Changes in Physical and Sensory Characteristics of Doughs and of Bread Containing Various Amounts of Fish Protein Concentrate and Lysine[1]

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ABSTRACT

A study was made of the physical and sensory characteristics of bread fortified with various amounts of either fish protein concentrate (FPC) or lysine. Doughs were prepared from mixtures containing wheat flour and 0, 5, 10, 15, 20, and 25% FPC or 0.2, 0.4, 0.6, 0.8, and 1.0% lysine. Standard methods were used to evaluate the rheology of doughs and characteristics of bread. When 20% or less FPC was added to wheat flour, more water was absorbed by the dough than without FPC. FPC increased farinograph development time and stability and in the extensigraph test, it caused a decrease in extensibility and an increase in resistance to extension. Fortification of wheat flour with various amounts of lysine did not change the characteristics of dough appreciably. Addition of FPC decreased the volume of loaves, and the crumb became darker, coarser, and more compact. Addition of lysine to bread had little effect on either loaf volume or appearance. Judges accepted the texture and flavor of bread with 5 or 10% FPC about as well as that with no FPC. Bread containing higher amounts of FPC was less acceptable. Acceptability studies revealed no appreciable differences between breads containing various amounts of lysine.

Bread plays a significant role in the diet of a large portion of the world's population, especially for the people in the lower economic strata. The protein in wheat is low in nutritional quality, for it is deficient in certain amino acids, especially lysine. Its nutritional value can be improved by the addition of a protein supplement or of lysine. First, fish protein concentrate (FPC) contains protein of high quality and it could be used to increase the quality as well as the quantity of the protein in the bread (1). Lysine improves the quality of the protein. Second, bread fortified with FPC contributes significantly to the dietary intake of animal protein. This is especially important in countries where the source of animal protein is quite limited.

Information on the rheology of doughs and baking characteristics of bread that contain FPC or lysine is limited; therefore, this study was undertaken to determine the dough and baking characteristics of wheat flour mixtures containing various percentages of FPC or of L-lysine hydrochloride and to evaluate the acceptability of the fortified breads.

MATERIALS AND METHODS

FPC used in this study was made by the extraction of red hake (*Urophycis chuss*) with isopropyl alcohol (2).

Two lots of hard spring wheat, short patent flour which was bromated and

[1]Presented in part at the 52nd Annual Meeting, Los Angeles, Calif., April 1967. Contribution from the Bureau of Commercial Fisheries, National Center for Fish Protein Concentrate, College Park, Md. 20740.

bleached, but not enriched[2], were obtained from a local baker's supply dealer. Table I shows the proximate composition of the FPC and the wheat flour that were used in this study.

The flour and FPC or lysine mixtures were made by replacing 5, 10, 15, 20, and 25% of the flour with FPC or 0.2, 0.4, 0.6, 0.8, and 1.0% of the flour with lysine. These mixtures were used to study the rheology of doughs, to study baking quality, and to prepare the bread for sensory evaluations.

The procedures described in Sections 54-21 and 54-10 of AACC Approved Methods (3) were used to evaluate the characteristics of the doughs. Water absorption and mixing characteristics of flour-water doughs were determined with a farinograph; extensibility and resistance to extension of the doughs were measured by the extensigraph.

Table II shows the baking formula that was used to prepare the bread from the various mixtures. The bread doughs were mixed according to the straight-dough method in a large Hobart mixer. The dough was proofed in an incubator at 85°F., punched down twice, scaled 600 g. per loaf, proofed for 50 min., and baked at 375°F. for 1 hr.

TABLE I. PROXIMATE COMPOSITION OF WHEAT FLOUR AND OF FPC USED IN THE STUDY

Ingredients	Crude Protein (N X 6.25) %	Moisture %	Fat (Ether Extract) %	Ash %
Fish protein concentrate	85.0	5.1	0.2	13.1
Wheat flour (A)	14.2	13.1	0.1	0.4
Wheat flour (B)	13.7	13.8	0.8	0.4

TABLE II. FORMULATION FOR THE PREPARATION OF BREAD

Ingredients	Formulation g.	g. % of flour
Flour	2,500[a]	2,500[a]
Sugar	75	3.0
Yeast	40	1.6
Salt	25	1.0
Fat (hydrogenated)	50	2.0
Water	1,500[b]	60.0

[a]Percentages of 5, 10, 15, 20, and 25 of FPC and 0.2, 0.4, 0.6, 0.8, and 1.0 of L-lysine hydrochloride were added to the flour at the expense of the flour used in the formula.

