Effects of Lysine on Dough and Protein Quality of Whole Wheat Meal Chapatis and Leavened Bread

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The farinograph water absorption dough development time and stability were unaffected by L-lysine monohydrochloride (LMH) at levels of 0.1–0.4% in whole wheat meal (atta). The loss of lysine in chapatis of fortified whole wheat meal (0.15% LMH) was negligible compared with a loss of 12.5% in the case of fortified whole wheat meal yeast bread (0.20% LMH) as determined by a microbiological assay. Tests with 21-day-old weanling male albino rats of Wistar strain showed that the protein efficiency ratios of fortified chapatis and of bread (2.04 and 2.21) were significantly higher than those of similar products (1.48 and 1.36) prepared from unfortified whole wheat meal. The PER losses were negligible.

Bulk of wheat in developing countries is used as wheat meal called atta, which usually represents 95–100% extraction. The atta is consumed chiefly in the form of unleavened pan cakes commonly referred to as chapatis. Potentialities of whole wheat meal yeast bread in these countries appear to be considerable.

The effect of lysine fortification of flour on dough properties has been studied by Akutsu (1968). Variable losses of lysine during baking have been reported by several workers, including McDermott and Pace (1957), Jansen *et al.* (1964), Jansen and Ehle (1965), and Maleki and Djazayeri (1968). The literature regarding improvement of quality of protein of white bread has been referred to by Bains *et al.* (1969). Fortification of whole wheat meal or atta of 100% extraction with lysine in the context of traditional method of utilization of wheat in developing countries, *e.g.*, as unleavened bread (chapatis) and as leavened bread made from it has not received similar attention. The purpose of this investigation was to find out the effects of lysine on the dough properties of whole wheat meal and losses in baking in relation to the quality of protein in chapatis and yeast bread.

EXPERIMENTAL

The whole wheat meal for unleavened pan cakes, *viz.*, chapatis, was prepared by grinding cleaned commercial wheat in a power driven disc mill. No bran was removed and so the meal represented 100% extraction.

For yeast bread, wheat was milled on the Buhler pneumatic mill, the bran was ground fine separately in a hammer mill and, together with shorts, was incorporated with the fines to obtain 100% extraction.

The wheat meals for chapatis and yeast bread were fortified at levels of 0.15 and 0.2% L-lysine monohydrochloride (LMH), respectively.

Dough Properties. A Brabender farinograph assembled with the 50-g mixing bowl and set at maximum sensitivity was used to evaluate whole wheat meal dough properties, as influenced by lysine fortification (0.1–0.4% LMH). Samples weighing 50 g on 14% moisture basis were mixed to a dough consistency centered around the 500 line.

Preparation of Chapatis. The dough was prepared in the Hobart mixer using 80 parts water per 100 parts of the atta. The chapatis were baked on a hot plate adjusted at 400° F (Hot Point National Sanitation Foundation Testing Laboratory) from 50-g dough pieces rolled out to a diameter of approximately 11 cm. The chapatis were turned on the hot plate intermittently for about 2 min followed by puffing carefully on a gas flame without charring.

The chapatis were cut into small pieces for drying in trays in a current of hot air (45–50° C), and ground to a fine powder in a hammer mill.

Preparation of Leavened Bread. The formula for yeast bread consisted of 5 kg of whole wheat meal atta, 100 g of salt, 100 g of active dry yeast (ADY) reconstituted with water at 40° C, 25 g of glycerol monostearate (GMS) emulsion, 50 g of fat, 35.5 g of nondiastatic malt syrup, 25 g of caramel, 15 g of full fat soya fluor prepared from dehulled raw beans, 100 ml of 0.25% potassium bromate solution, and 3125 ml of water cooled to 4° C. The ingredients were mixed in the Tweedy 10 mixer for 3.5 min. One-kilogram lots of dough were molded manually, proofed for 50 min in the Bailey Fermentation Cabinet, and baked at 450° F for 30 min in an experimental rotary oven.

The loaves were sliced, dried, and powdered as in the case of chapatis.

Animal Experiments. The experimental diets for assessment of protein quality of whole wheat meal products as influenced by lysine fortification and baking were prepared from the following.

A. Chapati series
1. Whole wheat meal
2. Chapatis (of whole wheat meal)
3. Whole wheat meal + 0.15% LMH
4. Chapatis (of whole wheat meal + 0.15% LMH)
5. Chapatis (of whole wheat meal) + 0.15% LMH

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B. Leavened bread series
1. Whole wheat meal + 2% inactivated dry yeast + 0.3% soya flour
2. Bread (of whole wheat meal + 2% ADY + 0.3% soya flour)
3. Whole wheat meal + 2% inactivated dry yeast + 0.3% soya flour + 0.2% LMH
4. Bread (of whole wheat meal + 0.2% LMH + 2% ADY + 0.3% soya flour)
5. Bread (of whole wheat meal + 2% ADY + 0.3% soya flour) + 0.2% LMH

Each diet contained calculated amounts of baked or unbaked wheat ingredients as listed in A and B series, respectively, to provide about 10% protein when mixed with arachis oil 10, salt mixture 2, vitaminized starch 2, shark liver oil 0.5 parts, and starch as balance to make 100 parts. Bulk diets were prepared by mixing the ingredients homogeneously in the Hobart mixer followed by sifting. The moisture and protein contents of diets ranged from 8.4–9.2%, and 9.94–10.20%, respectively. The diets were adequate with regard to the vitamins (Chapman *et al.*, 1959) and mineral (Hubbel *et al.*, 1937) requirements of the growing animals.

