Quality Parameters of Noodles Made with Various Supplements

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Abstract

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The influence of various supplements (extruded maize, maize, defatted soy flour and maize/soy flour blends, lecithin and wheat straw) on the pasta quality has been examined. Noodles were prepared by means of conventional laboratory equipment. Common wheat flour supplemented with 1% lecithin powder, 20% extruded maize flour, 20% maize flour, 10% defatted soy flour, 20% defatted soy and maize flour blend (1:1), and 7.5% wheat straw was used. The produced pasta was dried at 55°C in a laboratory dryer (Instrumentaria, Croatia) to 13.0% moisture. Pasta colour was evaluated with fresh pasta by measuring L*, a*, b* parameters by means of a reflectance colorimeter (CR 300 Chroma-metter, Minolta, Japan). The following parameters of cooked noodles were determined: volume increase coefficient, water uptake (g/g), optimum cooking time (min), and cooking loss (%). Sensory quality was evaluated on a scale of 1–5 for: odour, external appearance, flavour and mouth feel, and total quality scores. The noodles made with extruded maize flour, maize flour, and wheat straw supplements had the highest total sensory score. Cooking losses of these samples were below 10%. Regardless of the fact that the sample with lecithin had the lowest cooking loss, it was not acceptable for the panel members. Supplementation with extruded maize, maize and defatted soy flours, and wheat straw could be used to produce pasta without eggs, with a reduced cholesterol content, enriched with dietary fibre and possessing a lower glycemic index.

Keywords: noodle with supplements; colour parameters; cooking properties

In Croatia, pasta is not adequately present in nutrition and its annual consumption has been permanently decreasing since 1985. The reasons vary from the consumers' habits to the reduced assortment of products, especially of their constituent parts. The limited availability and the high cost of durum wheat result in Croatian market being particularly characterised by egg pasta produced from common wheat flour which accounts for 80% of the total pasta consumption. However, the modern trends in the pasta production paralleled with the growing interest in the potential health benefits of cereals are connected with the reduction of the use of eggs due to the cholesterol control, and with the use of other ingredients (Feillet *et al.* 1996). Maize flour was used in pasta production both untreated and heat-treated, with or without soy flour (Molina *et al.* 1975, 1976, 1982; Wu *et al.* 1987; Buck *et al.* 1987; Koleva Jotova & Seibel 1992; Taha *et al.* 1992a). Keshinro *et al.* (1993) reported on the changes in the nutrient composition during the preparation of Nigerian maize products. Adom and Liu (2002) published a report on the phytochemical profile and antioxidant activity of yellow maize (phenolics, ferulic acid, and flavonoid contents). Plate and Gallaher (2005) indicated that ferulic acid and xantohophylls have a significant antioxidant activity and are present in corn in much higher concentrations than in other cereals. The consumption of maize fiber affects human blood lipids profile and may contribute to the maintenance of a healthy colon. Extruded maize flour was used in order to improve the structuring of pasta. It is known that the addition of pregelatinised flours resulted in a better cooking quality (Pagani 1986). Soy flour was also used to produce high-protein pasta products (Laignelet *et al.* 1976; Taha *et al*. 1992b). It is well known that soy protein and fiber have been shown to lower blood cholesterol and alter the distribution of plasma lipid fractions (Erdman & Fordyce 1989). Lecithin is derived from soybean oil. During the refining of crude soybean oil to food-grade oil, phospholipids are removed. A number of additional compounds can be attached, forming different types of phospholipides. Choline, part of the B vitamin complex, is considered one of most nutritionally significant lecithin constituents because it is required for various physiological functions (cell membranes, fat transport) (Miller 2002). Wheat straw is mostly used for livestock feed, bedding, paper production, strawboard products, plastics, and as mushrooms compost. Besides cellulose, straw also contains mineral substances, lignin, and pentosans that have an increasing role in the present diet. New researches offer more detailed information on the straw composition (Arisoy 1998; Pearce *et al.* 1998; Rouzbehan *et al.* 2001; Fazaeli *et al.* 2003).

In order to produce technological, nutritious and sensorilly satisfactory pasta using common wheat flour, the influence of various supplements (maize, extruded maize, defatted soy flours and maize/soy flour blends, lecithin and wheat straw) on the quality properties of pasta has been examined. Despite their considerable production, maize and soy flours are insufficiently used in human nutrition in Croatia. Maize is the predominant cereal crop in Croatia but is used mainly for animal consumption. More attention has been given recently to the increase of the production of maize hybrids for human food in Croatia.

