Fortification of Pasta with Pea Flour and Air-Classified Pea Protein Concentrate

M. A. NIELSEN, A. K. SUMNER, and L. L. WHALLEY,[1] College of Home Economics, University of Saskatchewan, Saskatoon, S7N 0W0

ABSTRACT

Cereal Chem. 57(3):203–206

Noodles and spaghetti were prepared from hard red spring wheat flour fortified with 33% pea flour or 20% air-clasified pea protein concentrate to increase the protein quantity and quality. Fortification increased the protein content up to 22.1% for noodles and 24.1% for spaghetti. Noodle dough handling characteristics deteriorated as the level of fortification increased. Addition of pea flour and protein concentrate reduced the cooking time for noodles, but cooking losses were greater. Sensory evaluation of the color, flavor, and texture of the more successful types of fortified pasta compared favorably with that of the 100% hard red spring wheat pasta. Pea products gave the pasta a yellow color that was generally considered desirable. Fortification with raw pea protein concentrate produced spaghetti that was most similar to durum spaghetti in textural quality, but its tolerance to overcooking and its flavor were inferior. Precooking the pea products improved the fortified spaghetti flavor score.

Field peas are an increasingly important high protein crop on the Canadian prairies. Processes have been developed to produce pea flour and air-classified pea protein concentrate (Vose et al 1976), for which new food uses are being investigated. One of the most promising areas for use of these pea products, especially for low income groups and developing countries, is in the production of protein-enriched pasta products.

Pasta products have been fortified with supplements from various high-protein sources to improve their nutritional properties. Noodles were produced from various flours fortified with fish protein concentrate (Kwee et al 1969, Woo and Erdman 1971). Soy flour was used to supplement protein in macaroni products (Paulsen 1961) and to produce a quick-cooking pasta product (Kinsley 1965). Rice noodles fortified with up to 30% soy flour were acceptable to Thai children (Siegel et al 1975). Processes for producing high-protein pasta containing wheat, corn, and soy flour (Scharschmidt and Aubel 1971) and wheat gluten, soy protein concentrate, milk, and milk products (D'Alessandro and D'Alessandro 1973) have been patented. Also, other high-protein sources such as cottonseed meal, egg albumin, and whey proteins as well as bean and yeast protein concentrates and soy isolate (Breen 1977, Hanna et al 1978) have been investigated for pasta production.

The object of this research was to evaluate the fortification of hard red spring wheat flour for the production of economical noodles and spaghetti with improved protein and nutritional qualities. Hard red spring wheat flour was selected instead of the customary durum semolina because the lower cost should make it more suitable for low income groups. The resulting products were compared to 100% hard red spring wheat pasta and to soy-fortified spaghetti on the basis of their chemical, physical, and sensory properties. Texture and overcooking properties of the fortified spaghetti were also compared to the 100% durum product.

MATERIALS AND METHODS

Flours and Concentrates

Pea products were prepared by the Prairie Regional Laboratory of the National Research Council. Whole, smooth seeded green peas (*Pisum sativum* L. var. Trapper) were ground in an Alpine pin mill to produce raw pea flour (RPF). Some of the flour was processed in an Alpine air-classifier to produce raw pea protein concentrate (RPPC) as described by Vose et al (1976). Cooked pea flour and protein concentrate (CPF, CPPC) were prepared from a 2:1 (w/w) water/flour or water/concentrate slurry that was drum dried and ground to pass 100 mesh.

Hard red spring wheat flours were used, top patent (HRS-1) for noodles and a straight grade flour (HRS-2) for spaghetti. Promosoy, a soy protein concentrate (SPC), was supplied by Central Soy, Chicago, IL for use in fortified spaghetti.

Composite flours were prepared by blending 67% wheat flour with 33% pea flour or 80% wheat flour with 20% protein concentrate to obtain blends of protein that were nutritionally optimum on the basis of their chemical scores.

Noodle and Spaghetti Production

Noodles were made by a manual sheeting process on a Rollecta home noodle machine from wheat flour and wheat-pea blends containing raw and cooked pea flours and concentrates. The flour was hand-mixed with a predetermined amount of water to form a stiff dough, which was covered and rested for 30 min to permit optimum moisture equilibrium and hydration. The dough was sheeted at least 10 times at increasingly reduced roll clearance settings until it was smooth and elastic. The final pass sheeted the dough to a thickness of 1.8 mm. The dough was then cut into noodles 2 mm wide and air-dried for 24 hr.