Protein Efficiency Ratio (PER) Determination. The protein efficiency ratios of each series were determined separately according to the Rat Growth method described by Campbell (1961). Twenty-one-day-old weanling male albino rats of Wistar strain were randomized into five groups of ten rats each on the basis of litter mates and initial weights. The animals were housed in individual cages with wire mesh bottoms and fed *ab libitum* with weighed aliquots of test diets each made into thick slurry with warm water for a period of 4 weeks. The diet residue of each rat was collected daily. The weekly gain in weight and diet consumption was recorded. The PER was calculated from: increase in weight 4 weeks (g)/total protein (g) eaten; the PER data have been examined statistically for significance.

Analytical. The samples of wheat, chapatis, and yeast bread of fortified and unfortified whole wheat meals were analyzed for moisture and protein ($N \times 5.7$) contents according to the methods of the American Association of Cereal Chemists (1962). Lysine was determined microbiologically using *Leuconostoc mesenteroides* P.60 as described by Tara *et al.* (1969).

RESULTS AND DISCUSSION

Effect of Lysine Fortification on Dough Properties. The farinograph curve characteristics of the doughs of fortified and unfortified whole wheat meal were almost similar when 0.1–0.4% of LMH was added to the meals. The water absorption dough development time and stability of dough of the fortified meals resembled those of control (Figure 1).

Effect of Baking on Lysine Content of Chapatis and Yeast Bread. From the lysine contents of fortified and unfortified chapatis in Table I, it is seen that the losses caused by baking on a hot plate, which is comparable to the traditional system of baking, were negligible. The loss of lysine in fortified yeast leavened loaves was 12.5% compared with 5.5% of the unfortified loaf. The chapatis are baked for a much shorter period of time, approximately 2 min, compared with 30 min for the leavened bread. A negligible loss of lysine in chapatis of 93% extraction wheat meal has been reported by Matthews *et al.* (1969), using ion exchange chromatographic method of lysine estimation.

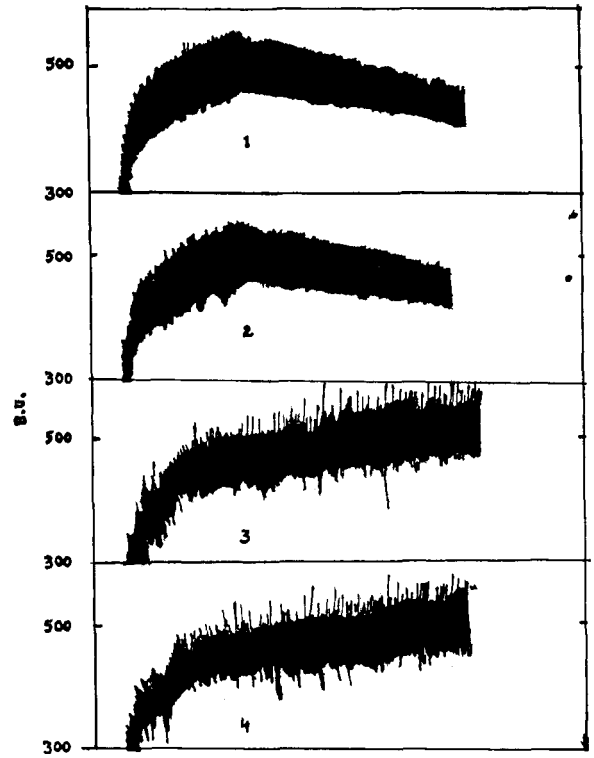

Figure 1. Effect of lysine on the farinograms of whole wheat atta. Curves 1 and 3 of a soft and a high protein wheat atta without lysine; 2 and 4 each with 0.3% LMH, respectively

Table I. Effect of Baking on the Lysine Content of Chapatis and Yeast Bread of Fortified and Unfortified Whole Wheat Meal

Description	Lysine, g/100 g protein	Loss, %
A. Chapati series		
1. Whole wheat meal	3.03	
2. Whole wheat meal + 0.15% LMH	3.95	
3. Chapatis (of whole wheat meal)	2.98	
4. Chapatis (of whole wheat meal + 0.15% LMH)	3.79	4.5
B. Bread series		
1. Whole wheat meal	2.79	
2. Whole wheat meal + 2% inactivated dry yeast[a] + 0.3% soya flour	2.88	
3. Whole wheat meal + 0.2% LMH + 2% inactivated dry yeast[a] + 0.3% soya flour	4.07	
4. Bread (of whole wheat meal + 2% ADY + 0.3% soya flour)	2.72	5.5
5. Bread (of whole wheat meal + 0.2% LMH + 2% ADY + 0.3% soya flour)	3.56	12.5

[a] Inactivated by steaming.