MATERIAL AND METHODS

Sample preparation. The sample of common wheat flour (CWF) T-400 was taken from an industrial blend of wheat harvested in the year 2005, and it was used as a regular raw material for the commercial pasta production. Commercial soybean lecithin powder Leciflow 60 (L), defatted soy flour (S), maize flour (M), and extruded maize flour (E) were purchased on the local market. Microbiologically examined wheat straw (WS) was milled in a laboratory mill "Simple" (Tecator). The common wheat flour sample contained 13.65% of particles < 100 µm, 79.23% of particles between 100 and 250 µm, and 7.12% of particles > 250 µm. 35.60% of the milled wheat straw particles were < 100 µm, 51.08% ranged between 100 and 250 µm, and 13.32% were > 250 µm. All other supplements contained 95% of particles smaller than 100 µm.

Laboratory tests. Chemical components of wheat, maize and soy flours, and wheat straw were determined using Standard Methods (International Association for Cereal Science and Technology – ICC 1992), for the determination of moisture (Method 110/1), ash (Method 104/1), protein (Method 105/2), total dietary fibre (Method 156), and fat (Method 136).

Noodle production. Noodles were produced by mixing 1000 g of wheat flour or blends as shown in Table 1. The optimal amount of the supplements added was defined in previous researches (Ugarčić-Hardi *et al.* 2003). To give total moisture content of 32.2%, deionised water was slowly added. The mixing lasted 15 minutes at 80 rpm using a commercial laboratory mixer. The resulting dough was fed in between the rollers of a laboratory noodle sheeting and cutting machine (Ampia, Marcato S.p.A., Padova, Italy) at room temperature to give noodle strands of the length

Table 1. Samples identification

Sample mark	Sample
CWF	Common wheat flour
L	CWF + 1% lecithin
E	80% CWF: 20% extruded maize flour
M	80% CWF: 20% maize flour
S	90% CWF: 10% defatted soy flour
SM	80% CWF: 20% defatted soy and maize flour blend (1:1)
WS	92.5% CWF: 7.5% wheat straw

of 15 cm, breadth of 1 cm, and thickness of 2 mm. The produced pasta was dried in a laboratory dryer (Instrumentaria, Croatia) to 13.0% moisture using a two-stage drying cycle. In the first stage, the cabinet temperature was raised from 25 to 55°C during the first hour and held at 55°C for 2 hours. Relative humidity was lowered from 85 to 30%. The moisture content of the dried pasta ranged from 12.6 to 13.5%. The samples were stored at 20°C before analyses. All pasta samples were produced in duplicates.

Colour analyses. Pasta colour was evaluated by measuring L*, a*, b* parameters by means of a reflectance colorimeter (CR 300 Chroma-meter, Minolta, Japan) using fresh pasta shaped into square forms (10 g), size 7 × 7 cm, with thickness of 2 mm. The instrument was standardised against a white tile before the measurements. Colour was expressed in CIE-Lab parameters as L* (whiteness/darkness), a* (redness/greenness), and b* (yellowness/blueness). Ten measurements were performed on each sample and the mean value and standard deviation were calculated.

Sensory analysis. The properties of the cooked pasta were examined. The following parameters were determined: the volume increase coefficient, water uptake, cooking time (min), and cooking loss (%), according to the Croatian Official Methods (1991). The volume increase coefficient was calculated as the ratio of the volume of the cooked pasta to that of raw pasta. Water uptake was calculated by subtracting the initial sample weight (50 g) from the cooked sample weight and dividing by the initial sample weight. For the measurement of cooking time, the standard cooking method was used: 100 g of pasta (strands of 15 cm length, 1 cm breadth and 2 mm thickness) was cooked in 1 l salted (5 g/l NaCl) boiling tap water for optimum time which is defined as the time when the white core in the centre of the pasta disappears. Cooking loss is defined as the mass of solids lost into the cooking water during boiling.

The pasta samples supplemented with maize, defatted soy flour, lecithin, and wheat straw were evaluated on the scale of 1–5 for four quality parameters: odour, external appearance, flavour, and mouthfeel, according to Table 2. A trained panel of seven assessors made the sensory assessment. The panellists were selected in a preliminary session and were experienced in the products and terminology.

