Quality and Nutritive Value of Pasta Made from Rice, Corn, Soya, and Tapioca Enriched with Fish Protein Concentrate[1]

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ABSTRACT

Fish protein concentrate (FPC) supplemented to flours of rice, corn, soya, and tapioca could contribute significantly to the protein intake of the population of developing countries. As pasta may well be considered a universal food, it was chosen as a carrier for FPC. Pasta were evaluated organoleptically and in animal feeding studies, and were also evaluated objectively. Both 10 and 20% FPC additions were efficient in increasing the protein content and nutritional value of pasta. From sensory and objective evaluations, rice pasta appeared to be the most acceptable. Of corn, soya, and tapioca pasta, tapioca seemed most promising for further investigation; it promoted a more attractive color and counteracted grittiness in the FPC, but its texture became too soft during cooking.

Fish protein concentrate (FPC) supplemented to flours of rice, corn, soya, and tapioca, which are widely used in Indonesia, could contribute significantly to the protein intake of the population,which now consumes approximately 5 g. of animal protein per capita per day.

Since pasta products appear frequently in the daily diet of poor as well as rich people of Indonesia, a means to incorporate FPC into such products could well remedy this dietary imbalance. The products were evaluated organoleptically for appearance, texture, and flavor and for nutritional value in animal feeding studies. They were also evaluated objectively for texture, proximate composition, and cooking properties.

MATERIALS AND METHODS

Four flours – rice, corn, soya, and tapioca, which are in common use in Indonesia – were used as basic ingredients in pasta samples. Other flours, such as peanut, sesame, phaseolus, and sweet potato, were added in small amounts to improve appearance, flavor, or texture of pasta samples. Semolina was used primarily as binding agent. The FPC was prepared from red hake according to the method described in Fishery Leaflet 584 (1).

Preliminary experiments were conducted to study the amount of water required for the pasta, amount of binding agent required, and resistance to breakage and disintegration during the drying and cooking process.

Samples formulated in the preliminary experiments were evaluated subjectively by taste panels, and 14 samples were selected for further studies (Fig. 1), coded according to the first letter of the main ingredient used, such as C for corn, etc. The numbers assigned next to these letters were randomly selected. These 14 samples were selected primarily on the basis of appearance. If no significant differences in appearance were observed, then selection was based on the highest appearance score and estimated cost of production.

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Pasta samples were prepared according to the batch technique described by Matz (2). A Parmigiana pasta machine was used, consisting of a kneader and an extruder; the kneader functions also as a mixer, and has a capacity of 4 kg. of wet pasta. The dough was extruded in the form of spaghetti 1/8 in. in diameter and 1.5 to 2.0 in. long. The pasta was dried in a vacuum oven for 12 hr. at 125° F.

Sensory Evaluations

To evaluate the acceptability of the product, sensory tests were conducted by the method described by Peryam and Pilgrim (3) for appearance, flavor, and texture. To obtain a common basis for comparison, two reference samples were used, one for each FPC level of treatment. Therefore, a mixture of 60% semolina, 30% all-purpose flour, and 10% FPC was used as reference in the samples containing 10% FPC, and a mixture of 60% semolina, 20% all-purpose flour, and 20% FPC for the 20% samples (Fig. 1). The reference samples, though higher in protein content, were comparable to commercial-type pasta in texture; some panel members indicated a slight grittiness in the 20% FPC reference samples. The slight tannish color and characteristic flavor were also more pronounced in these samples. However, both reference samples were acceptable.

Three different panels, 14 persons in each, participated in the sensory tests: 1) employees of the Embassy of Indonesia, Washington, D. C.; 2) employees of the U.S. Bureau of Commercial Fisheries, Technological Laboratory, College Park, Maryland; and 3) staff and graduate students of the Department of Horticulture, University of Maryland, College Park, Maryland.

Samples were cooked for 10 min. and then drained for 2 min. The drained pasta was poured into a chicken broth to which 0.2% salt was added, and brought to a boil.