Effect of Lysine Fortification of Whole Wheat Meal on PER. A. CHAPATIS. The PER of fortified chapatis was significantly higher than that of the unfortified chapatis. There was an increase of 38% in the PER value of fortified chapatis. Differences in the PER of chapatis and of unbaked ingredients were almost negligible and statistically nonsignificant. Unfortified chapatis on supplementation with 0.15% LMH showed a PER (2.13) which was comparable with that of the fortified chapatis (2.04). This confirmed that the loss of

Table II. Effect of Baking on the PER of Lysine-Fortified and Unfortified Whole Wheat Meal Chapatis and Yeast Bread

Diet no.	Source of protein	LMH added, %	Mean initial body weight, g	Mean increase in body weight (4 weeks), g	Mean food intake,[a] (4 weeks), g	Mean protein intake (4 weeks), g	PER
A. Chapati series							
1.	Whole wheat meal	0.00	36.2	35.8	203.7	22.6	1.58
2.	Chapatis (of whole wheat meal)	0.00	36.2	35.3	213.8	23.7	1.48
3.	Whole wheat meal + LMH	0.15	36.2	58.5	242.8	26.9	2.17
4.	Chapatis (of whole wheat meal + LMH)	0.15	36.1	58.4	258.0	28.6	2.04
5.	Chapatis (of whole wheat meal) + LMH	0.15	36.1	60.1	254.6	28.2	2.13
							(C.D)[b] 0.23
B. Bread series							
1.	Whole wheat meal + 2% inactivated dry yeast + 0.3% soya flour	0.00	32.8	32.6	184.2	20.3	1.61
2.	Bread (of whole wheat meal + 2% ADY + 0.3% soya flour)	0.00	32.7	29.3	195.3	21.5	1.36
3.	Whole wheat meal + LMH + 2% inactivated dry yeast + 0.3% soya flour	0.20	32.7	58.6	230.2	25.7	2.28
4.	Bread (of whole wheat meal + LMH + 2% ADY + 0.3% soya flour)	0.20	32.7	59.9	247.4	27.1	2.21
5.	Bread (of whole wheat meal + 2% ADY + 0.3% soya flour) + LMH	0.20	32.7	65.4	252.5	27.9	2.34
							(C.D)[b] 0.28

[a] Dry basis. [b] (C.D) = critical difference at 1% level of significance.

lysine in baking was negligible, as had also been shown by the microbiological analyses. The groups of animals fed lysine-fortified diets registered considerably more food consumption and correspondingly higher gains in weight than the controls.

B. Leavened Bread. The PER of fortified bread was significantly higher than the PER of unfortified bread. There was an increase of about 60% in the PER of fortified bread, compared with the PER of unfortified bread. Loss of 12.5% occurred in lysine content determined by a microbiological assay due to baking, but its effect on PER of bread was negligible. The PER of unfortified bread, when supplemented with 0.2% LMH, was 2.34 compared with 2.21 of fortified bread. Increases in weight and amounts of food consumed by groups on lysine-fortified bread and wheat meal were higher than the corresponding values of control groups fed diets containing unfortified bread or the unbaked ingredients. An increase of 40% in PER of lysine-fortified whole wheat bread prepared by the straight dough method has been reported previously by Sabiston and Kennedy (1957). The baking loss of lysine reported by them was 16%.

From the foregoing discussion of results (Table II), it is observed that whole wheat meal supplemented with a small amount of lysine, *viz.*, 0.15 and 0.2% LMH, brought about a significant improvement of the quality of protein of chapatis and yeast bread, respectively. The differences between the PER's of fortified bread or chapati diets and unfortified bread or chapati diets with lysine addition were also negligible. The slightly higher reduction of lysine in yeast bread than in chapatis may be ascribed to the longer time necessary for proper baking, but negligible PER losses were found in rat feeding tests.

McDermott and Pace (1957) found practically no loss of lysine in a typical white bread. Ericson *et al.* (1961) reported a loss of 5–10% lysine in white bread, estimated microbiologically. Maleki and Djazayeri (1968) obtained a significant increase of the PER of Arabic bread of 68% extraction flour on supplementation with lysine.

Summarizing, the results indicate possibilities of improving qualitatively the protein resources of developing countries accustomed to whole wheat products as staple food by fortification with the limiting amino acid lysine.

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Received for review February 18, 1971. Accepted June 16, 1971. The investigation formed part of National Institute of Health (USA), Indian Council of Medical Research and Central Food Technological Research Institute research program for the improvement of cereal products.