Effects of Legume Fortifiers on the Quality of Udon Noodles[1]

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ABSTRACT

The influence of several legume fortifiers on the quality characteristics of udon, a Japanese noodle, was investigated. Wheat flour was blended with 5, 10, and 20% of several commercially and experimentally prepared legume flours. The commercial flours were raw and cooked yellow pea and defatted soybean. Whole yellow peas, green peas, soybeans, and navy beans were experimentally prepared by steam cooking for 1 and 5 min, air-dried, and ground before being used to supplement wheat flour at the 10% level. Germinated soybean flours (cooked and uncooked) were also incorporated into wheat flour at the 10% level. Udon was prepared from these blends. Texture and yield of udon were only slightly affected by the presence of a fortifier. The overall quality of the fortified noodles decreased with increasing levels of fortifier compared with that of the control noodle made with all-wheat flour. Cooking the legume fortifiers for as little as 1 min improved the taste and color of the noodles but had no effect on texture. The taste was dramatically improved by removal of the grassy flavor. Longer cooking time used in the commercially prepared pea flour was detrimental to udon color, indicative of inactivation of lipoxygenase. Noodles prepared with germinated and ungerminated soybean flours were similar. Generally, results indicate that for good quality udon, the level of legume flour supplementation should be no higher than 5–10%, depending on the individual legume.

Composite flours to improve protein content and nutritive quality of bread have received great emphasis. Generally, composite flours are wheat flours fortified with high-protein nonwheat flours such as those made from legume seeds. Because the literature on composite flours and protein supplementation is so extensive, a complete review is not included in this report.

Soy flour and several other legume flours are effective fortifiers of wheat flour products not only because of their high protein contents but also because they contain more lysine than wheat flour does. Researchers studying flours from soybeans (Kim and de Ruiter 1968, Tsen 1971, Finney and Shogren 1971, Marnett et al 1973, Fellers et al 1976), faba beans (McConnell et al 1974), pinto beans, navy beans, mung beans, and lentils (D'Appolonia 1977), mung beans (Thompson 1977), peanut protein concentrate (Khan et al 1975), cowpea powder (Okaka and Potter 1977), four concentrated plant proteins—soybeans, sunflower, faba bean, and field pea—(Fleming and Sosulski 1977), and raw and cooked yellow pea flours (Jeffers et al 1978) have found that with increased levels of legume additives in breads, loaf volume and crumb grain quality deteriorated. Generally, wheat flour containing 10–15% legume flour can be used to make acceptable fortified bread.

Many other cereal-based products besides bread might also be fortified with legume flour to increase nutritive value. In Japan, soft wheat flour consumption in noodles, confectionary products, and family flours is estimated to be about 23, 13, and 4%, respectively, of the total flour consumption (Nagao et al 1976). Soft and medium white wheats (Western White, Australian Standard White) and domestic Japanese wheats are used for the Japanese type of noodle (Nagao et al 1977a). Noodle quality is related directly to the protein content of the wheat and the most preferred level for the Japanese type of noodle is around 10% (Nagao et al 1977b). Eating quality is the primary criterion for acceptance of Japanese noodles can be classified as very thin (somen), thin (hiyamugi), standard (udon), and wide (himokawa) noodles. The numerous variations in each classification reflect locality, manufacturing methods, and differences in tastes (Nagao et al 1976). Generally, softness, tenderness, and some feeling of elasticity during mastication are highly desirable.

Studies on fortification of udon, a Japanese wet noodle, are limited. Kaneko (1966) mentioned the addition of soy protein to noodles but said that the practice has been limited because of the high cost and an off-flavor in the product. Denaturation of soy

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protein during processing was reduced by the use of a low-temperature oil-extraction method, which increased the retention of water-soluble proteins. Soy protein so obtained becomes cohesive after absorbing water and has a good binding capacity in food systems. Addition of 5% soy protein to the noodles improves the texture without adversely affecting color and flavor.

Murayama (1974) found that addition of 2% vital gluten improved the machinability of the noodle dough, increased the elasticity of the noodles, which were of good texture, and increased the yield of the boiled noodles. However, it also increased the loss of solubles to the boiling water.