Spaghetti was processed by the Grains Research Laboratory from wheat-pea blends and, for comparison, from 100% HRS-2, a wheat-soy blend, and 100% durum semolina. A Demaco semicommercial scale laboratory extruder was used as described by Dexter and Matsuo (1977).

Analytical Methods

Moisture and protein analyses were performed, using approved AACC methods 44-15A and 46-13. Protein determinations were based on nitrogen factors of 5.7 for wheat and 6.25 for pea and soy flours and concentrates. Nitrogen factors for blends were weighted on the basis of the relative proportion of proteins in the ingredients. All analyses were carried out at least in duplicate. The chemical score for these products reflects their nutritional value and was calculated from published amino acid data (Anonymous 1973, Central Soy Chemurgy 1971, Tkachuk 1966) and the FAO reference protein (FAO/WHO 1973).

Cooking water absorption and cooking loss determinations were based on methods outlined by Paulsen (1961) and Holliger (1963). Optimum cooking time was determined by boiling 10 g of pasta in 300 ml of water on a Labconco crude fiber apparatus until the center white core just disappeared when a strand was squeezed between two glass plates. The cooked pasta was drained and weighed to detemine water absorption. Noodle cooking loss was determined by drying the cooked noodles for 4 hr in a 100°C air oven and weighing (Holliger 1963). Cooking loss was then calulated on a dry weight basis. Spaghetti cooking loss was determined by freeze-drying the solids extracted from the cooking water. Protein in the cooking loss was analyzed by AACC method 46-13.

Noodle texture was evaluated with the Food Technology Corp. model T-2100 Texturecorder, using the following conditions: 300-lb ring, ram speed 0.28 in./sec, and 100-lb pressure. A minimum of

[1]Present address: Kamloops, B.C.

0009-0352/80/03020304/$03.00/0

TABLE I
Protein and Cooking Quality of Noodles

Noodles[a]	Protein[b] (%)	Chemical Score	Cooking Time (min)	Cooking Water Absorption[b] (%)	Cooking Loss[b] (%)
100% HRS-1	13.5	39	11	225 a[c]	3.3 c
33% RPF/67% HRS-1	16.9	81	7	220 a	5.9 b
33% CPF/67% HRS-1	16.9	81	6	217 a	9.3 a
20% CPPC/80% HRS-1	22.1	91	8	206 a	5.7 b

[a]HRS-1 = top patent hard red spring wheat flour, RPF = raw pea flour, CPF = cooked pea flour, CPPC = cooked pea protein concentrate.
[b]Dry basis.
[c]Numbers with different letters are significantly different ($P < 0.01$).

TABLE II
Instrumental Texture and Sensory Evaluation of Noodles

Noodles[a]	Texturecorder Maximum Force, lb Raw	Texturecorder Maximum Force, lb Cooked	Sensory Preference Test[b] Color	Sensory Preference Test[b] Flavor	Sensory Preference Test[b] Texture
100% HRS-1	9.7 a[c]	22.8 a	2.5 b	2.3 a	3.1 ab
33% RPF/67% HRS-1	6.0 b	23.8 a	3.9 a	3.1 a	3.6 a
33% CPF/67% HRS-1	6.2 b	22.0 a	3.4 ab	3.1 a	3.5 ab
20% CPPC/80% HRS-1	5.3 b	22.1 a	2.1 b	2.8 a	2.6 b

[a]HRS-1 = top patent hard red spring wheat flour, RPF = raw pea flour, CPF = cooked pea flour, CPPC = cooked pea protein concentrate.
[b]1 = dislike extremely, 5 = like extremely.
[c]Numbers with different letters are significantly different ($P < 0.01$).

four replications was made. For raw pasta, 10 2-in lengths were centered on the single blade cell platform perpendicular to the blade slot. Cooked pasta texture was measured in the Texturecorder multi-blade shear compression cell. Ten grams of dry pasta was cooked the optimum time and drained, and all of the sample was added to cell.

Spaghetti texture tests for tenderness index, compressibility, and recovery were conducted by the Grains Research Laboratory on spaghetti cooked the optimum time and spaghetti overcooked 10 min (Matsuo and Irvine 1969, 1971).

Spaghetti color was measured by AACC method 14-22, using a Hunterlab model D-25 color and color difference meter.