Statistical analyses. The measured colour parameters of the pasta samples are the average values of ten determinations. Colour and sensory analysis data were statistically analysed by Statistica 6.0 (Statsoft Inc.) for computing analysis of variance (ANOVA) and Fisher's least significant difference (LSD) ($P < 0.05$).

RESULTS AND DISCUSSION

Ash, protein, fat, and total dietary fibre contents of common wheat flour, maize flour, and defatted soy flour are presented in Table 3. The highest

Table 2. Scoring sheet for pasta samples

Parameter	Score				
	5	4	3	2	1
Odour of cooked pasta	odour characteristic of pasta	weak odour of pasta, less odour of the raw material	very weak odour, strong odour of the raw material	weak sour odour, strong odour of additives (eggs etc.)	very strange odour not characteristic of cooked pasta
Appearance (stickiness and resilience)	pasta is fully resilient, voluminous	pasta is mainly resilient	pasta is partially sticky	pasta is very sticky	pasta is completely sticky without volume
Flavour and mouthfeel of cooked pasta	pasta is of satisfactory full characteristic and consistent but neither too firm nor too sticky	pasta is not aromatic enough; pasta is consistent enough and a little sticky	pasta has weak taste and it is soft and sticky	pasta has very weak taste and it is much softer and very sticky	the flavour is not characteristic of cooked pasta and it is very soft and very sticky

Table 3. Chemical composition (% on dry weight basis) of wheat, maize and defatted soy flours and wheat straw

Component	Common wheat flour	Maize flour	Defatted soy flour	Wheat straw
Ash	0.47	0.44	5.54	5.79
Protein	9.8*	5.4**	47.6***	2.9**
Fat	0.7	2.9	3.2	1.7
Total dietary fiber	0.7	5.4	8.7	46.6
	*N × 5.7	**N × 6.25	***N × 5.71	**N × 6.25

content of protein (47.6%) was found in soy flour, whereas the ash content was the highest in wheat straw and soy flour (5.79 and 5.54%, respectively). The total dietary fibre was the highest in wheat straw (46.6%). Total dietary fibre and fat content were higher in maize and soy flours than in the common wheat flour, whereas the protein content of the maize flour was lower than that of wheat flour.

Pasta colour

Colour is an important quality parameter of pasta. It results from the desirable yellow component and the undesirable brown component. The tristimulus colour system CIE-Lab was used to record the colour parameters of the surface of the pasta samples. The L* is the measure of the brightness (lightness) from black (0) to white (100). The a* is the function of the red-green difference. Positive a* indicates redness, negative a* indicates greenness. The b* is the function of the green-blue difference. Positive b* indicates yellowness, negative b* indicates blueness. The units within the L*, a*, b* system give equal perception of the colour difference to a human observer. The L*, a*, b* values of the pasta samples with different supplements are presented in Table 4.

The highest L* values (brightness) were found with the fresh noodle sample L and the dried sample M. All samples with defatted soy flour and wheat straw had the lowest L* values (higher brownness), which can be explained by the higher content of ash and dietary fibre. a* values were

Table 4. Colour parameters[a,b] of noodles with various supplements

Sample	CWF	L	E	M	S	SM	WS
Fresh noodles							
L*	78.3 ± 0.2[b]	78.9 ± 0.2[a]	76.2 ± 0.2[d]	76.9 ± 0.5[c]	71.9 ± 0.2[f]	72.5 ± 0.4[e]	63.8 ± 2.3[g]
a*	–2.1 ± 0.1[d]	–2.3 ± 0.1[e]	–3.4 ± 0.1[g]	–3.2 ± 0.1[f]	0.6 ± 0.1[b]	0.3 ± 0.1[c]	1.5 ± 0.1[a]
b*	13.1 ± 0.2[f]	15.3 ± 0.1[e]	20.7 ± 0.3[c]	20.4 ± 0.4[d]	25.1 ± 0.3[b]	27.0 ± 0.4[a]	12.9 ± 0.4[f]
ΔE^*_{CWF} [c]		2.3 ± 0.1[e]	8.0 ± 0.4[c]	7.5 ± 0.4[d]	13.8 ± 0.3[b]	15.2 ± 0.4[a]	15.1 ± 1.1[a]
Dried noodles							
L*	73.8 ± 1.4[b]	70.2 ± 1.9[de]	71.8 ± 2.1[cd]	76.6 ± 1.0[a]	69.7 ± 2.5[e]	72.3 ± 2.2[bc]	66.8 ± 1.6[f]
a*	–1.6 ± 0.1[d]	–1.6 ± 0.1[d]	–2.4 ± 0.1[f]	–1.9 ± 0.1[e]	1.4 ± 0.1[b]	1.7 ± 0.2[a]	1.2 ± 0.1[c]
b*	17.4 ± 0.4[e]	17.7 ± 1.0[e]	23.5 ± 0.9[c]	22.4 ± 0.3[d]	24.1 ± 0.6[b]	26.4 ± 0.6[a]	12.7 ± 0.2[f]
ΔE^*_{CWF}		3.8 ± 0.3[d]	7.0 ± 0.6[c]	6.0 ± 0.4[c]	8.7 ± 1.1[b]	9.8 ± 0.8[a]	9.4 ± 0.6[a]

