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Quality Attributes of Soy-pasta During Storage Period

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Abstract: The influence of Full Fat Soy Flour (FFSF) and different extrusion conditions on the acidity content and color characteristics of spaghetti during 7-month storage were evaluated. The spaghetti was produced by laboratory pasta maker and was dried at 50°C. Treatments were packed in polyethylene bags and were kept in room temperature during storage. Addition of FFSF and extrusion processing conditions influenced the acidity content of spaghetti. This enrichment resulted in significant increases ($p \leq 0.05$) in the acidity during storage. On the other hand, color characteristics of dry spaghetti showed significant changes after seven months of storage. So, the shelf life of this new product was lesser than traditional spaghetti.

Key words: Image analysis, acidity, shelf life, spaghetti

INTRODUCTION

Hard Wheat Flour (HWF) is the main ingredient of pasta products in some part of the world, which has deficient in lysine, an essential amino acid. Therefore, many researchers have focused on improving the quality of pasta by the addition of other ingredient (Rayas *et al*., 1996; Bergman *et al*., 1994; Chillo *et al*., 2008; Wang *et al*., 1999; Prabhasankar *et al*., 2007; Edwards *et al*., 1995; Manthey and Schorno, 2002; Edwards *et al*., 1995). Soybean is a valuable source for soluble carbohydrate, proteins (rich in lysine), lipids, dietary fiber, minerals and vitamins. Consumption of soybean products is useful for bone health, brain functionality, body immunology and also controls heart attack and prevent cancer (Anderson *et al*., 1999; Badger *et al*., 2002). In the previous studies, we have investigated the effect of Full Fat Soy Flour (FFSF) on the nutritional and sensory characteristics (Nasehi *et al*., 2009a) and cooking and color quality of spaghetti (Nasehi *et al*., 2009b). Since the content of lipids in the FFSF is too high (~20%), therefore it seems that rancidity of lipids has important role on the storage periods. So the objective of the present study was to determine the shelf life of spaghetti enriched with FFSF via evaluation of color quality and amount of acidity during storage.

MATERIALS AND METHODS

The HWF, was produced from Iranian spring hard wheat variety, namely Golestan and supplied by Razavi Company (Mashhad, Iran). FFSF was obtained from Toos Soya Company (Mashhad, Iran). All the chemical materials used for sample analysis had a good quality (Merk, Germany).

Flours analysis: The chemical composition of HWF and FFSF including crude protein, crude fat, crude fiber, moisture and ash were determined according to AACC standard methods (1990).

Production of spaghetti: The amount of the ingredients used for making spaghetti was calculated based on the standard methods of AACC (1990). The ingredients of formulation for sample preparation were ranged as follows: hard wheat flour (42.0-69.0 g/100 g), full fat soy flour (0-27.0 g/100 g) and distilled water (31.0-35.0 g/100 g). Table 2 shows the actual weight of each ingredient for preparing of 8 kg dough mixtures for each sample. The dough was mixed for 10 min at 70 rpm by a laboratory pasta maker before it was transferred to an extruder. Extrusion was performed using a laboratory scale extruder with screw length of 400 mm; barrel diameter of 35 mm; die diameter of 200 mm; flow rate of 6-26 kg/h at a screw speed of 10-40 rpm and temperature of circulating water of 35-70°C. The device was designed by R & D Center of Modern Food Technology, Ferdowsi University of Mashhad, Iran. Mixing and extrusion parts were operated under partial vacuum (0.7-0.8 atm). The operating extruder pressure was measured at a position just before the die section using a mechanical gauge that was fixed to the extruder. The pressure was measured in the range of 200-1000 psi. The average diameter of spaghetti was 1.90±0.03 mm. Spaghetti samples were dried in a dryer at Adish Company (Mashhad, Iran). Temperature of dryer was 50°C and relative humidity was reduced gradually from 95.0% to 65.0% during 20 h of drying period. Prepared samples were packed in polyethylene bags and were kept in room temperature during storage.