Sensory Evaluation

A 16-member untrained panel evaluated noodles for color, flavor, and texture preferences. Panelists were asked to indicate preference on a five-point hedonic scale and also to rank the noodles in order of overall preference.

The sensory properties of spaghetti were measured using Larmond and Voisey's method (1973). An untrained panel of 14 members evaluated flavor, chewiness, adhesiveness, and gumminess on a five point hedonic scale and firmness on an eight-point scale.

Analysis of variance and Duncan's multiple range test for differences were applied to sensory responses for both noodles and spaghetti (Larmond 1970).

RESULTS AND DISCUSSION

Noodles

Noodles fortified with RPF, CPF, and CPPC contained up to 22.1% protein compared to 13.5% in the all-wheat (HRS-1) control noodles; chemical scores increased from 39 up to 91 (Table I). This fortification increased dough water absorption from 40% for HRS-1 up to 65% for CPPC and caused stickiness and deterioration in dough handling properties. Dough containing RPPC was too sticky to sheet satisfactorily and was excluded from further trials. Cooking the pea products before blending reduced stickiness and eliminated most of the objectionable pea odor that arose during dough development.

Fortified noodles cooked in a shorter time than did 100% wheat noodles. The optimum cooking time was reduced from 11 min for 100% wheat noodles to 6–8 min for the blends. A similar reduction in cooking time was reported for soy blends (Scharschmidt and Aubel 1971, D'Alessandro and D'Alessandro 1973).

Cooking water absorption was slightly lower for the fortified noodles (Table I), but cooking loss was significantly higher ($P < 0.01$), especially for noodles containing CPF with its pregelatinized pea starch.

Table II shows the results of instrumental texture and sensory evaluation of noodles. Fortification decreased raw noodle strength significantly ($P < 0.01$) as measured by the Texturecorder but caused essentially no difference in cooked strength. The taste panel significantly ($P < 0.01$) preferred the yellow color of noodles containing RPF but showed little flavor preference for the fortified noodles over the HRS-1 noodles. The objectionable raw pea odor detected in noodle dough containing raw pea products was not detected in the cooked noodles, which indicated that it was largely removed during processing and cooking. The panelists ranked RPF noodles highest in overall preference followed by CPF, HRS-1, and CPPC, respectively.

Spaghetti

Raw spaghetti fortified with pea products contained up to 24.1% protein compared to 15.2% for HRS-2 and 27.3% for soy-fortified spaghetti (Table III). Chemical scores improved from 39 to as much as 90. Dough water absorption was 30% for the various types of spaghetti except for those containing RPPC and CPPC, which decreased to 24%. Durum semolina was processed at 32% water absorption. No major difficulties were encountered in processing the pea-fortified products. The variation in water absorption and dough stickiness for comparable noodle and spaghetti blends was probably due to the different effects of manually mixing and sheeting the noodle dough and mechanically mixing the spaghetti dough.

Cooking quality of pea-fortified spaghetti compared favorably with that of the soy-fortified product and was similar to results reported by Kwee (1969), Paulsen (1961), and Holliger (1963) for various types of fortified pasta. Spaghetti cooking time of 12 min was unaffected by fortification. Cooking water absorption was significantly lower ($P < 0.05$) in CPPC and SPC spaghetti than in the other samples, possibly due to a higher proportion of denatured protein caused by prior heat treatment. Fortification increased cooking losses from 8.3% in the control to as high as 16.5% for the CPF spaghetti. Both CPF and CPPC spaghetti were especially vulnerable to cooking loss, probably because pregelatinization increased starch solubility. Cooking losses were higher for spaghetti than for noodles, possibly due to more rigorous processing conditions and different analytical methods. Protein in the cooking loss solids was lower than in the original raw spaghetti, causing a small increase in the percent protein in cooked spaghetti.

Fortification of HRS-2 flour with pea products improved the textural characteristics of spaghetti cooked for the optimum time (Table IV). In all cases the tenderness index was reduced. Both RPF and RPPC improved the compressibility and recovery of the fortified spaghetti compared to that of the 100% HRS-2 control and other samples of fortified spaghetti. The RPPC spaghetti was the most similar to durum spaghetti in textural and cooking qualities but was more vulnerable to overcooking.

