Indian Durum Wheats. II. Effect of Conditioning Treatments on the Quality of Spaghettis

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ABSTRACT

Two Indian durum wheats (DWL-5023 and DWL-5031) and one bread wheat (WL-711) were heat-conditioned and used to prepare spaghetti. Quality of spaghetti in relation to carotenoid pigments, lipoxygenase activity, cooking time, water uptake, gruel solids loss, and sensory attributes was determined. Spaghetti prepared from DWL-5023 was most acceptable to consumers and was followed by DWL-5031 and WL-711, respectively. Hot-water treatment (30 min) improved the color of cooked spaghetti. Steam-conditioning treatments at 1 atm for 2 min and at 2 atm for 1 min adversely affected texture, stickiness, odor, disintegration, and overall acceptability.

Durum wheat usually gives high yield of semolina of bright yellow color and high protein content (Dexter and Matsuo 1977); it often has a medium-strength gluten (Matsuo and Irvine 1970) and produces spaghetti of good quality (Feillet 1977). The yellow color, which is due to the presence of carotenoid and lutein pigments, is bleached by lipoxygenase (McDonald 1979). The effect of heat-conditioning on the inactivation of lipoxygenase enzyme and the milling quality of Indian durum wheats was reported earlier (Kathuria and Sidhu 1984). The objective of the present study was to investigate the effect of heat-conditioning treatments on the quality and acceptability of spaghetti prepared from the semolina of Indian wheats.

MATERIALS AND METHODS

Semolina from different varieties of durum and aestivum wheats preconditioned by different heat treatments was obtained as reported earlier (Kathuria and Sidhu 1984). To obtain dough of proper consistency for spaghetti production, the durum semolina required 50–55% and aestivum semolina 47–50% water, depending upon the conditioning treatments. Slightly more water was required for doughmaking in this case than is commonly used for spaghetti manufacture, because only a soft dough could be extruded through the hand-operated machine. The semolina and water were mixed in a National Manufacturing Company mixer to obtain a dough of proper consistency. Spaghetti 0.0625 in. (1.59 mm) in diameter and approximately 10 in. long was extruded through a hand-operated laboratory machine. The extruded spaghetti was dried to about 8% moisture content in a forced-circulation cabinet drier at 60°C for 1.5 hr (Rahim et al 1976). Spaghetti prepared from DWL-5023 and DWL-5031 wheat varieties was vitreous in texture, whereas spaghetti from WL-711 was mealy and had a rough surface. The cooking quality of spaghetti was evaluated according to the procedure described by Matsuo and Irvine (1970). The organoleptic evaluation was done with a nine-point hedonic scale for attributes such as color, odor, disintegration, stickiness, texture, and overall consumer acceptability.

Methods of Analysis

A standard AACC method was used for the estimation of total carotenoid pigments in raw spaghetti (AACC 1972). The experimental data were analyzed statistically for analysis of variance, and the critical difference at 5% confidence is reported.

RESULTS AND DISCUSSION

So that the effect of different treatments on the finished product as well as on cooking quality could be evaluated, spaghetti prepared from semolina was analyzed for its various constituents. The effect of those treatments on the retention of carotenoid pigments in raw spaghetti is reported in Table I.

The different conditioning treatments increased the retention of pigments significantly. The lipoxygenase activity (Table II) of spaghetti decreased as the duration of hot-water and steam-conditioning treatments was increased. Irvine and Winkler (1950) and Faubion and Hoseney (1981) have suggested that pigments are bleached by the coupled-oxidation reaction and unsaturated fatty acids by lipoxygenase in the presence of atmospheric oxygen. Retention of carotenoid pigments in the finished product increased because lipoxygenase was inactivated during heat treatment. The steam conditioning of wheat samples also helped spaghetti to retain more pigment.

Differences in the pigment contents of bread and durum wheats were also significant. Spaghetti prepared from the bread wheat (WL-711) semolina had a lower pigment content than durum wheats.

When the overall pigment content of spaghetti was combined with that of semolina (Kathuria and Sidhu 1984), carotenoid pigment content decreased (25–46%) during spaghetti manufacture. Such a decrease (47–55%) in pigment content was also reported by Mkhitaryan et al (1974). This decrease may be caused by the oxidation of carotenoid pigments by oxygen and lipoxygenase during the manufacture and drying of spaghetti. The lower recovery of carotenoids from the finished product was also reported by Burov and Nazarenko (1976). According to these researchers, the carotenoids form complexes with proteins during dough mixing and become difficult to extract.

