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Supplementation of Arabic and Indian Breads with Fish Protein Concentrate

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The utilization of different kinds of fish protein concentrates (FPC) in the supplementation of Arabic bread and Indian bread (puri) was studied. Taste panel tests showed that the supplemented breads were well accepted when 10% of bread flour was replaced by FPC. Such a supplementation with the best test FPC used elevated the protein efficiency ratio of the bread to equal that of casein. It was demonstrated that extremely high dry heat (650 °C) required for the Arabic bread or cooking in oil (190 °C) for puri did little to decrease the protein value of FPC when the heating time was about 1 min. Significant differences in nutritional value were observed between the different kinds of FPC used.

Bread, in all its various forms, is eaten in most countries and the quantitative consumption of bread is not easily surpassed by any other single food product. This is the reason why bread has been the main food item in several studies involving the improvement of the nutritional status of many people.

So far studies have been carried out where bread has been enriched with amino acids, especially lysine, oilseed protein concentrates, and fish protein concentrates. The so-called "modern bread" in India is an example of good commercial success of lysine-enriched products (Altschul, 1969). Both Stillings et al. (1971) and Hegsted (1968) gave similar reports that 0.4% lysine added to wheat flour results in the same nutritional protein value as wheat flour with 5% fish protein concentrate (FPC). Enrichment of 1 kg of wheat flour at these levels costs 0.8 cent using lysine and 2.5 cents using FPC (Beigler, 1969). However, Stillings et al. (1971) in a comparative study between FPC and lysine supplemented breads reported that maximum responses of weight gain, protein efficiency ratio (PER), and net protein utilization (NPU) obtained with FPC were greater than those obtained with lysine.

Among plant protein concentrates soy protein has been the most widely used, giving the best results. However, in comparative studies, the biological value of soy protein concentrates has been found to be inferior to FPC (Pond et al., 1971).

Several baking studies with FPC have been reported in the literature. Generally, flour samples with FPC levels of 3–9% have given acceptable results depending on the experimental product and on the quality of FPC used. In the U.S. the Bureau of Commercial Fisheries (now the National Marine Fisheries Service) had initiated several food experiments with FPC as reported by Sidwell et al. (1970) and Kwee et al. (1969). In bread the color was found to be affected by the kind of fish used for FPC. Incorporation of FPC into bread also decreased the loaf volume.

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The main objective in the present study was to incorporate FPC in breads widely eaten in some malnourished areas. The Arab countries, with a population close to 250 million, derive 60–70% of the daily protein intake from grains (Abbott, 1969). One of the most important foods is the Arabic bread, commonly used in all Arab lands. The average daily bread consumption is 5 to 12 loaves, each weighing approximately 100 g. This bread has some very interesting characteristics. It is made of yeast leavened dough and baked in an extremely hot oven, 500–600 °C, for approximately 1 min. During baking the bread puffs up leaving a hollow pocket inside. During cooling the bread flattens out, but the bottom and top crust remain separated from each other. In this study FPC was incorporated in the Arabic bread in order to study the effect of this protein supplement on the acceptability and nutritional quality of the bread. Dalby (1969) has reported on studies where different vegetable protein sources, such as chick peas, horse beans, and cottonseed flour, were incorporated in Arabic bread. Only the acceptability of the bread was tested. Hallab and Khatchadourian (1974) enhanced the nutritive value of Arabic bread by addition of chickpea flour and soybean flour.

In India, nearly 60% of the daily protein intake is derived from cereals, and the second largest protein source consists of legumes and nuts (West, 1969). The dietary food staples vary widely among the Indian people. Chapati, a type of unleavened bread, is mostly used in India; however, another bread called puri, generally prepared from whole wheat flour and cooked in oil, is also common in many parts of India. Puri was chosen in order to study the effect of cooking in oil on the nutritional value of FPC supplemented bread.

Since the quality of FPC varies depending on the raw materials and processing methods (Makdani et al., 1971), three different FPC's were selected in the present study.

MATERIALS AND METHODS

Materials. Three different FPC preparations were used. FPC I was purchased from the Alpine Marine Protein Industries, Inc., New Bedford, Mass., and was prepared from red hake by extraction with 1,2-dichloro-

Table I. Proximate Composition and Color of Fish Protein Concentrate

FPC	Crude protein[a] (N × 6.25), %	Lipid[a] (ether), %	Ash,[a] %	Moisture,[a] %	Color
I[b]	81.1	0.2	15.0	3.6	Beige
II[c]	90.7	0.3	8.1	3.3	Grey
III[d]	90.8	0.4	2.1	10.0	White

[a] AOAC, 1970. [b] Instant-Protein (trade name) prepared by Alpine Marine Protein Industries, Inc., New Bedford, Mass. [c] Prepared by Astra-Nutrition AB, Sweden. [d] Prepared in T. L. Meade's Laboratory, University of Rhode Island.