Objective Quality Evaluations

Proximate analyses were conducted on both raw and cooked samples according to the AOAC method (4).

Cooking analyses of 1) percent of water absorption, 2) percent cooking loss, and 3) percent protein in the cooking loss as described by Holliger (5) were conducted.

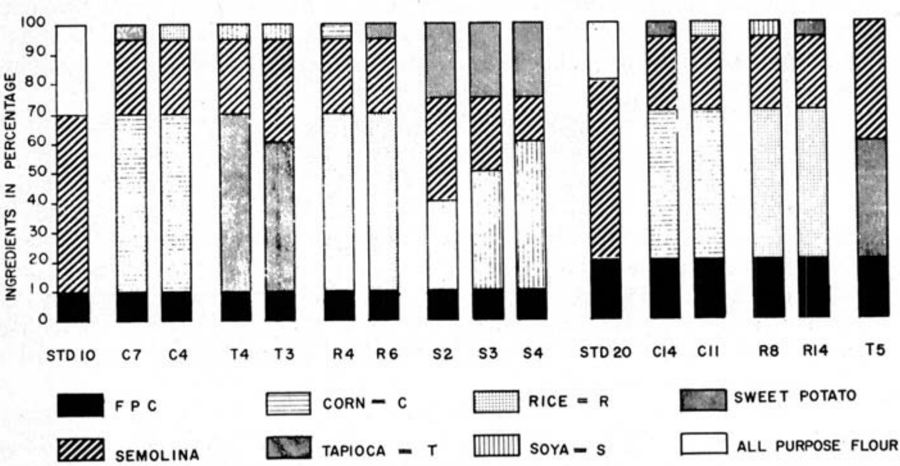

Fig. 1. Composition of pasta samples, in percent dry weight.

Texture of cooked pasta was measured on the Allo-Kramer shear press with standard cell and 5,000-lb. ring, using the 2% range. The pasta was cooked for different lengths of time, namely, 4, 8, 10, 12, 14, 16, and 20 min. The resulting curve was measured in sq. in. with a planimeter.

Nutritional Evaluations

Protein quality of samples was evaluated according to Campbell (6). The raw or cooked pasta was fed *ad lib.* to male albino weanling rats, randomly assigned to groups of 10 (Charles River CD strain, 23 days old, weighing 45-55 g.). The animals were housed individually in screen-bottomed cages kept in an air-conditioned room maintained at 74°-76°F. Control animals were fed a diet containing 10% protein from casein, and the nutritive value of the pasta was compared with the performance of these control animals.

The cooked pasta was boiled in a 0.2% salt solution and freeze-dried for 12 hr. at 125°F. The raw and the cooked pasta were both ground in a Wiley mill.

The basal diet as described by Campbell (6) consisted of:

	%
Fat	10
Vitamin mix	4
Mineral mix	4
Nonnutritive cellulose	5
Corn starch	77

Ground pasta, raw or cooked, was added to the basal diet at the 10% crude protein level at the sacrifice of corn starch. Weight gain and amount of food consumed for each individual rat were recorded at the end of each week during the 4-week experimental period.

RESULTS AND DISCUSSION

A highly significant interaction between treatment and panels was observed. In evaluating the 10% FPC samples, the Indonesians were critical of pale samples and more lenient toward slightly tannish ones. The American panel members seemed to be more interested in texture than in appearance, particularly degree of firmness. With the 20% FPC samples, all panel members were critical of both appearance and texture, although the Indonesians were less critical than the Americans regarding grittiness.

From the different flours used as basic ingredients, the rice pasta appeared to be the most acceptable in that all samples were liked as well as the standard.

R14 (60% rice, 10% sweet potato), in particular, was judged to be even better than the standard in all aspects of sensory evaluation. The other samples, containing corn, soya, and tapioca as basic ingredients, were judged as acceptable as the standard. Three proved to be exceptions: C4 (60% corn, 10% rice), S3 (35% soya, 25% tapioca), and T4 (60% tapioca, 10% soya); they were downgraded by the panels.

