fairly high levels of lysine, tryptophan and sulfur amino acids and compared well with the FAO/WHO (1973) reference pattern (Table 2). However, the threonine content of MWF and PWF was considerably lower than the reference protein. But supplementing the MWF with 10% SMP slightly improved its threonine score. The available lysine content of MWF and PWF proteins were 4.5 and 4.3%, respectively. The severity of heat treatment during preparation of PWF, probably resulted in a slight reduction of its available lysine content [19].

The results of PER experiments are summarised in Table 3. The PER of MWF was nearly the same as that of PWF (2.3); but was significantly lower than that of the SMP (3.2). Supplementation of the MWF with 10% SMP

Table 4. Net protein utilisation of weaning foods

Diets	Protein intake (g)	Change in body weight (g)	Dry weight of carcass (g)	Carcass protein (g)	NPU
MWF	7.2	18.1	23.2	11.9	51.6(1)
MWFM	7.3	20.8	29.4	12.8	63.4(2)
PWF	8.1	21.9	30.8	13.2	62.0(3)
SMP	7.8	29.0	30.5	14.7	83.4(4)
Non-protein diet	0.2	8.3	16.8	8.4	–
SEM					± 2.7 (21df)

Test of significance: 1, 2,3, 4

Any two means of columns underscored by the same line are not significantly different ($P < 0.05$) according to Duncan's new multiple range test

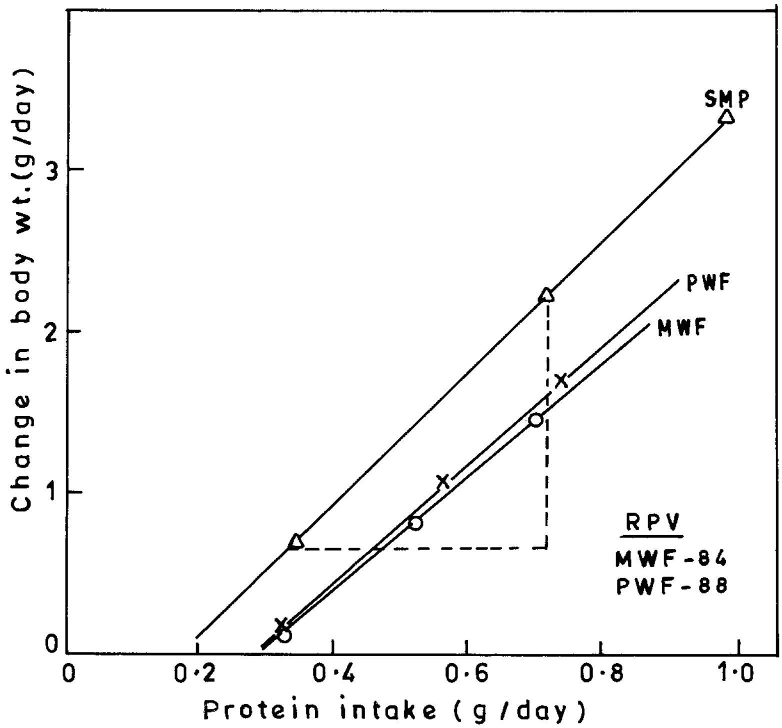

Figure 1. Relative protein value of malted weaning food (MWF) and proprietary weaning food (PWF) as compared with skim milk powder taken as 100.

enhanced its PER to 2.7. A similar observation was also made by Chandrasekhara et al. who reported that incorporation of 10% milk solids to a food formulation based on sorghum malt and low fat peanut flour increased its PER from 1.2 to 1.5 [3].

The salient features of the NPU determinations are presented in Table 4. The NPU values for MWF, PWF and SMP diets were 51.6, 62.0 and 83.4,

Table 5. Biological value and true digestibility of MWF

Diets	Nitrogen intake (mg/d/rat)	Nitrogen excreted (mg/d/rat)		Nitrogen balance	Nitrogen retention (%)	BV	TD
		Faecal	Urinary				
MWF	168.5	36.9	48.2	83.4	48.6	73.8	82.8(1)
PWF	181.8	34.5	44.5	102.5	56.1	79.2	79.2(2)
SMF	239.3	28.4	39.5	166.6	69.4	85.0	91.9(3)
SEM						± 1.9	± 1.8 (14df)

Test of significance: BV. 1,2 3 TD. 1,2 3
Any two means not underscored by the same line are significantly different ($P < 0.05$) according to Duncan's new multiple range test

respectively. As was observed in the PER experiment, the NPU of MWF supplemented with 10% SMP was also significantly higher than that of the plain MWF.