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Determination of acidity: Acidity of cooking water was measured by titration method during seven months of storage. For this purpose, spaghetti samples were cooked for optimum and over cooking time (based on the method 02-31; AACC 1990), then ten milliliters of cooled cooking water sample was titrated with 0.01 N NaOH after addition of phenolphthalein as an indicator. Acidity was calculated as lactic acid percentage (%LA).

Color quality: The image analysis technique was used to determine spaghetti color during seven months of storage. A strand (5 mm in length) of uncooked spaghetti was placed under a digital microscope (Dino-Lite AM-313, Nazca Inc., California, USA) and photographed with 60X objective. Then, the pictures were analyzed with a Clemex software (v.6.0, Meyer Instruments Inc., Houston, USA), for Intensity (I), Hue (H) and Saturation (S) values determination. The H, I and S values indicate the yellowness, lightness and redness of the spaghetti color.

Experimental design: Response surface methodology has been used in many investigations for obtaining optimized formulation. In this mixture experimental design, the total amount is held constant and a measured property of the mixture changes when the proportions of the components of the mixture are changed. Therefore, the main purpose of using this design is to verify how the acidity value and color quality of spaghetti are affected by the variation of the proportions of the mixture components i.e. the ingredients used in the spaghetti formulation. Table 1 was used to formulate the 3-component mixture systems comprising of hard wheat flour (42.0-69.0 g/100 g), full fat soy flour (0-27.0 g/100 g) and water content (31.0-35.0 g/100 g), at two extrusion process variables which are screw speed (10-40 rpm) and temperature of circulating water (35-70°C). A mixture design via the 36-point-extreme-vertices (Cornell, 2002) was constructed to study the effect of varying ratios of hard wheat flour, full fat soy flour and water content and process conditions on measured parameters. The Stat/DOE menu of the MINITAB software (V14.2, 2005, Minitab Inc.) was used to build the experimental design.

Statistical analysis: Scheffe's canonical special cubic equation for three components and two process variables was fitted to data collected at each experimental point using forward selection stepwise multiple regression analysis as described by Cornell (2002). This canonical model differs from full polynomial models in that it does not contain a constant term intercept (equal to zero). Variables in the regression models, which represent two-ingredient or three-ingredient interaction terms, were referred to as "non-linear" terms.

Table 1: The proximate analysis of flours (g/100 g)[1]

Flour	Protein	Fiber	Fat	Moisture	Ash
FFSF	37.7	14.0	18.0	5.0	5.0
HWF	8.3	0.3	0.9	13.0	0.5

[1]F: Hard wheat flour, S: Full fat soy flour

Table 2: Actual composition of ingredients in the different mixtures (kg)[1]

Mixture	F	S	W
1	6.0	0.0	2.02
2	6.4	0.0	1.63
3	5.5	0.5	2.04
4	5.7	0.5	1.85
5	5.0	1.1	1.96
6	4.4	1.7	1.97
7	4.5	1.5	2.08
8	3.8	1.9	2.39
9	3.9	2.3	1.80

[1]F: Hard wheat flour, S: Full fat soy flour, W: Water content

RESULTS AND DISCUSSION

Flours analysis: The proximate analyses of flours are shown in Table 1. It can be seen that except for moisture content all nutritional components in FFSF were higher than HWF. Shogren *et al.* (2006) reported that adding defatted soy flour in the formulation result in higher protein, fiber, ash, lysine and threonine and lower the fat content in pasta. In previous work we also found that addition of FFSF led to significant increases ($p\leq0.05$) in the protein, ash, fiber and fat content (Nasehi *et al.*, 2009a). The crease in the fat content of fortified samples was due to supplementation with full fat soy flour instead of defatted soy flour used by Shogren *et al.* (2006).