Research at the University of Saskatchewan evaluated the use of raw and cooked yellow pea flour and pea protein concentrate in noodles to improve protein quality[4]. The noodles were not udon, but the characteristics measured were similar to the measured factors of udon.

Dough made of wheat flour supplemented with raw or cooked pea flour at the 33% level was sticky but could be sheeted and cut into noodles. Dough made with a composite of 80% wheat flour and 20% cooked pea protein concentrate had satisfactory handling properties similar to those of dough made with 100% wheat flour. Cooking losses were greater for noodles fortified with the pea products. A taste panel judged the noodles containing raw or cooked pea flour to be more acceptable in color, flavor, and texture than either the 100% wheat flour noodles or the noodles supplemented with pea protein concentrate.

We investigated the use of commercially prepared yellow pea flours (raw and cooked) and defatted soy flour as fortifiers for udon. Experimentally ground raw and cooked dried yellow peas, green peas, soybeans, germinated soybeans, and navy beans were also evaluated. Our objective was to determine the influence of several legume fortifiers on the functional and organoleptic properties of udon.

MATERIALS AND METHODS

Legumes

Commercially prepared raw and cooked yellow pea flours, yellow peas, and green peas (*Pisum sativum*) were obtained from the Dumas Seed Company, Moscow, ID. Defatted soy flour (Ardex 550) was furnished by Archer-Daniels-Midland Company, Decatur, IL. The soybeans (*Glycine max*) were obtained from Illinois Foundation Seeds, Champaign, IL, and the navy beans (*Phaseolus vulgaris*) from a local grocery outlet. Table I shows the moisture and protein contents of the various legume flours used.

Wheat Flour

The control wheat flour was a Buhler experimentally milled composite of 80% Nugaines and 20% Paha wheat varieties that closely simulated the commercial market class Western White. It had a protein content of 9.1% (N × 5.7, 14% mb) and was excellent for making quality udon.

Flour Blends

In preliminary tests, flours of various legumes were substituted for 5, 10, and 20% of the control wheat flour in the preparation of udon. The legumes included commercially prepared raw and cooked yellow pea and defatted soy flours. All other legume flour substitutions were made only at the 10% level.

Soybean Germination Procedure

Soybeans were steeped 12 hr at 20°C in an aerated waterbath. The moisture content of the soybeans increased from 9 to 60%. Soybeans were then layered 2 cm thick, wrapped in a wet cloth and placed in a high humidity (98% RH) cabinet (23.5 ± 1.0°C) for 60 hr to germinate. The germinated soybeans were cooked, quick-frozen, and then ground with an equal amount of distilled water to a mash (2.0 ± 2.0°C) in a Stein Laboratory mill. The samples were refrozen and lyophilized to 3–4% moisture.

Preparation of Cooked Legume Flours

A steam pressure cooker at one atmosphere pressure was used to cook the soybeans, yellow peas, green peas, and navy beans. They were dried to 5–10% moisture in forced air at room temperature and ground on a Udy Cyclone Sample mill through a screen with 0.5-mm diameter openings.

Other Determinations

Moisture and protein contents of the control wheat and legume flours were determined by standard AACC procedures (1962).

Udon Testing

The noodles were made with an Otake Laboratory noodle machine and tested according to the methods of Nagao et al (1976). The flour sample weight, however, was reduced from 500 to 400 g. Five important noodle characteristics (color of the raw noodle, color of the cooked noodle, texture, taste, and yield) were judged and rated. Yield is the increase in weight determined by placing 100 g of noodle dough strings in boiling water for 20 min and calculating the percent increase in weight of the wet noodles. The color of the raw and cooked noodles was judged by visual observation and comparison with the control. Eating quality was subjectively rated by several individuals who ate noodles soaked in soy-sauce soup and scored them by comparison with the control. Each characteristic was given 16 points if its quality equaled that of the control noodle characteristic, more than 16 points if better, and less than 16 points if poorer. The five numerical scores for each noodle were added to give an overall score for each test noodle. Each quality characteristic was evaluated on an equal weight basis; the control noodle had an overall score of (5 × 16) 80 points.

No statistical application was applied to the quality findings.

[4]A. K. Sumner and L. Whalley, College of Home Economics, University of Saskatchewan, Saskatoon, Canada. Personal communication.