[a]Mean value ± standard deviation (n = 10)

[b]Mean values marked with different letters in the same row are significantly different by the Fisher's LSD test ($P < 0.05$)

[c]Total colour differences calculated relative to the common wheat flour pasta samples

negative (green direction) in all samples except the fresh and dried pasta samples S, SM, and WS. The highest b* values were observed in samples S and SM. The fresh and dried samples WS had the lowest b* values. Although the high value of the b* parameter is desirable for pasta colour scoring, the external appearance of S and SM samples was poorly graduated during the sensory evaluation. This was probably due to the fact that brown colour (low L* value) tends to mask the yellow colour when it reaches substantial values (Irvine & Anderson 1952). Samples E and M were bright yellow (higher b* values and lower a*). This was due to the higher carotene content of maize flour as compared to that of wheat flour. The b* values of dried noodles were higher than those of fresh pasta, except for the samples with defatted soy flour and wheat straw. Total colour differences calculated relative to the common wheat flour pasta samples were noticed for samples SM and WS.

Cooking characteristics

Cooked pasta must be firm, resilient and non sticky for maximum consumer acceptance. The volume increase coefficient of cooked noodles caused by cooking water absorption was higher with the samples containing maize flour. On the contrary, samples containing defatted soy flour, wheat straw and extruded maize flour showed lower values than the control samples (Table 5). Buck *et al.* (1987) also reported that the pasta containing soy had a lower cooked weight than the pasta with maize flour. Water uptake increased significantly with samples L and WS and decreased with samples E. Lagassé *et al.* (2006) explained the decrease of the water uptake by shorter cooking time. In our research sample WS exhibited a significantly higher water uptake but a shorter cooking time than the control sample. The lowest values for the water uptake and the volume increase coefficient were revealed by sample E. Samples L and E exhibited significantly longer cooking times than the control sample. Sample WS showed a significantly reduced cooking time. Cooking loss is undesirable and according to Wu *et al.* (1987), it should not exceed 10% of the dry weight. According to Croatian Official Regulation, cooking loss should not exceed 12%. The significantly lowest value of the cooking loss occurred with sample L, and the highest with sample S. Buck *et al.* (1987) reported a high cooking loss with soy flour blends.

Sensory evaluation

Mean scores of the sensory parameters and the total quality scores are shown in Table 6. Among the blends, sample E had the highest total sensory score (4.7), followed by samples M (4.6) and WS (4.5), while samples L (3.4) and S (3.6) had the lowest score. Sample E had very pleasant flavour. Sample L had significantly lower values or all quality parameters than the control samples. Especially low was the score for the external appearance due to pale colour and decreased firmness. The scores of the samples containing defatted soy flour were also low. The samples with defatted soy flour indicated a strange odour and dark-grey colour. Sample WS had very high values for odour and flavour