Acidity content: In general, the acidity content of samples cooked in optimum time was higher ($p\leq0.05$) for the spaghetti with FFSF in comparison to control (Fig. 1a). The acidity increased from 0.045% in the spaghetti made from HWF to 0.216% in sample enriched with 27 g/100 g FFSF. The regression analyses indicated that the ingredients used in the formulation had significant effect on the acidity content after optimum cooking time by linear ($p\leq0.01$) and quadratic ($p\leq0.01$) terms. This was predictable because FFSF has abundant unsaturated oil (Table 1), therefore acidity increased in enriched samples. The interactions between water content and temperature of circulating water had significantly positive effect on acidity content via linear ($p\leq0.001$) term. Similarly, interactions between component of mixture and screw speed also showed significantly positive effect on the acidity via special cubic ($p\leq0.01$) term. Also interactions between component of mixture, temperature of circulating water and screw speed increased acidity via quadratic ($p\leq0.01$) term (Fig. 1c). When spaghetti samples were overcooked, the percentage of acidity content increased significantly ($p\leq0.05$) from 0.110 to 0.367% (Table 2, Fig. 1b). Interactions between component of mixture, temperature of circulating water and screw speed increased acidity via quadratic ($p\leq0.001$) term (Fig. 1d).

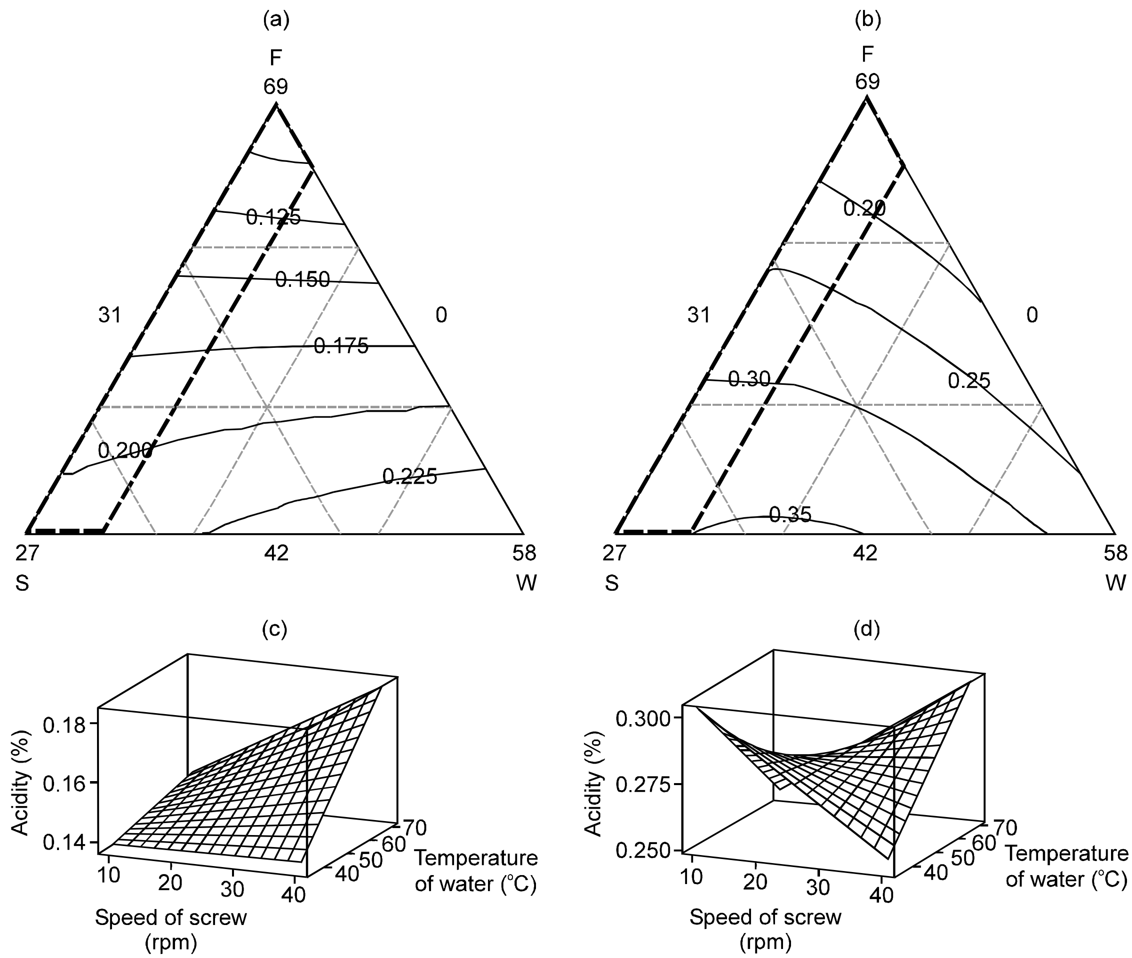

Fig. 1: Mixture contour plots of the predicted surface for acidity of spaghetti enriched with Full Fat Soy Flour (FFSF) dependent on components in the conditions optimized (a) In optimum cooking time (b) In over cooking time and mixture surface plot for acidity of spaghetti (c) In optimum cooking time (d) In over cooking time