Although tapioca pasta was much softer than rice pasta, samples containing about 50% tapioca form a very acceptable product by promoting an attractive color and smoothing the grittiness of FPC.

From the different flours added in small amounts, such as sesame, peanut, phaseolus, and sweet potato, only sweet potato was found useful. It improved the appearance of the rice and corn pasta samples and appearance, texture, and flavor of the R14 sample.

Sweet potato flour, therefore, may contribute to greater acceptability of enriched pasta products. Further investigation is necessary, however, to reduce its leaching-out tendencies during the cooking process.

Objective Quality Evaluations

Proximate analyses indicated that the pasta containing 10 and 20% FPC were higher in protein content than commercial-type pasta (Table I). The protein content of rice pasta containing 10% FPC (16-17%) was about twice that of plain rice (7%), but 20% FPC did not increase the protein content proportionally. Further, the protein content of cooked pasta was slightly higher than that of raw. This is due to the different methods of drying applied: cooked pasta were freeze-dried and raw ones dried with hot air. It is also possible that leaching-out of carbohydrate in cooked pasta (Table II) causes a slight increase in protein content.

TABLE I. PROXIMATE COMPOSITION OF RAW AND COOKED PASTA (EXPRESSED ON WET BASIS)

	Protein (N x 6.25)		Moisture		Ash		Fat (Ether Extract)	
Mixture Code	Raw %	Cooked %	Raw %	Cooked %	Raw %	Cooked %	Raw %	Cooked %
10% FPC:								
R4	16.9	20.1	9.7	1.1	1.3	1.2	0.2	0.1
R6	16.1	19.9	12.3	0.7	1.2	1.0	0.3	1.8
C4	16.1	19.6	12.8	3.4	2.1	1.3	1.1	0.4
C7	15.6	22.4	15.1	2.2	2.3	1.3	0.9	0.6
S2	26.0	30.3	13.1	7.6	3.3	2.2	2.5	3.0
S3	30.0	36.4	9.0	1.0	4.1	2.7	4.4	4.3
S4	32.8	40.0	8.6	0.9	4.7	3.1	5.6	6.2
T3	16.3	21.6	17.0	2.6	2.6	1.9	1.2	1.4
T4	13.2	17.2	19.1	2.7	1.9	1.3	0.6	0.5
Std. 10	20.3	24.4	12.3	2.5	2.1	1.5	0.2	5.2
20% FPC:								
R8	25.5	31.6	13.6	4.1	2.9	2.0	0.6	0.6
R14	24.9	30.4	9.0	3.0	2.8	1.5	0.3	0.3
C11	23.1	30.0	18.3	3.0	2.3	1.5	0.5	0.3
C14	22.0	36.7	21.4	0.9	2.1	1.5	0.6	0.2
T5	21.4	25.6	10.1	0.8	2.5	1.9	0.2	1.3
Std. 20	28.3	32.0	10.7	3.9	2.9	2.0	0.2	2.0
Commercial-type pasta	12.5	...	10.0	...	0.7	...	1.2	...

Cooking analyses showed that percent water absorbed varied from 240 to 500%; R4 was significantly higher than the other 10% samples and R6 was lowest (Table II).

Cooking losses in 10% samples were significantly higher for R6, C7, and S4. C7 contained 10% sweet potato, which is quite water-soluble, and this factor may explain the high loss. The same evidence was noted in C14, which also contained sweet potato. Protein in cooking loss was significantly higher in S3 and S4 and also in R8 and R14 (Table II).

Cooking analyses indicated that the samples formulated were not inferior to commercial-type pasta. Water absorption was in the normal range as reported by Holliger (5). Cooking losses were also similar to the results obtained by Holliger (5) except for samples containing sweet potato. The percentage of protein in cooking loss was also very low in all formulated samples (Table II).