Taste panel evaluations of sensory characteristics are shown in Table IV. The RPPC spaghetti, which had the lowest tenderness index, was judged by the panel to be significantly firmer ($P < 0.01$)

TABLE III
Protein and Cooking Quality of Spaghetti

Spaghetti[a]	Protein (%)[b] Raw	Protein (%)[b] Cooked	Chemical Score	Cooking Water Absorption[b] (%)	Cooking Loss (%)	Protein in Cooking Loss[b] (%)
100% HRS-2	15.2	15.9	39	189 a[c]	8.3 c	6.6 e
33% RPF/67% HRS-2	19.2	20.7	85	183 a	9.9 bc	8.4 d
33% CPF/67% HRS-2	18.2	21.4	84	181 a	16.5 a	14.7 a
20% RPPC/80% HRS-2	22.4	24.1	85	185 a	9.3 bc	7.8 f
20% CPPC/80% HRS-2	24.1	25.4	86	170 b	12.7 ab	11.2 b
20% SPC/80% HRS-2	27.3	29.5	90	164 b	11.0 bc	9.7 c

[a] HRS-2 = straight grade hard red spring wheat flour, RPF = raw pea flour, CPF = cooked pea flour, RPPC = raw pea protein concentrate, CPPC = cooked pea protein concentrate, SPC = soy protein concentrate.
[b] Dry basis.
[c] Numbers with different letters are significantly different ($P < 0.05$).

TABLE IV
Instrumental Texture and Sensory Evaluation of Spaghetti

Spaghetti[a]	GRL Tenderness Tester[b] TI ($mm/sec \times 10^3$)	C (%)	R (%)	Sensory Evaluation Firmness[c]	Flavor[d]
100% HRS-2	61	100	0	4.3 b[e]	3.4 a
33% RPF/67% HRS-2	35 (55)	49 (100)	64 (0)	5.1 ab	1.9 c
33% CPF/67% HRS-2	37	100	0	4.5 ab	2.8 abc
20% RPPC/80% HRS-2	29 (44)	38 (57)	72 (48)	5.5 a	1.9 c
20% CPPC/80% HRS-2	39	100	0	4.9 ab	2.9 ab
20% SPC/80% HRS-2	41	100	0	4.6 ab	2.3 bc
100% Durum	28 (33)	68 (70)	42 (49)	...	...

[a] HRS-2 = straight grade hard red spring wheat, RPF = raw pea flour, CPF = cooked pea flour, RPPC = raw pea protein concentrate, CPPC = cooked pea protein concentrate, SPC = soy protein concentrate.
[b] TI = tenderness index, C = compressibility, R = recovery, ( ) = overcooked 10 min.
[c] 1 = very soft, 8 = very firm.
[d] 1 = poor, 5 = excellent.
[e] Numbers with different letters are statistically different ($P < 0.01$).

TABLE V
Hunterlab L and b Values for Raw and Cooked Spaghetti

Spaghetti[a]	Hunterlab L[b] Raw	Hunterlab L[b] Cooked	Hunterlab b[c] Raw	Hunterlab b[c] Cooked
100% HRS-2	48.6	63.3	15.3	5.3
33% RPF/67% HRS-2	45.8	62.5	19.0	10.8
33% CPF/67% HRS-2	43.7	62.4	19.1	9.9
20% RPPC/80% HRS-2	41.4	63.7	19.8	13.3
20% CPPC/80% HRS-2	47.0	60.4	19.6	11.8
20% SPC/80% HRS-2	47.9	62.4	17.4	7.8

[a] HRS-2 = straight grade hard red spring wheat flour, RPF = raw pea flour, CPF = cooked pea flour, RPPC = raw pea protein concentrate, CPPC = cooked pea protein concentrate, SPC = soy protein concentrate.
[b] Black = 0, white = 100.
[c] + yellow, − blue.

than the 100% HRS-2 spaghetti. Precooking pea products improved the flavor of the resulting spaghetti. Both CPF and CPPC were judged to have flavor qualities which were similar to HRS-2 spaghetti, but RPF and RPPC were given a significantly poor flavor rating ($P < 0.01$). Chewiness, adhesiveness, and gumminess of fortified spaghetti were found to be similar to the HRS-2 control.

Results for raw and cooked spaghetti color measurements are provided in Table V. Only two parameters, L (black 0, white 100) and b (+ yellow, − blue) are reported; the a parameter (+ red, − green) showed little change. Pea-fortified spaghetti was yellower than HRS-2 and SPC spaghetti. Cooking bleached all samples, resulting in increased whiteness and decreased yellowness.