TABLE I
Moisture and Protein Content of Various Legume Flours

Legume	Moisture (%)	Protein[a] (%)
Commercial raw yellow pea flour	9.9	22.5
Commercial cooked yellow pea flour	8.9	21.9
Whole yellow peas	10.1	20.7
Whole green peas	7.7	19.4
Whole soybeans	10.3	31.7
Germinated soybeans (freeze-dried)	3.2	33.7
Commercial defatted soy flour (Ardex 550)	6.9	46.5
Whole navy beans	10.8	21.4

[a]Results expressed on 14.0% moisture basis. Protein = N × 6.25.

TABLE II
Quality Characteristics and Scores of Udon Fortified with Commercially Prepared Legume Flours

		Yellow Pea Flour						Defatted Soy Flour		
		Raw			Cooked					
	Control	5%	10%	20%	5%	10%	20%	5%	10%	20%
Weight Increase (%)	348	333	351	335	344	337	299	352	342	336
Color										
Raw Noodle	16	15	12	8	13	10	6	13	10	6
Cooked noodle	16	15	14	12	13	10	6	13	11	8
Texture	16	16	17	15	16	15	13	16	15	13
Taste	16	12	10	10	16	16	16	16	16	14
Yield	16	15	16	15	16	15	12	16	16	15
Overall score	80	73	69	60	74	66	53	74	68	56

Acceptable scores for udon noodles depend on the extent to which each quality characteristic is affected. For instance, a six-point decrease in taste would make that noodle unacceptable, even if the other quality characteristics remained equal to the control. A two-point change in score of a quality characteristic would indicate a significant difference.

RESULTS AND DISCUSSION

Udon Made With Commercially Prepared Legume Flours

Wheat flour was fortified at the 5, 10, and 20% concentration levels with commercially processed raw yellow pea flour, cooked yellow pea flour, and defatted soy flour. These three legume flours were used in preliminary tests to determine their acceptable levels in udon.

The optimum amount of salted water to maintain proper dough consistency decreased from 34 to 29 ml/100 g of flour as the percentage of raw yellow pea flour was increased from 5 to 20%. More water (1–5 ml) was required with increasing levels of cooked yellow pea flour and defatted soy flour.

Table II shows the quality characteristics and scores of udon made with these commercially prepared legume flours. The overall scores for the noodles with legume flour were lower than the score for the control. Increased levels of raw or cooked yellow pea flours caused an increase in yellow-brown color of both the raw and cooked noodles, whereas increased levels of defatted soy flour resulted in an increase in yellow-green color of both the raw and cooked noodles. Noodles made with defatted soy flour and with cooked yellow pea flour at the 20% fortification level had a tough and sticky texture. Although the raw yellow pea flour did not significantly affect texture, it was detrimental to udon taste. The main objection was that it imparted a grasslike flavor to the product. This off flavor was detectable in both uncooked and cooked fortified udon.

The test results (Table II) indicate that more research should be done to improve the color of udon prepared with commercial cooked pea and soy flours and the taste of udon made with commercial raw yellow pea flour. These factors are most important if the fortified product is to be made more acceptable to the consumer.

Udon Fortified with Experimentally Processed Raw and Cooked Legumes

Several individual legume fortifiers (yellow peas, green peas, soybeans, and navy beans) were cooked for 1 and 5 min. After cooking, the legumes were dried, ground, blended with wheat flour at the 10% level, and used for making noodles.

The amount of salted water required for optimum dough consistency was slightly higher (from 1 to 3 ml/100 g of flour) for the cooked than for the uncooked legumes. Cooking the legumes for an additional 4 min (beyond 1 min) did not necessitate any further adjustment in salted water for optimum consistency.

The resulting quality characteristics and scores are given in Table III. Heat treatment of all legumes generally improved the color of the raw but not of the cooked noodle. Nevertheless, all color scores of the raw noodles were lower than 16. The texture of noodles made with the pea flours was slightly better than that of the control. Cooking the legumes did not affect udon texture. Cooking of all legume supplements for as short a period as 1 min dramatically improved taste, but additional cooking did not improve the taste further. Overall, scores indicate that a short heat treatment improved noodle quality.