Furthermore, acidity content of enriched samples after optimum and over cooking time increased significantly during seven month storage (Table 3). These results are similar to previous studies (Duszkiewiccz-Reinhard *et al*., 1988; Pinarli *et al*., 2004). Duszkiewiccz-Reinhard *et al*. (1988) showed the acidity content of spaghetti fortified with flour and concentrate of Legume (navy and pinto) was higher than control and increased during storage. In addition, Pinarli *et al*. (2004) demonstrated that adding wheat germ to formulation of macaroni caused higher acidity which was also significantly increased during 12 months of storage. This was due to high amount of unsaturated fatty acids, lipase and lipoxidase in the germ. On the other hand study of Siedow (1991) demonstrated that reduction-oxidation reactions are responsible for almost all biochemical changes. Lipoxygenase expedites oxidation of unsaturated fatty acids with oxygen and increases free fat contents.

Color quality: Table 4 represents the color characteristics of all uncooked spaghetti based on H, I and S values obtained from the image analysis technique. As it is shown, in the enriched spaghetti samples the intensity and hue values were significantly decreased ($p \leq 0.05$) whereas saturation parameter was significantly increased ($p \leq 0.05$). Our previous work (Nasehi *et al*., 2009b) on the impact of ingredients formulation on the color quality of spaghetti indicated that yellowness (H), lightness (I) and redness (S) were significantly affected by linear ($p \leq 0.001$) terms and also for S via quadratic ($p \leq 0.05$) terms.

On the other hand, color characteristics of dry spaghetti showed significant changes during 7-month storage period (Table 4). However this variation was unexplainable. Hue scores decreased in most samples, but in a few treatments hue values increased during storage. In addition, intensity and saturation of color in

Table 3: Acidity content of spaghetti samples during storage[1]