The spaghetti prepared from semolina obtained from steam-conditioned wheat at 1 atm for 2 min and at 2 atm for 1 min was expected to give higher amounts of pigments because of lower lipoxygenase activity in semolina (Irvine and Winkler 1950, McDonald 1979). However, the quantity of pigments recovered did not differ significantly from that of the hot-water treatments. The dough from semolina obtained from steam-conditioned wheat required a longer time for mixing than that from semolina obtained from hot water-treated wheats. The prolonged mixing time could have resulted in excessive destruction of carotenoid pigments. The steaming might have affected the gluten quality adversely because of protein denaturation (Andres 1979). This results in longer mixing time, which is required to obtain dough of desirable consistency.

Lipoxygenase Activity

The lipoxygenase activity of spaghetti followed a trend that resembled that of semolina (Kathuria and Sidhu 1984). Significant differences in lipoxygenase activity of spaghetti were observed between different treatments and varieties. Lipoxygenase activity of finished product decreased significantly (70–73%) compared with that of original semolina. This probably happened during the drying of spaghetti at 60°C for 1.5 hr.

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TABLE I
Effect of Conditioning Treatments on the Carotenoid Pigments (as ppm β-Carotene) of Spaghetti[a]

Variety	Control	Hot-Water Conditioning at 50°C				Steam Conditioning		
		10 min	20 min	30 min	40 min	0 atm, 5 min	1 atm, 2 min	2 atm, 1 min
DWL-5023	2.52	2.96	2.91	3.25	3.32	3.16	3.37	3.53
DWL-5031	2.34	2.87	2.85	3.01	3.15	2.91	3.03	3.12
WL-711	1.16	1.31	1.37	1.39	1.38	1.30	1.41	1.36

[a]Critical difference: treatment = 0.17, variety = 0.10.

TABLE II
Effect of Conditioning Treatments on the Lipoxygenase Activity of Spaghetti (μl of O_2/g/min)[a]

Variety	Control	Hot-Water Conditioning at 50°C				Steam Conditioning		
		10 min	20 min	30 min	40 min	0 atm, 5 min	1 atm, 2 min	2 atm, 1 min
DWL-5023	1.66	1.55	1.42	1.44	1.26	0.90	0.98	0.48
DWL-5031	1.78	1.50	1.49	1.40	1.24	0.90	0.98	0.48
WL-711	5.12	4.30	4.02	3.81	3.54	2.20	1.18	0.49

[a]Critical difference: variety = 0.75.

TABLE III
Effect of Conditioning Treatments on the Cooking Time,[a] Water Uptake,[b] and Gruel Solids Loss[c] of Spaghetti[d]

Treatment	DWL-5023			DWL-5031			WL-711		
	Cooking Time	Water Uptake	Solids Loss	Cooking Time	Water Uptake	Solids Loss	Cooking Time	Water Uptake	Solids Loss
Hot-water conditioning (50°C)									
Control	5.0	5.44	8.19	5.5	5.96	10.73	4.5	5.58	7.26
10 min	5.0	5.66	9.07	5.5	6.11	11.29	5.0	6.17	8.33
20 min	5.5	5.79	9.16	6.5	6.18	11.79	5.0	6.31	10.06
30 min	5.5	5.92	9.42	7.0	6.26	11.94	5.0	6.43	10.39
40 min	5.5	6.12	9.87	7.0	6.35	12.26	5.0	6.60	10.67
Steam conditioning									
0 atm, 5 min	5.0	5.72	8.04	5.0	5.85	9.71	4.5	6.17	9.36
1 atm, 2 min	4.5	5.92	13.66	5.0	6.13	15.19	4.5	6.33	13.20
2 atm, 1 min	4.5	6.09	12.37	5.0	7.09	18.42	4.5	6.33	13.44

[a]In minutes.
[b]Grams of water per gram of spaghetti critical difference for water uptake; treatment = 0.35, variety = 0.21.
[c]Solids loss (%) critical difference for solids loss; treatment = 1.64, variety = 1.00.
[d]Critical difference for cooking time; treatment = 0.63, variety = 0.38.

TABLE IV
Sensory Analysis of Cooked Spaghetti (average score)[a]