Table II. Basic Formulation for the Preparation of the Arabic Bread

All-purpose flour (Gold Medal)	1000 g[a]
Salt	15 g
Sugar	30 g
Yeast (fresh)	45 g
Water[b]	570 g

[a] Five and ten percent of FPC I and III were added to the flour. [b] More water was required for doughs containing FPC in order to obtain the same consistency as that of the basic dough.

Table III. Basic Formulation for the Preparation of Puri

Whole wheat flour	1000 g[a]
Salt	10 g
Corn oil	42 g
Water[b]	540 g

[a] Five and ten percent of FPC II and III were added to the flour. [b] The amount of water required increased when FPC was added as follows: for 5% FPC, 57% water; for 10% FPC, 60% water.

ethane (Levin, 1959). FPC II was donated by Astra-Nutrition and it was prepared from eviscerated herring by the 2-propanol extraction method. FPC III was prepared in Dr. T. L. Meade's laboratory using deboned cod which was passed through a three-stage countercurrent extraction with methanol. Proximate composition and color of the test FPC's are listed in Table I.

The formula used for the Arabic bread is given in Table II. The dough was prepared using the straight dough method. After rising, it was divided into 100-g portions, shaped into a ball, and allowed to rise for 0.5 h. Then the dough pieces were rolled into flat circles of 17-cm diameter and 1-cm thickness. Rolled breads were allowed to rise for 20 more min before baking. A 15-m long oven with a moving belt was used for baking. Temperature in the front part of the oven was 650 °C, 540 °C in the middle, and 510 °C at the end. The total baking time was 67 s. In order to obtain the same degree of development in all doughs, more water was needed for the doughs containing FPC. The required mixing time was also longer for the FPC doughs. In all other respects conditions under which the bread was made, proofed, and baked were the same.

The basic formula used for puri is given in Table III. The dough was prepared in a batch mixer. After all the flour was dampened the dough was mixed for 5 min at medium speed. Each 5% replacement of flour by FPC required an additional 1 min of mixing time to bring all the doughs to the same state. The dough was divided into 25-g portions, rolled flat, and cooked in 180 to 190 °C corn oil for 45 s.

Taste Panels. Thirteen Arab students comprised the taste panel for the Arabic bread and 14 Indian students evaluated the puri breads. The hedonic scale method (ASTM Special Technical Publication 434, 1968) consisting of nine alternatives from "like extremely" to "dislike extremely" was used to rate the samples.

Table IV. Basic Diet for the Estimation of Protein Efficiency Ratio

	%
Crude protein (N × 6.25)	10.0
Carbohydrates (corn starch,[a] dextrin,[a] glucose,[a] and sucrose in 1:1:1:1 ratio)	72.8
Lard	5.0
Corn oil	5.0
Cellulose, nonnutritive[b]	2.0
Mineral mix[c]	4.0
Vitamin mix[d]	1.2
	100.0

[a] Corn Products Co., Englewood Cliffs, N.J. [b] General Biochemicals, Laboratory Park, Chagrin Falls, Ohio. [c] Rogers-Harper salt mix (Rogers and Harper, 1965). [d] Campbell, 1963.

Table V. Proximate Composition of Protein Sources Used in the Rat Diets[c]

Protein source	Crude protein[a] (N × 6.25), %	Moisture,[a] %	Lipid[a] (ether), %
Arabic bread, standard	15.10 ± 0.82	4.44 ± 0.80	0.38 ± 0.11
Arabic bread, 10% FPC I[b]	21.84 ± 1.77	5.07 ± 0.91	0.22 ± 0.07
Arabic bread, 10% FPC III[b]	21.36 ± 1.63	5.81 ± 1.56	0.23 ± 0.10
Puri, standard	13.17 ± 0.92	4.08 ± 0.56	15.43 ± 1.08
Puri, 10% FPC II[b]	19.43 ± 1.13	3.92 ± 0.68	10.55 ± 1.92
Puri, 10% FPC III[b]	20.90 ± 1.82	3.55 ± 0.94	13.92 ± 0.96

[a] Air-dried basis, analysis performed according to AOAC (1970). [b] The amount of FPC used in the formulations was based on the percent of flour in the dough. [c] Mean ± standard deviation (five replicate runs).

Nutritional Evaluation. In order to study the nutritional quality of the breads, weanling 23-day-old, male Charles River Laboratories CD strain rats were used for the determination of protein efficiency ratio (PER). The animals were fed with an ANRC reference casein (Sheffield Chemical Co., Norwich, N.Y.) diet for 3 days, after which they were divided into groups of ten. The basic diet was a modification of AOAC (1970) reference PER diet and its composition is presented in Table IV.