Table 5. Cooking properties[a,b] of noodles with different supplements

Sample	Volume increase coefficient	Water uptake (g/g)	Cooking time (min)	Cooking loss (%)
CWF	2.71 ± 0.08[ab]	1.22 ± 0.16[c]	7.31 ± 0.22[bc]	11.35 ± 0.78[b]
L	2.50 ± 0.14[bc]	1.65 ± 0.14[a]	8.21 ± 0.13[a]	7.07 ± 0.08[e]
E	2.29 ± 0.13[c]	0.59 ± 0.04[d]	8.30 ± 0.11[a]	9.51 ± 0.13[cd]
M	3.00 ± 0.11[a]	1.26 ± 0.14[bc]	7.21 ± 0.21[bc]	8.64 ± 0.62[d]
S	2.40 ± 0.21[bc]	1.00 ± 0.14[c]	7.42 ± 0.06[b]	13.21 ± 0.56[a]
SM	2.86 ± 0.14[a]	1.22 ± 0.17[c]	7.01 ± 0.13[c]	10.30 ± 0.64[bc]
WS	2.70 ± 0.07[ab]	1.58 ± 0.14[ab]	6.51 ± 0.22[d]	9.90 ± 0.25[c]

[a]Mean value ± standard deviation (n = 2)

[b]Mean values marked with different letters in the same column are significantly different by the Fisher's LSD test ($P < 0.05$)

Table 6. Sensory scores[a,b] of pasta samples

Sample	Odour	External appearance	Flavour and mouth feel	Total quality score
CWF	4.7 ± 0.3[a]	3.4 ± 0.6[b]	4.4 ± 0.2[b]	4.3 ± 0.2[c]
L	3.6 ± 0.4[c]	2.7 ± 0.5[c]	3.5 ± 0.4[d]	3.4 ± 0.2[e]
E	4.8 ± 0.3[a]	4.2 ± 0.3[a]	4.8 ± 0.3[a]	4.7 ± 0.2[a]
M	4.6 ± 0.4[a]	4.1 ± 0.2[a]	4.8 ± 0.3[a]	4.6 ± 0.2[ab]
S	3.5 ± 0.5[c]	3.6 ± 0.2[b]	3.6 ± 0.4[d]	3.6 ± 0.3[e]
SM	4.2 ± 0.5[b]	3.7 ± 0.2[b]	3.9 ± 0.4[c]	3.9 ± 0.3[d]
WS	4.7 ± 0.2[a]	4.0 ± 0.1[a]	4.7 ± 0.1[ab]	4.5 ± 0.2[bc]

[a]Mean value ± standard deviation ($n = 7$)
[b]Mean values marked with different letters in the same column are significantly different by the Fisher's LSD test ($P < 0.05$)

and mouth feel. The panel members commented that the noodles with wheat straw addition had a pleasant odour and flavour.

CONCLUSIONS

Noodles made with extruded maize (E), maize flour (M) and wheat straw (WS) supplements had the highest total sensory score. These samples exhibited the highest scores for sensory parameter external appearance due to a desirable yellow colour (especially sample E). Cooking loss with these samples was bellow 10%. The lowest sensory scores were obtained with samples containing lecithin (L) and defatted soy flour (S). Regardless of the fact that sample L had the lowest cooking loss, this sample was not acceptable for the panel members. The addition of defatted soy flour in the pasta production improves the quantity and nutritional quality of protein, since cereal proteins are deficient in lysine and tryptophan. The improvement of the nutritional value of the product justifies the use of soy flour in spite of the very high cooking loss (13.21%) and low sensory scores. Based on these results, extruded maize, maize and defatted soy flours, and wheat straw can be used in the pasta formulation to produce pasta without eggs, with a reduced cholesterol content, enriched with dietary fibre and with lower glycemic index.

References

Adom K.K., Liu R.H. (2002): Antioxidant activity of grains. Journal of Agricultural and Food Chemistry, **50**: 6182–6187.

Arisoy M. (1998): The effect of sodium hydroxide treatment on chemical composition and digestibility of straw. Turkish Journal of Veterinary and Animal Sciences, **22**: 167–170.

Buck J.S., Walker C.E., Watsoon K.S. (1987): Incorporation of corn gluten meal and soy into various cereal-based foods and resulting product: functional, sensory and protein quality. Cereal Chemistry, **64**: 264–269.

Croatian Official Methods (1991): Official Methods of Cereal Analyses in Croatia. Official Gazette, Zagreb, **53**: 1854–1883.

Erdman J.W., Fordyce E.J. (1989): Soy products and the human diet. American Journal of Clinical Nutrition, **49**: 725–737.