[b]Amount of water used varied with the amount of FPC in the mixture from 60.0 to 76.6%.

[2]Product of the Peavey Company, Minneapolis, Minn. The use of trade names is merely to facilitate description. No endorsement is implied.

To determine the loaf volume, 200 g. of flour from each mixture was made into two pup-loaves. The formula shown in Table II was used to prepare these loaves by the procedure described in section 10-10 of AACC Approved Methods (3).

The sensory evaluation was based on a 5-point hedonic scale (5, preferred much more than standard; 3, equal to standard; 1, much less than standard) as described by Peryam and Pilgrim (4). Forty judges were used in the sensory evaluation. To measure their acuity, a duplicate of the standard (bread with no FPC or lysine) was included among the experimental samples. During evaluation of flavor and texture, the judges were blindfolded to eliminate the influence of any difference in the color of the samples. The samples were presented to the judges in random order. The test was primarily a preference test, and the judges determined whether they liked the experimental samples better than, less than, or equally as well as the standard.

The appearance of the samples was evaluated by the judges from a display where they were able to compare the bread containing either FPC or lysine with the standard white bread made from 100% wheat flour.

RESULTS AND DISCUSSION

Rheological Properties

Table III lists the results of the farinograph studies on flour mixtures containing various amounts of FPC. The amount of water (absorption) required to center the farinogram curve on the 500 B.U. (Brabender Units) line increased steadily with each increment of FPC from 59% for 0% FPC to 70.2% for 20% FPC. Less water, 68%, was needed for the 25% FPC mixture.

Mixing characteristics were markedly changed by the replacement of 5% of the flour with FPC. Peak dough development time became longer and stability increased as indicated by an increase in the interval between "arrival time" and "departure time" and also by a decrease in "tolerance index" and "20 minute drop" values. These effects were more pronounced and appeared to have reached a maximum at 10% FPC incorporation. Changes in farinograph curve characteristics are illustrated in Fig. 1.

Table IV shows the farinograph characteristics of the doughs containing lysine.

The addition of L-lysine hydrochloride also caused changes in farinogram characteristics. Absorption decreased with increasing levels of lysine from 58% for

TABLE III. FARINOGRAPH CHARACTERISTICS OF DOUGHS MADE FROM MIXTURES OF WHEAT FLOUR WITH VARIOUS PERCENTAGES OF FPC

Characteristics	Units	FPC 0 %	5 %	10 %	15 %	20 %	25 %
Absorption	%	59.0	61.0	63.6	67.6	70.2	68.0
Arrival time	min.	1.2	2.0	2.2	4.2	4.0	4.0
Stability	min.	10.8	17.2	18.2	16.8	18.0	44.0
Peak time	min.	5.5	8.5	10.2	10.0	10.0	7.0
Tolerance index	B.U.[a]	30.0	20.0	20.0	20.0	0.0	20.0
20-min. drop	B.U.[a]	70.0	50.0	50.0	30.0	0.0	0.0

[a]Brabender units.

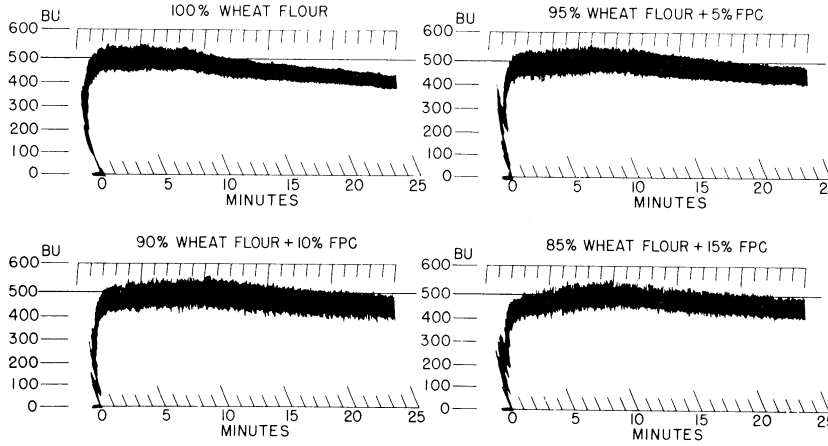

Fig. 1. Farinogram curves of flour mixtures containing various amounts of FPC.