For the preparation of rat diets, all breads were dried in an air oven at 40–45 °C for 24 h and ground. The proximate composition of these protein sources is given in Table V. The amounts of added carbohydrates in the diet mixtures varied depending on the protein source and were furnished by glucose, sucrose, dextrin, and corn starch in a 1:1:1:1 ratio. The additional corn oil was adjusted according to the amount already existing in puri breads. One group of rats received ANRC reference casein as a control diet and three others were fed FPC I, FPC II, and FPC III as protein sources.

The data from the taste panels and animal study were statistically analyzed according to a two-way analysis of variance computer program and the means were compared with the least significant difference at the 0.05 (95% confidence) level.

The experimental design in this study was not consistent for all experiments. The necessity of using a commercial

Table VI. Acceptability of Arabic Bread

Sample	Av scores[a]
Standard arabic bread	6.17 ± 0.46a[b]
5% FPC I, supplemented	6.13 ± 0.40a
10% FPC I, supplemented	5.61 ± 0.37a
Standard arabic bread	7.69 ± 0.24b[b]
5% FPC III, supplemented	7.46 ± 0.24b
10% FPC III, supplemented	7.15 ± 0.36b

[a] Mean ± standard error based on a nine-point hedonic scale. [b] A common roman letter following the number indicates no significant difference ($P < 0.05$).

Table VII. Acceptability of Puri

Sample	Av scores[a]
Standard puri bread	7.00 ± 0.26a[b]
5% FPC II, supplemented	6.50 ± 0.36ab
10% FPC II, supplemented	6.29 ± 0.37ab
5% FPC III, supplemented	6.79 ± 0.42a
10% FPC III, supplemented	6.36 ± 0.44ab

[a] Mean ± standard error based on a nine-point hedonic scale. [b] A common roman letter following the number indicates no significant difference ($P < 0.05$).

bakery for prolonged periods of time made it difficult to carry out the complete set of experiments that had been planned.

RESULTS AND DISCUSSION

Acceptability of the Arabic Bread. FPC supplementation of up to 10% of the flour did not alter the characteristics of the Arabic bread texture. When rolled out, FPC-containing breads were slightly more flexible than the standard breads. FPC I gave the breads a darker color; dark-colored bread, however, is typical in many Arab countries where whole wheat flour or less refined wheat flour is used. The difference in acceptability between 10 or 5% FPC-containing breads and the standard was not significant ($p < 0.05$). Both kinds of breads were well accepted as judged by the panel (Table VI).

Acceptability of Puri. Table VII shows the taste panel results on the acceptability of puri. There appears to be little difference in the scores. The samples with FPC II had a darker color due to the grey color of this FPC while FPC III, being white, did not alter the original color of puri. Fishy taste was not observed by any of the panelists. Furthermore, neither of these FPC's altered the important characteristics of puri, and puffing up in hot oil was similar to that of standard breads. The results showed that FPC could be successfully incorporated in puri and be accepted by the Indian panel.

Nutritional Evaluation of Fortified Breads. Weight gain, protein intake, and protein efficiency ratio in the rat feeding study are given in Table VIII.

The 10% FPC III supplemented Arabic bread diet produced a significantly larger weight gain than the casein diet or the FPC I supplemented Arabic bread diet. The weight gain on 10% FPC I supplemented diet was about three and a half times that with standard bread. When FPC III was used at the 10% level, the latter figure was doubled; the rats on this diet gained approximately seven times as much weight as those on the standard bread diet. The adjusted PER of the plain Arabic bread was 0.91. Supplementation of the bread with FPC at 10% of the flour gave a PER of 2.04 with FPC I, and a PER of 3.00 with FPC III. This PER value is equivalent to that of casein.

FPC which is extracted with 1,2-dichloroethane has been shown to be toxic to rats (Munro and Morrison, 1967). However, if this FPC was subsequently treated with methanol or ethanol the toxicity was eliminated (Munro and Morrison, 1967; Makdani et al., 1971). The FPC I used in the Arabic bread study did not inhibit rat growth and the PER found was 2.82 which was close to the value of 2.63 reported by Makdani et al. (1971) for the same FPC.

When puri was supplemented at the 10% level with FPC II or III, the diets produced greater weight gains than the casein diet (Table VIII). Puri bread supplemented at the 10% level with FPC II produced a weight gain that was about four times as great as that of the standard puri group. With the FPC III supplementation the weight gain was four and a half times that of the standard group. The PER of the standard puri diet approximately doubled when FPC II was incorporated at the 10% level. The rise was still higher when FPC III was used for supplementation.

The drastic heat treatment to which FPC-supplemented Arabic bread was subjected (650 °C for 1 min) apparently did not affect its nutritional value. Similarly, cooking in oil (190 °C) did not seem to affect the nutritional value of puri bread supplemented with FPC.