	Optimum cooking			Overcooking		
Mixture	First	Fourth	Seventh	First	Fourth	Seventh
1	0.095b	0.100ab	0.105a	0.158b	0.160b	0.200a
2	0.075c	0.105b	0.115a	0.150b	0.157ab	0.165a
3	0.125b	0.135a	0.140a	0.193c	0.205b	0.280a
4	0.135b	0.143b	0.168a	0.215c	0.245b	0.312a
5	0.162c	0.185b	0.257a	0.255c	0.277b	0.405a
6	0.200c	0.217b	0.275a	0.295c	0.357b	0.420a
7	0.203c	0.220b	0.282a	0.325c	0.375b	0.455a
8	0.213c	0.225b	0.300a	0.350c	0.401b	0.485a
9	0.216c	0.227b	0.305a	0.365c	0.415b	0.495a
10	0.090b	0.120a	0.127a	0.155b	0.167ab	0.192a
11	0.045c	0.083b	0.095a	0.147b	0.153ab	0.158a
12	0.090b	0.118a	0.122a	0.190b	0.220a	0.217a
13	0.095c	0.120b	0.150a	0.232b	0.240b	0.305a
14	0.130c	0.185b	0.200a	0.237c	0.250b	0.340a
15	0.137c	0.200b	0.215a	0.257c	0.305b	0.360a
16	0.165b	0.247a	0.255a	0.260c	0.328b	0.372a
17	0.150c	0.180b	0.262a	0.270c	0.358b	0.397a
18	0.162c	0.185b	0.272a	0.275c	0.365b	0.405a
19	0.080b	0.083b	0.115a	0.150c	0.163b	0.190a
20	0.075c	0.075b	0.100a	0.110c	0.128b	0.172a
21	0.090c	0.115b	0.150a	0.220c	0.240b	0.277a
22	0.095c	0.120b	0.157a	0.230c	0.253b	0.285a
23	0.125c	0.150b	0.200a	0.290c	0.310b	0.327a
24	0.140c	0.183b	0.212a	0.322b	0.328b	0.357a
25	0.150c	0.193b	0.215a	0.340c	0.375b	0.405a
26	0.190c	0.215b	0.267a	0.355c	0.400b	0.440a
27	0.195c	0.225b	0.275a	0.367c	0.413b	0.450a
28	0.092b	0.117a	0.125a	0.175b	0.190a	0.197a
29	0.075c	0.093b	0.120a	0.142b	0.145b	0.190a
30	0.110b	0.135a	0.140a	0.168c	0.213b	0.275a
31	0.125b	0.143a	0.152a	0.173c	0.225b	0.280a
32	0.145c	0.170b	0.190a	0.238c	0.280b	0.340a
33	0.156c	0.170b	0.200a	0.250c	0.287b	0.360a
34	0.165c	0.175b	0.225a	0.277c	0.295b	0.365a
35	0.170c	0.190b	0.240a	0.295c	0.317b	0.390a
36	0.172c	0.195b	0.245a	0.300c	0.360b	0.405a
LSD[2]	0.0169	0.03	0.0351	0.0303	0.0293	0.0339

[1]Same letter within a row are not significantly ($p \leq 0.05$). [2]The smallest difference in column ($p \leq 0.05$)

Table 4: Color characteristic of spaghetti samples during storage[1]

	Intensity			Hue			Saturation		
Mixture	First	Fourth	Seventh	First	Fourth	Seventh	First	Fourth	Seventh
1	128.0c	133.0b	135.0a	42.0b	42.5ab	43.0a	22.0a	21.8a	21.5a
2	130.0a	130.0a	130.0a	42.0b	42.5ab	43.0a	20.4b	21.0ab	21.8a
3	124.6b	125.0ab	125.8a	43.0a	42.5b	43.5a	22.3c	25.5b	26.5a
4	116.7a	116.5a	116.5a	43.0a	42.5b	43.5a	23.0c	25.6b	28.6a
5	113.6c	115.0b	117.0a	41.8b	42.5a	41.5b	25.0c	26.0b	30.0a
6	113.5c	116.0b	121.5a	38.6b	40.0a	40.0a	35.6a	34.0b	33.0c
7	113.0b	113.5b	120.2a	39.2a	40.0a	40.0a	35.8a	35.4a	35.0a
8	113.2a	111.0b	104.5c	39.5a	39.0ab	38.5b	38.6c	40.5b	43.0a
9	112.6a	112.0a	112.0a	38.0a	37.0b	36.5b	39.0c	40.5b	42.3a
10	125.0c	126.5b	128.0a	45.0a	42.5b	43.0b	23.0a	22.0b	21.6b
11	126.0a	126.0a	126.2a	44.0b	43.5b	45.5a	22.2a	21.5a	20.5b
12	124.0c	128.5b	132.6a	43.0b	42.5b	44.0a	23.0a	22.0b	21.2b
13	125.0a	124.0a	122.8b	42.0b	42.5ab	43.0a	25.0b	25.7c	26.8a
14	117.0c	120.0b	123.0a	42.0b	42.5b	46.0a	26.0b	28.4a	28.7a
15	116.0c	121.0b	126.0a	41.5a	40.8a	40.7a	30.0a	29.5ab	29.0b
16	115.0c	119.5b	124.2a	39.0b	40.5a	40.7a	31.0b	31.7b	32.7a

Table 4 Cont.