The results of the nitrogen balance studies are summarised in Table 5. The protein digestibility of MWF was slightly higher than that of PWF, although the difference was not significant. The biological value of MWF proteins was slightly lower than that of PWF proteins. However, this difference also was not significant. Under the experimental conditions, the BV values for MWF, PWF and SMP diets were 73.8, 79.2 and 85.0 respectively, while the corresponding TD values were 82.8, 79.2 and 91.9, respectively.

The results of the RPV experiment are presented in Figure 1. At 5% protein level, the diets of both weaning foods were just able to maintain the body weight of rats [17]; whereas the rats gained body weights with superior response at 8 and 11% protein levels. The RPV for MWF and PWF were 84 and 88, respectively as compared with the value for SMP diet taken as 100.

The present studies indicate that the nutritional quality of mixed proteins of malted ragi and malted green gram were nutritionally comparable with that of a proprietary weaning food. The MWF supplemented with 10% skim milk solids had protein quality superior to that of the proprietary weaning food.

Acknowledgement

The authors thank Mr D. Narayanaswamy and Mr A. Sattar for technical assistance, and Ms Indira A.S. Murti and Mr B.S. Ramesh for statistical analysis of the data.

References

1. Barton-Wright EC (1952) The microbiological assay of amino acids. In: The microbiological assay of the vitamin B-complex and amino acids. London: Sir Issac Pitmen and Sons, pp 116–154
2. Carpenter KJ (1970) The estimation of available lysine in protein concentrates. Biochem J 77:604–610
3. Chandrasekhara MR, Swaminathan M, Sankaran AN, Subrahmanyan V (1957) Studies on nutritive value of balanced malt foods. Indian J Physiol *all* Sci 11:27–41
4. Chandrasekhara MR, Krishnaiah MM, Chandrasekhar HN, Shurpalekar SR (1957) Preparative trials on roller-dried weaning foods. J Food Sci Technol 4:115–119
5. Chapman DG, Castillo R, Campbell JA (1959) Evaluation of protein in foods. I. A method for the determination of the protein efficiency ratio. Can J Biochem Physiol 37:679–686
6. Desikachar HSR (1979) Weaning food formulations with low hot paste viscosity suitable for home/village level application. In: Proc Symp Food Needs of Infants and Pre-School Children. AFST Madras (India), pp. 54–61
7. Eggum BO (1973) A study of certain factors influencing protein utilization in rats and pigs. Copenhagen Beretn. 406 National Institute of Animal Science
8. Gopaldas T, Inamdar F, Patel J (1982) Malted versus toasted young child mixes: viscosity, storage and acceptability trials. Indian J Nutr Dietet 19:329–336
9. Hegsted DM, Chang Y (1965) Protein utilization in growing rats. I. Relative growth index as a bioassay procedure. J Nutr 85:159–168
10. Hubbell RB, Mendel LB, Wakeman AJ (1937) A new salt-mixture for use in experimental diets. J Nutr 14:273–285

11. ISI Guidelines No. 7481 (1974) Methods for determination of protein efficiency ratio. New Delhi: Indian Standards Institution
12. Ljungguist BG, Mellander O, Svanberg U (1981) Dietary bulk as a limiting factor for nutrient intake in pre-school children. I. A problem description. J Trop Pediatr 27:68–73
13. Malleshi NG, Desikachar HSR (1981) Studies on the suitability of roller flour mill, hammer mill and plate grinder for obtaining a refined flour from malted ragi (*Eleusine coracana*) J Food Sci Technol 18:37–39
14. Malleshi NG, Desikachar HSR (1982) Formulation of a weaning food with low hot-paste viscosity based on malted ragi (*Eleusine coracana*) and green gram (*Phaseolus radiatus*). J Food Sci Technol 19:193–197
15. Miller DS, Bender AE (1955) The determination of net utilization of proteins by a shortened method. Brit J Nutr 9:382–388
16. Pellett PL, Young VR (1980) Some rat and human bioassay procedures. In: Nutritional Evaluation of Protein Foods. Tokyo: United Nations University, pp 103–110
17. Steinke FH (1977) Protein efficiency ratio, pitfalls and causes of variability – a review. Cereal Chem 54:549–554
18. Swaminathan M (1970) Protein requirements – A critical evaluation of the FAO/WHO expert group recommendations. Nutr Rep Int 2:153–171
19. Venkat Rao S, Vijayalakshmi D, Kurien S, Prasannappa G, Chandrasekhar HN, Swaminathan M, Chandrasekhara MR (1976) Nutritive value of weaning foods and malted milk powder. J Food Sci Technol 13:209–213