Figure 2 shows the change of shear press area in sq. in. after 4, 8, 10, 12, 14, 16, and 20 min. of cooking: the longer the samples were cooked, the smaller the area under the curve; the longer they were cooked, the softer they became. The curve also demonstrates that the more water the samples absorbed, the softer they became, such as standard 10, which absorbed more water than standard 20 and was also softer (Table II).

TABLE II. COOKING ANALYSES OF PASTA CONTAINING 10 OR 20% FPC

Mixture Code	Water Absorption[a] %	Cooking Losses[b] %	Protein in Cooking Loss %	Mixture Code	Water Absorption[a] %	Cooking Losses[b] %	Protein in Cooking Loss %
10%FPC				20%FPC			
R4	503*	9.5	1.01	R8	434	9.5	1.34*
R6	240*	12.8*	.98	R14	345	10.7	1.34*
C4	381	6.7*	1.10	C11	286	9.9	1.28
C7	346	13.3*	.78	C14	403	12.3*	1.17
S2	367	10.6	1.36	T5	317	9.1	1.16
S3	311	7.6	1.62*	Std.-20	292	8.7	1.19
S4	331	13.1*	1.77*				
T3	298	8.0	.75*				
T4	480	9.3	1.33				
Std.-10	371	8.0	.75*				
0.95 Fiducial interval	275-449	7.4-12.4	.86-1.42		132-460	5.5-11.7	1.20-1.28

[a]Determined at 10-20% moisture.
[b]Determined at approximately 1% moisture.

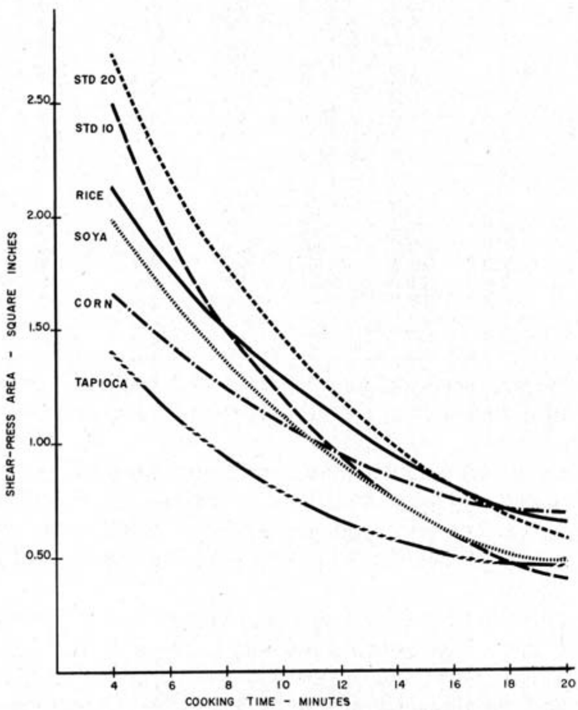

Fig. 2. Effect of cooking on texture of pasta samples.

Nutritional Evaluations

Average weight of experimental animals was in general greater than that of the control group fed casein, except for S4(Figs. 3 and 4). Protein efficiency ratio was computed for the 10 and 20% FPC samples (Table III).

TABLE III. PROTEIN EFFICIENCY RATIO VALUES FOR A SERIES OF FEEDING TRIALS ON TEN RATS, EACH DIET CONSISTING OF RAW OR COOKED PASTA CONTAINING 10 OR 20% FPC

	PER			PER	
Diet 10% FPC	Raw	Cooked	Diet 20% FPC	Raw	Cooked
Casein			Casein		
(control)	(3.69	0.102)	(control)	(3.69 ± 0.102)	
Std.-10	3.59± 0.074	3.29± 0.086*	Std.-20	4.17 ± 0.010*	3.80 ±0.182
C7	3.71± 0.105	3.61± 0.112	C14	3.97 ± 0.113	3.81 ±0.054
C4	3.69± 0.114	4.10± 0.139*	C11	4.19 ± 0.116	3.70 ±0.233
T4	3.71± 0.074	3.77± 0.091	R8	3.95 ± 0.124	3.98 ±0.098
T3	3.76± 0.147	3.47± 0.084	R14	4.17 ± 0.122*	3.96 ±0.071
R4	3.78± 0.047	3.86± 0.147	T5	4.15 ± 0.111*	4.05 ±0.114*
R6	4.30± 0.119*	4.10± 0.117*			
S2	3.51± 0.104	3.50± 0.099			
S3	3.40± 0.090	3.81± 0.098			
S4	3.16± 0.050*	3.10± 0.175*			
LSD = 0.37			0.31		