	Intensity			Hue			Saturation		
Mixture	First	Fourth	Seventh	First	Fourth	Seventh	First	Fourth	Seventh
17	114.0b	114.5b	122.5a	41.0a	40.4a	40.2a	33.0b	33.5ab	34.0a
18	112.0c	117.5b	122.3a	40.0a	40.5a	40.2a	35.0a	34.5ab	34.0b
19	128.0a	127.5ab	127.0b	41.5b	42.5a	43.0a	21.6a	21.4a	21.2a
20	125.0c	127.5b	130.5a	43.0a	43.5a	43.5a	23.0a	21.5b	19.5c
21	124.3c	126.5b	129.8a	41.8b	42.5b	43.8a	23.0a	21.5b	20.2c
22	124.3a	123.5ab	123.2b	43.2a	42.5a	43.2a	24.3c	26.0b	27.4a
23	135.3a	135.5a	135.2a	40.3a	41.5a	41.5a	26.2b	28.4a	27.0b
24	126.0a	125.5a	123.2b	39.2a	40.0a	39.6a	27.0c	28.0b	29.2a
25	123.2a	119.0b	115.8c	39.0b	40.2a	40.7a	28.2c	29.5b	31.0a
26	120.0a	117.0b	114.8c	38.0b	40.0a	40.3a	31.5c	36.5b	37.6a
27	116.7b	118.0a	117.6ab	38.0b	40.5a	40.2a	31.2c	32.2b	33.2a
28	127.0c	129.5b	132.2a	40.8a	41.5a	41.5a	22.2a	22.5a	22.7a
29	125.2c	128.5b	131.8a	43.2a	42.5ab	42.0b	23.2a	23.6a	24.0a
30	123.3b	124.0ab	124.7a	42.8a	42.5a	42.7a	25.2b	26.5a	25.0a
31	120.3a	119.5ab	119.0b	44.8a	42.5b	42.7b	26.2a	26.5a	27.0b
32	124.6a	124.0a	124.3a	41.0a	41.0a	41.5a	24.4c	26.0b	29.6a
33	122.2b	123.0b	124.2a	40.7a	40.0a	40.2a	26.8c	27.8b	32.5a
34	119.8b	120.0b	121.3a	39.0c	40.5b	40.0a	27.6c	28.6b	35.5a
35	107.0b	107.5ab	108.2a	40.0a	39.0a	39.2a	37.8c	40.0b	42.5a
36	107.6c	110.5b	115.5a	39.7ab	30.0a	39.0b	37.6b	38.9b	40.0a
LSD[2]	5.255	6.359	8.139	2.249	1.681	2.236	3.095	4.051	5.02

[1]Same letter within a row are not significantly ($p \leq 0.05$). [2]The smallest difference in column ($p \leq 0.05$)

most samples increased. Results showed that treatments had tendency towards redness and lesser darkness. Hence the color character of enriched spaghetti was more unsuitable after storage. These results were in agreement with previous researchers, for example study of Duszkiewiccz-Reinhard *et al.* (1988), that showed the color score of spaghetti fortified with flour and concentrate of Legume (navy and pinto) was lower than control and they found disorder changes during storage. On contrary, Pangolin *et al.* (2000) discovered that adding defatted soy flour and sweet potato to formulation of noodle causes increasing of lightness and yellowness and decreasing redness of sample during 6 months of storage.

Conclusion: Addition of FFSF influenced the storage quality of spaghetti samples. This enrichment resulted in significant increases ($p \leq 0.05$) in the acidity after optimum and over cooking time and during storage in room temperature conditions. It was also found that water temperature or screw speed of extruder alone had no significant effect on the acidity content of spaghetti. Also, interaction between screw speed, water temperature and ingredients, showed a negative effect on this characteristic. The color characteristics of dry spaghetti showed significantly negative changes during seventh month's storage and in overall these changes in enriched spaghetti were more. Consequently, on the basis of our results the shelf life of this new product is lesser than traditional spaghetti.

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Abbreviations: FFSF: Full Fat Soy Flour; HWF: Hard Wheat Flour; I: Intensity; H: Hue; S: Saturation.