TABLE IV. FARINOGRAPH CHARACTERISTICS OF DOUGHS MADE FROM MIXTURES OF WHEAT FLOUR CONTAINING VARIOUS PERCENTAGES OF L-LYSINE HYDROCHLORIDE

Characteristics	Units	L-Lysine Hydrochloride 0 %	0.2 %	0.4 %	0.6 %	0.8 %	1.0 %
Absorption	%	58.0	57.0	56.6	56.2	55.6	54.4
Arrival time	min.	2.8	3.0	2.8	3.5	4.2	4.0
Stability	min.	13.0	12.2	12.8	14.2	13.0	18.0
Peak time	min.	6.5	7.5	7.5	8.0	9.2	10.0
Tolerance index	B.U. [a]	30.0	30.0	30.0	20.0	40.0	0.0
20-min. drop	B.U. [a]	50.0	40.0	40.0	0.0	40.0	0.0

[a]Brabender units.

the flour with no added lysine to 54.4% for the flour mixture with 1% added lysine. Increasing levels of lysine caused an increase in dough development time although stability showed little change.

Table V shows extensigraph results for doughs containing FPC. Incorporation of increasing levels of FPC caused a decrease in extensibility and increased the resistance against deformation, as measured by curve height. As a consequence, the ratio of extension:resistance-to-extension decreased and the extensigraph curves were very poorly balanced at the high levels of FPC addition. These changes were quite small with 5% FPC addition, but were much more marked at higher levels.

Curve area, an indication of the amount of energy needed to bring about a break in the dough along a predetermined path, decreased for the 45-min. curves with increasing FPC incorporation. For the 180-min. curves, area increased for the 5% FPC level and decreased steadily with each higher level of FPC.

Baking Tests

The loaf volume of the bread containing various amounts of FPC decreased with

TABLE V. EXTENSOGRAPH PROPERTIES OF DOUGHS MADE FROM MIXTURES OF WHEAT FLOUR CONTAINING VARIOUS PERCENTAGES OF FPC AFTER 45- AND 180-MIN. REST PERIODS

FPC	Total Extension		Maximum Resistance		Area under Curve		Extension:Resistance	
	45 min.	180 min.	45 min.	180 min.	45 min.	180 min.	45 min.	180 min.
%	mm.	mm.	B.U.[a]	B.U.[a]	sq.cm.	sq.cm.		
0	185	150	460	580	116	104	.402	.258
5	178	148	480	660	114	125	.370	.224
10	102	130	530	700	103	116	.192	.186
15	105	118	520	740	73	113	.202	.159
20	98	95	515	680	72	91	.090	.139
25	68	68	850	880	82	78	.080	.077

[a]Brabender units.

TABLE VI. LOAF VOLUME AND PERCENT CHANGE OF BREAD MADE FROM FLOUR MIXTURES CONTAINING VARIOUS AMOUNTS OF FPC AND L-LYSINE HYDROCHLORIDE

FPC	Loaf Volume		L-Lysine HCl	Loaf Volume	
%	ml.	%	%	ml.	%
0	800	100	0	800	100
5	705	88	0.2	817	102
10	635	79	0.4	744	93
15	560	70	0.6	739	92
20	540	68	0.8	766	96
25	515	64	1.0	755	94

each increment of FPC from 12% at the 5% FPC level to 36% at the 25% FPC level (Table VI). These changes paralleled the marked decrease in the extensibility:resistance ratio observed in the extensigraph tests. The loss of volume in our studies was somewhat greater than the loss reported by the South African investigators (5) who used a 90% extracted flour and calcium acetate in a formulation similar to that which we used. They obtained a decrease in loaf volume from 3 to 5% at the 5% level and from 8 to 18% at the 10% level. The variability in the percent loss was not owing entirely to the addition of the FPC but to the baking quality of the original wheat flour. The loaf volume of the bread containing various amounts of lysine did not differ markedly from that obtained for the bread with no lysine.

Although at the 5 and 10% levels of FPC the crumb grain was a little more regular than in the bread with no FPC (Fig. 2), the crumb cell walls became thicker and coarser and the crumb structure became more compact with increasing levels of FPC. With different amounts of lysine, the texture of the bread did not change.

The results of the rheological studies and of the baking tests showed that only small changes occurred in the final product when 5% of the flour was replaced with FPC. Marked changes occurred when higher levels of FPC were used.