In most cases, weight gain of animals fed raw pasta was slightly higher than that of the group fed cooked pasta; however, a degree of the weight gain is due to higher food intake. Analysis of covariance (AOC) of 10% FPC samples showed some significant differences, but they were not more nutritious than casein;AOC of 20% FPC samples showed no significant differences; thus the high weight gain was due

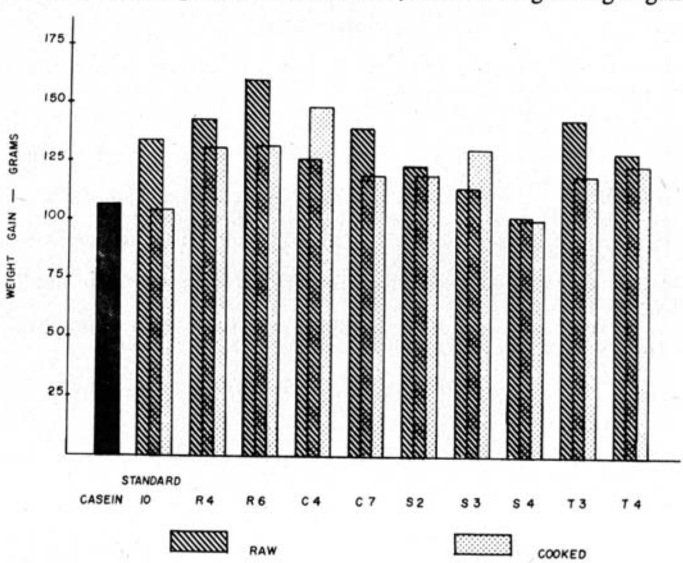

Fig. 3. Mean weight gain of male albino rats fed diets containing raw or cooked pasta made with 10% FPC, compared to casein. (Diets contained 10% crude protein.)

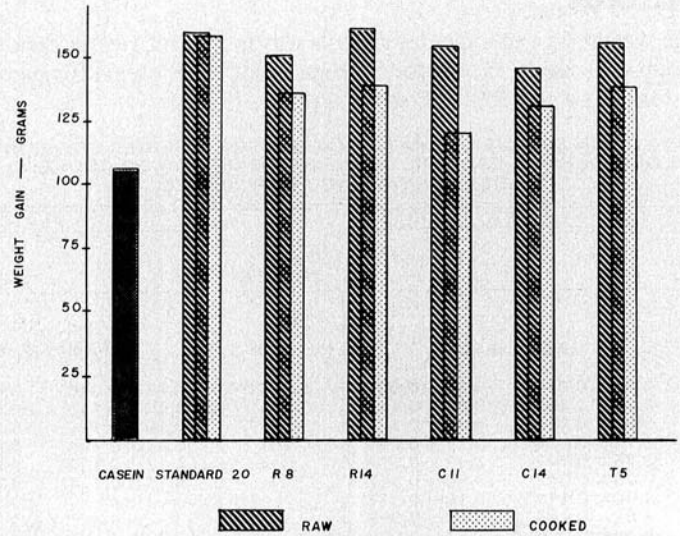

Fig. 4. Mean weight gain of male albino rats fed diets containing raw or cooked pasta made with 20% FPC, compared to casein. (Diets contained 10% crude protein.)

to food intake. Therefore, it can be concluded that the 10% as well as 20% FPC samples were as nutritious as casein in protein quality; in the latter case, however, the additional cost and the possibility of lessening acceptability of the product may not warrant addition of the extra 10% increment of FPC.

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