CONCLUSIONS

Pea flour and protein concentrate offer alternatives to soy products for fortification of pasta used as high protein specialty food and as nutritious staple food for low income and developing areas. Fortification with pea products generally improves the quality of pasta from HRS wheat. It reduces cooking time, but cooking losses are higher. Increasing the pea protein content reduces raw noodle strength and tends to decrease cooking water absorption slightly. Precooking the pea products decreases noodle dough stickiness and improves noodle flavor, but it increases the cooking loss and causes deterioration of fortified spaghetti's cooked texture. Pea flour produces the most acceptable fortified noodles on the basis of color, flavor, and cooked texture. RPPC added to HRS wheat flour yields the best fortified spaghetti except for the flavor.

ACKNOWLEDGMENTS

Financial support was supplied by the Saskatchewan Research Council and the Canada Agriculture New Crop Development Fund. Expert technical assistance was provided by the Prairie Regional Laboratory; National Research Council, Saskatoon; and the Canadian Grain Commission, Grain Research Laboratory, Winnipeg.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1976. Approved Methods of the AACC. Method 44-15A, approved October 1975; Methods 46-13 and 14-22, approved October 1976. The Association: St. Paul, MN.

ANONYMOUS. 1973. PFPS Bulletin No. 1. Prairie Regional Laboratory, National Research Council and College of Home Economics, University of Saskatchewan: Saskatoon.

CENTRAL SOY CHEMBURGY. 1971. Promosoy 20/60—Soya Protein Concentrate. Technical Service Bulletin. Chicago: IL.

BREEN, M. D. 1977. Use of various protein sources in pasta. Macaroni J. 58(9):26.

D'ALESSANDRO, S., and D'ALESSANDRO, P. 1973. Hyperproteinic

(dietetic) edible "pasta" possessing high biological value and markedly organoleptic qualities. Canadian patent 931,810, Aug. 14.
DEXTER, J. E., and MATSUO, R. R. 1977. Changes in semolina proteins during spaghetti processing. Cereal Chem. 54:882.
FAO/WHO. 1973. Tech. Report Series No. 522. Expert Committee on Energy and Protein Requirements. World Health Org.: Geneva, Switzerland.
HANNA, M. A., SATTERLEE, L. D., and THAYER, K. W. 1978. Sensory and selected textural properties of pasta fortified with plant proteins and whey. J. Food Sci. 43:231.
HOLLIGER, A. 1963. Improved method for testing macaroni products. Cereal Chem. 40:231.
KINSLEY, S. F. 1965. Process for producing a quick-cooking pasta-type product. U.S. patent 3,192,049, June 29.
KWEE, W. H., SIDWELL, V. D., WILEY, R. C., and HAMMERLE, O. A. 1969. Quality and nutritive value of pasta made from rice, corn, soya and tapioca enriched with fish protein concentrate. Cereal Chem. 46:78.
LARMOND, E. 1970. Methods for Sensory Evaluation of Food. Canada Dept. Agric. Publ. No. 1284.
LARMOND, E., and VOISEY, P. W. 1973. Evaluation of spaghetti quality by a laboratory panel. Can. Inst. Food Sci. Technol. J. 6:209.
MATSUO, R. R., and IRVINE, G. N. 1969. Spaghetti tenderness testing apparatus. Cereal Chem. 46:1.
MATSUO, R. R., and IRVINE, G. N. 1971. Note on an improved apparatus for testing spaghetti tenderness. Cereal Chem. 48:554.
PAULSEN, T. M. 1961. A study of macaroni products containing soy flour. Food Technol. 15:118.
SCHARSCHMIDT, R. K., and AUBEL, L. F. 1971. High protein alimentary pasta products. U.S. patent 3,615,677, Oct. 26.
SIEGEL, A., BHUMIRATANA, A., and LINEBACK, D. R. 1975. Development, acceptability and nutritional evaluation of high-protein soy-supplemented rice noodles for Thai children. Cereal Chem. 52:801.
TKACHUK, R. 1966. Amino acid composition of wheat flours. Cereal Chem. 43:207.
VOSE, J. R., BASTERRECHEA, M.J., GORIN, P. A. J., FINLAYSON, A. J., and YOUNGS, C. G. 1976. Air classification of field peas and horsebean flours: Chemical studies of starch and protein fractions. Cereal Chem. 53:928.
WOO, H. C., and ERDMAN, A. M. 1971. Fish protein concentrate enrichment of noodles. J. Home Econ. 63:263.

[Received March 20, 1979. Accepted September 14, 1979]