According to Pomeranz et al. (6), some of the degradation in loaf volume and crumb grain can be overcome by the inclusion of a glycolipid in the formulation. These investigators found that the use of a glycolipid in place of 3% shortening in

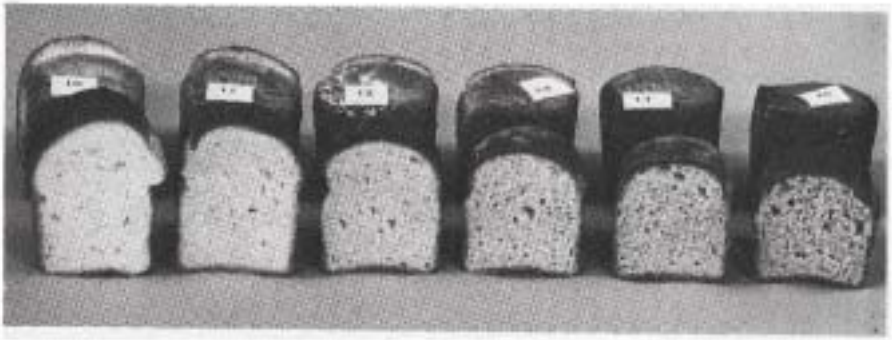

Fig. 2. Texture of bread made from mixtures of wheat flour and various amounts of FPC (0, 5, 10, 15, 20, and 25%).

the formulation improved the loaf volume and crumb grain of the bread that contained 8% defatted fish meal.

Acceptability

Appearance. With each increment of FPC in the formulation, the bread crumb became darker. The judges accepted the appearance of the bread crumb grain containing 5% FPC nearly as well as the standard with no FPC (Table VII). The appearance of the bread containing 10, 15, 20, or 25% FPC was less acceptable to the judges.

The judges found no significant difference in the appearance of the bread crumb grain containing various amounts of lysine.

Texture. In this investigation, texture referred primarily to mouth-feel and chewiness. Because the judges were blindfolded, they could not evaluate the texture visually. No significant differences were found between the bread with no FPC, and the ones with 5 or 10% FPC. The texture of bread containing higher levels of FPC was less acceptable.

The judges found the texture of the bread containing 0.2 and 0.4% lysine

TABLE VII. ACCEPTABILITY OF CRUMB FROM BREAD SUPPLEMENTED WITH VARIOUS PERCENTAGES OF EITHER FPC OR L-LYSINE HYDROCHLORIDE

FPC %	Appearance	Texture	Flavor	L-Lysine HCl %	Appearance	Texture	Flavor
0	3.3±0.12[a]	3.0±0.08[a]	3.1±0.06[a]	0	3.0±0.11[a]	3.0±0.14[a]	3.0±0.08[a]
5	3.0±0.16	2.8±0.13	2.8±0.19	0.2	2.8±0.10	2.6±0.12	2.8±0.09
10	2.8±0.14*	2.6±0.16	2.8±0.14	0.4	2.8±0.12	2.6±0.09	2.8±0.09
15	2.6±0.16*	2.0±0.16*	2.1±0.25*	0.6	3.2±0.12	3.0±0.10	2.8±0.10
20	2.3±0.17*	2.4±0.18*	2.4±0.12*	0.8	2.9±0.10	2.8±0.11	2.9±0.11
25	1.8±0.13*	1.5±0.15*	1.4±0.12*	1.0	3.0±0.14	2.8±0.09	2.7±0.11
*Tukey's W P < .05	0.4	0.5	0.6		0.4	0.4	0.3

[a]Standard error of mean.

differed slightly from the texture of the standard. The bread with the higher levels of lysine was comparable to the bread with no lysine. This difference may have been an experimental artifact.

Flavor. As the level of FPC increased, the typical flavor associated with bread decreased. The judges accepted the flavor of bread with 5 or 10% FPC, however, as well as they did that of the bread with no FPC, but they did not accept the flavor of the bread with 15, 20, or 25% FPC.

Some judges were able to depict a slight difference in the flavor of the bread containing the highest level of lysine. They often described the off-flavor as burnt, flat, tasteless, or sweet.

The results of the sensory evaluation may well be quite different for the bread fortified with FPC, if it had been evaluated by people who live outside of the U.S. In many foreign countries the bread often has a coarse and compact crumb structure. Also, it is not as white as the bread usually eaten in America.

In conclusion, the results of this study strongly indicate that 5% FPC can be used in bread without causing significant changes in the product. Changes in the formulation or processing would have to be made to compensate for the changes in the bread structure when higher levels of FPC are added to a standard formulation. According to the nutritional investigations conducted by Stillings et al. (1), however, replacement of 5 or 10% of the flour with FPC produces a marked increase in the nutritive quality of the fortified bread.

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[Received September 15, 1969. Accepted June 11, 1970]