Table III shows that the color of raw noodles was slightly better when they had been made with cooked rather than with raw legume flour. Table II shows the reverse for noodles fortified with cooked commercial yellow pea flour. Commercially prepared raw yellow pea flour produced a better color score at all concentration levels. The commercial cooked yellow pea flour imparted more color than did the raw yellow pea flour, but it was an undesirable color. Jeffers et al (1978), preparing breads from flour fortified with commercial raw yellow pea flour, noted that a 5–10% level of fortification resulted in a white crumb color equal to that of the control but higher levels of fortification resulted in a yellow crumb. D'Appolonia (1977) noted similar results in bread crumb color with various legumes but not yellow pea flours and tentatively concluded that a lipoxygenase type of enzyme in the raw legume flour was responsible. Some bleaching of carotene pigments apparently occurred, improving the color of the raw noodles. This enzyme would be active in the raw yellow pea flour but partially or totally inactivated in the cooked yellow pea flour, depending on the length of cooking. Commercial cooked yellow pea flour is prepared from peas steam-cooked for 10 min. Apparently this is too long and causes inactivation of the lipoxygenase type of enzyme. This commercial process may even be severe enough to create new or modified color compounds. This could explain the increased color in the raw noodles fortified with commercial cooked yellow pea flour.

The taste scores (Table II) of the noodles made with commercial cooked yellow pea flour were better than those of noodles made with the corresponding raw pea flour. Cooking obviously removed the grassy flavor associated with raw peas and other legumes. Cooking the legume supplements for a period as short as 1 min (Table III) was also apparently responsible for the dramatic improvement in the taste of the legume-fortified noodles. Additional cooking did not improve the taste further.

Udon Fortified with Ungerminated and Germinated Soybeans

Germination of cereals increases their nutritional and decreases their antinutritional factors (Burkholder and McVeigh 1942, Matheson and Strother 1969, and Dalby and Tsai 1976). We incorporated raw and cooked germinated soybean flours as well as raw and cooked ungerminated soybean flours into noodles at the 10% level. Cooking time of the soybeans was 1 min. Table IV shows that the quality characteristics of the soybean-fortified noodles were generally not as high as those of the control; the short heat treatment of the soybeans, both germinated and ungerminated, improved noodle quality in both color and taste. The raw noodles with fortified uncooked germinated soybean were significantly

TABLE III
Quality Characteristics and Scores of Udon Fortified with Raw and Cooked Legume Flour

		Yellow Peas, 10%, Cooked (min)			Green Peas, 10%, Cooked (min)			Soybeans, 10%, Cooked (min)			Navy Beans, 10%, Cooked (min)		
	Control	0	1	5	0	1	5	0	1	5	0	1	5
Weight Increase (%)	351	354	321	331	343	337	328	359	349	352	345	327	323
Color													
Raw noodle	16	12	13	14	9	10	11	11	12	13	12	14	15
Cooked noodle	16	14	14	13	10	11	10	10	14	11	17	15	16
Texture	16	17	17	17	17	17	17	15	15	15	15	15	15
Taste	16	10	15	15	10	15	15	9	15	14	12	15	15
Yield	16	16	14	15	16	15	14	16	16	16	16	14	14
Overall score	80	69	73	74	62	68	67	61	72	69	72	73	75

TABLE IV
Quality Characteristics and Scores of Udon Made from Flour Fortified with Raw and Cooked Ungerminated and Germinated Soybean Flours

		Ungerminated Soybeans, 10%, Cooked (min)		Germinated Soybeans, 10%, Cooked (min)	
	Control	0	1	0	1
Weight					
Increase (%)	322	329	320	320	313
Color					
Raw Noodle	16	11	12	8	13
Cooked noodle	16	10	14	9	13
Texture	16	15	15	15	15
Taste	16	9	15	9	14
Yield	16	16	16	16	16
Overall score	80	61	72	57	71

poorer in color. The color difference between the raw noodles made from ungerminated and germinated soybeans could be due to inhibition from the ascorbic acid produced during germination (McDonald 1979).

No significant changes were required in the amount of salted water needed for optimum dough consistency with either germinated or ungerminated soybean fortification in noodles.

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