The feasible fortification level is affected by many factors of which the most important are acceptability, economics, and the improvement in total nutritional value of the fortified product. A consistent acceptable fortification level in this study was 5% and the 10% level was also fairly acceptable. Obviously the fortification at the 5% level is less costly than at higher levels. This level of supplementation already elevates the lysine content of the Arabic bread to the level of the FAO reference protein pattern and also the methionine content of the same bread is raised to about 85% of the FAO reference protein. If bread in Arab countries could be fortified with a 5% level of FPC and the daily bread consumption is assumed to be 500 g, then the daily protein intake from this source would rise from the average of 48 g to about 68 g of protein with high biological value. In the same manner, if we assume

Table VIII. Average Weight Gain, Protein Intake, and Protein Efficiency Ratio[a] in the Rat Feeding Study

Protein source	Wt gain, g/28 days	Protein intake, g/28 days	PER (true)	PER[b] (adjusted)
Casein	131.90 ± 7.82ab[c]	35.39 ± 1.74a	3.717 ± 0.069ai	3.00
FPC I	121.00 ± 8.58b	34.48 ± 2.15a	3.496 ± 0.062b	2.82
FPC II	157.60 ± 6.49c	40.20 ± 1.66b	3.923 ± 0.047a	3.17
FPC III	179.50 ± 5.80d	42.10 ± 1.12b	4.266 ± 0.050c	3.44
Arabic standard bread	22.60 ± 1.99e	19.82 ± 1.20c	1.127 ± 0.062d	0.91
+ 10% FPC I	79.40 ± 4.87f	31.26 ± 1.44a	2.529 ± 0.050e	2.04
+ 10% FPC III	155.40 ± 7.55c	41.69 ± 1.59b	3.716 ± 0.052ai	3.00
Puri standard bread	35.70 ± 3.68g	21.33 ± 1.22c	1.637 ± 0.080f	1.32
+ 10% FPC II	140.60 ± 6.70ac	42.12 ± 1.25b	3.324 ± 0.070g	2.68
+ 10% FPC III	158.70 ± 9.83c	43.34 ± 1.92b	3.636 ± 0.087h	2.93

[a] Mean ± standard error. [b] Adjusted according to the PER 3.00 of casein. [c] A common roman letter following the number indicates no significant difference ($P < 0.05$).

an average daily bread consumption in India of about 200 g, then at the 5% supplementation level with FPC this bread would give about 30 g of protein of high biological value. Consequently, not only is the quality improved but also the quantity of protein is increased.

In spite of the nutritional advantages that FPC has to offer, it should be stated that in regions where fish are abundant it would be more economical and practical for the people to consume the fish directly in the fresh or processed state. However, there are different marine species that cannot practically be used for direct human consumption. It is those species that man could utilize for the production of fish protein concentrate or fish meal. It would be illogical to convert most of the fish caught into some kind of fish protein concentrate if the same fish could be utilized in another less expensive and acceptable manner for direct human consumption, especially in regions where animal source proteins are needed most.

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Analysis of Leek Volatiles by Headspace Condensation

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The flavor complex of freshly harvested leek (*Allium porrum* L.) was studied by a combination of capillary gas chromatography and mass spectrometry. Headspace condensation is used for isolation of the volatile flavor components. Possibilities and difficulties of the new isolation technique are examined. Odor properties are evaluated by running aromagrams on a thermal conductivity detector. The described method is very mild and produces a high quality flavor extract. This extract is compared with the essential oil obtained by steam distillation of leek.

The consumer's choice of fruits and vegetables is generally determined by appearance attributes such as color, shape, size, and defects. Those external features are no guarantee for a good internal sensorial quality such as flavor and consistency which, from the consumer's point of view, are even more important. For those reasons the establishment of methods to judge organoleptic qualities of fruits and vegetables on an objective base is up to date.

Such methods can lead to interesting applications such as flavor quality labeling of foods, selection of varieties by cultivators, and determination of the optimal harvesting time in order to obtain an optimum flavor quality. Since taste can be judged only on a subjective basis it is obvious that analysis of the volatile aroma determining components provides a means for objective flavor quality control. Complex mixtures of organic substances can now be analyzed by high-resolution gas chromatography. The gas–liquid chromatographic (GLC) pattern of aroma concentrates can be correlated with flavor quality. Therefore, it is necessary to determine contributory flavor components in a preliminary fundamental flavor analysis. The isolation of an aroma concentrate is at least as important as the analysis itself. In flavor quality control it can be important to use a simple and quick isolation method for flavors on small food quantities for economical reasons. Flavor quality of the obtained concentrate should be very high with minimum changes in composition and

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