Attribute	Variety	Control	Hot-Water Conditioning at 50°C				Steam Conditioning		
			10 min	20 min	30 min	40 min	0 atm, 5 min	1 atm, 2 min	2 atm, 1 min
Color	DWL-5023	7.4	8.2	7.4	7.8	7.0	7.1	6.8	7.4
	DWL-5031	7.1	6.3	7.2	7.0	7.0	6.6	6.0	6.3
	WL-711	6.3	5.4	6.2	5.5	6.1	6.1	6.1	5.6
Texture	DWL-5023	7.7	8.0	6.8	7.9	6.6	7.4	4.1	5.2
	DWL-5031	6.7	6.0	6.4	6.3	6.9	6.7	4.6	3.7
	WL-711	6.7	5.7	5.9	5.0	6.2	6.2	5.5	4.9
Stickiness	DWL-5023	7.5	7.7	7.0	7.4	6.4	7.1	5.0	6.0
	DWL-5031	6.5	5.8	6.3	6.0	6.4	6.1	3.8	4.3
	WL-711	6.3	5.5	5.5	5.4	5.6	6.0	4.7	4.5
Flavor	DWL-5023	7.3	7.5	6.9	7.1	7.0	7.2	6.7	6.8
	DWL-5031	6.6	6.7	6.7	6.6	6.5	6.7	6.0	5.2
	WL-711	6.5	5.8	6.1	5.9	6.4	6.4	5.8	5.6
Disintegration	DWL-5023	7.5	7.7	5.9	7.7	5.9	6.9	4.0	4.9
	DWL-5031	5.8	5.6	5.8	6.0	6.0	6.2	3.8	3.3
	WL-711	6.5	5.3	5.1	5.1	6.1	6.3	4.7	4.4
Overall acceptability	DWL-5023	7.4	7.9	6.4	7.4	6.5	7.3	3.6	4.4
	DWL-5031	6.0	5.7	6.3	7.0	7.0	6.8	3.4	3.4
	WL-711	6.4	5.9	5.5	5.5	6.2	6.1	4.7	4.3

[a]Critical difference for treatment and variety, respectively, for the following characteristics were: color, ns and 0.62; texture, 0.10 and 0.67; stickiness, 0.72 and 0.44; flavor, 0.40 and 0.28; disintegration, 1.14 and 0.70; overall acceptability, 1.16 and ns.

Cooking Time, Water Uptake, and Gruel Solids Loss

Ten grams of spaghetti cooked in 100 ml of water was used for determining optimum cooking time, whereas 300 ml of water was used for determining water uptake and solid losses at 1.0 min past the optimum cooking time. To determine the optimum cooking time, a small strand of spaghetti is removed at 0.5-min intervals from the cooking water and pressed between two watch glasses. The cooking time is taken as the time (min) required for the white core in the strand to disappear. Data for optimum time required for cooking, water uptake, and solid losses from spaghetti as affected by hot-water and steam-conditioning treatments are presented in Table III. Except for the 10-min hot-water treatment, all other hot-water treatments increased the optimum cooking time of spaghetti significantly. Water uptake and solid losses in cooking water increased significantly with hot-water treatment.

The steam treatment did not alter the cooking time except in a few samples, where it was decreased significantly. A significant increase in water uptake by spaghetti occurred during cooking. The loss of solids in cooking water also increased significantly in the samples treated with steam at a pressure of 1 atm and 2 atm for 2 min and 1 min, respectively. With steam treatments, the starch is partially gelatinized, resulting in higher losses into the gruel. A negligible amount of carotenoid pigments was extracted from cooked spaghetti. No lipoxygenase activity was found in cooked spaghetti.

Sensory Analysis of Cooked Spaghetti

Spaghetti was cooked 1.0 min past the optimum cooking time, rinsed three times with cold water, and evaluated for color, texture, stickiness, odor, disintegration, and overall acceptability by a semitrained panel on a nine-point hedonic scale (Table IV). The bright yellow color of uncooked spaghetti is desirable (Feillet 1977), but this color is significantly bleached during cooking. The difference in the treatment effect on the color score of spaghetti was observed to be nonsignificant, but the varietal differences were significant. The durum semolina has desirable yellow color because of higher concentrations of carotenoid pigments compared with bread wheat semolina. Semolina and raw spaghetti of DWL-5023 had higher initial pigment content followed by DWL-5031 and WL-711, respectively.

A smooth surface (Taranov 1973) and soft texture are desirable features of cooked spaghetti. The hot-water conditioning treatments had no significant effect on the texture of cooked spaghetti, but a significant difference in texture was observed only among the different varieties. The panelists judged DWL-5023 spaghetti to possess the most desirable texture upon cooking, followed by DWL-5023 and WL-711 varieties.

Spaghetti should cook as individual tubes for better consumer acceptability (Feillet 1977). The steam-conditioning treatment of 2 atm for 1 min affected the texture significantly and produced spaghetti that became very sticky and mushy when cooked. Significant differences in aroma of cooked spaghetti were observed among the varieties.

For better consumer acceptability (Feillet 1977), spaghetti should not break or disintegrate upon cooking. Significant disintegration in cooked spaghetti prepared from semolina obtained by conditioning wheat at 2 atm for 1 min and 1 atm for 2 min was observed. No other treatments had an undesirable effect on the disintegration of cooked spaghetti. The overall acceptability of cooked spaghetti was arrived at by panelists who judged it for all the sensory attributes. The hot-water treatments showed significant improvement in the overall acceptability of cooked spaghetti when compared with steam conditioning. Hot-water conditioning should be employed for milling Indian durum wheats into semolina for spaghetti manufacture.

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