Fazaeli H., Azizi A., Jelan Z.A.M., Mirhadi S.A. (2003): Effect of fungal treatment on the chemical composition, *in vitro* digestibility and in sacco degradability of wheat straw. In: Proceedings British Society of Animal Science. British Society of Animal Science, Midlothian: 166.

Feillet P., Abecassis J., Autran J.C., Laignelet T. (1996): Past and future trends of academic research on pasta and durum wheat. Cereal Foods World, **41**: 205–212.

Irvine G.N., Anderson J.A. (1952): Factors affecting the colour of macaroni. Cereal Chemistry, **29**: 65–70.

Keshinro O.O., Ogundipe A.O., Scot-Emuakpor M.M., Egele P.U. (1993): Effects of preparatory procedures on some tropical maize products. Journal of Cereal Science, **18**: 287–294.

Koleva Jotova N., Seibel W. (1992): Studien über die Herstellung von Teigwaren auf Reis-und Maisbasis. Getreide, Mehl und Brot, **51**: 49.

Lagassé S.L., Hatcher D.W., Dexter J.E., Rossangel B.G., Izydorczyk M.S. (2006): Quality characteristics of fresh and dried white salted noodles enriched with flour from hull-less barley genotypes of diverse amylose content. Cereal Chemistry, **83**: 202–210.

Laignelet B., Feillet P., Nicols D., Kadane V.V. (1976): Potential use of soy proteins in the pasta industry. Lebensmittel-Wissenschaft und -Technologie, **9**: 24–28.

Miller D.L. (2002): Health benefits of lecithin and choline. Cereal Foods World, **47**: 178–188.

Molina M.R., Mayorga I. Lanchance P.A., Bressani R. (1975): Production of high-protein quality pasta products using a semolina-corn-soy flourmixture. I. Influence of thermal processing of corn flour on pasta quality. Cereal Chemistry, **52**: 240–247.

Molina M.R., Mayorga I., Bressani R. (1976): Production of high-protein quality pasta products using a semolina-corn-soy flourmixture. II. Some physiochemical properties of the untreated and heat-treated corn flour and of the mixture studied. Cereal Chemistry, **53**: 134–140.

Molina M.R., Gudiei H., Baten M.A., Bressani R. (1982): Production of high-protein quality pasta products using a semolina-corn-soy flour mixture. III. Effect of cooking on the protein nutritive value of pasta. Cereal Chemistry, **59**: 34–37.

Pagani M.A. (1986): Pasta products from non conventional raw materials. In: Mercier C., Cantarelli C. (eds): Pasta and Extrusion Cooked Foods. London, Elsevier Applied Science: 52–68.

Pearce G.R., Beard J., Hillard E.P. (1998): Variability in the chemical composition of cereal straws and in vitro digestibility with and without sodium hydroxide treatment. Australian Journal of Experimental Agriculture, **19**: 350–353.

Plate Y.A., Gallaher D.D. (2005): The potential health benefits of corn components and products. Cereal Foods World, **50**: 305–314.

Rouzbehan Y., Fazaeli H., Kiani A. (2001): The chemical composition and digestibility of wheat straw treated with urea and white rot fungi. In: Proceedings British Society of Animal Science. British Society of Animal Science, Midlothian: 123.

Standard-Methoden für Getreide, Mehl und Brot (1992): Verlag Moritz Schäfer, Detmold, ICC-Standard No.: 104/1, 105/1, 106/2, 109/1, 136, 156.

Taha S.A., Kovács Z., Sági F. (1992a): Evaluation of economical pasta products prepared from durum semolina/yellow corn flour/soy flour mixtures. I. Mixing properties, chemical composition and colour components. Acta Alimentaria Hungarica, **21**: 153–162.

Taha S.A., Kovács Z., Sági F. (1992b): Evaluation of economical pasta products prepared from durum semolina/yellow corn flour/soy flour mixtures. II. Cooking behaviour, firmness and organoleptic properties. Acta Alimentaria Hungarica, **21**: 163–170.

Ugarčić-Hardi Ž., Hackenberger D., Šubarić D., Hardi J. (2003): Effect of soy, maize and extruded maize flour addition on physical and sensory characteristics of pasta. Italian Journal of Food Science, **2**: 277–285.

Wu Y.V., Youngs V.L., Warner K., Bookwalter G.N. (1987): Evaluation of spaghetti supplemented with distillers' dried grains. Cereal Chemistry, **64**: 434–436.

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