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NUTRITIONAL VALUE OF SPAGHETTI FORTIFIED WITH LOW FAT SOY AND SWEET POTATO FLOURS

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Zaki[1], Sahar M.; Eman[1] M. Salem and Fathia[1] K.S. Abo Zeid

ABSTRACT

The high consumption of macaroni as one of the most popular food obligate the necessity to develop this product with respect to the nutritional value. Spaghetti was prepared from (100%) semolina as control sample and semolina with 5, 10, and 15% sweet potato flour replacements (SPF) and a constant level (10%) of low fat soy flour (LFS). The chemical, physical and sensory parameters of the prepared spaghetti were evaluated. Supplementing semolina with (SPF) and (LFS) increased the nutritive value of spaghetti. These ingredients provided with β-carotein as a precourses for vitamin A, more protein, essential amino acids, mineral ions and fibers. Added LFS and SPF affected the Hunter L, a and b values. Similarly, high level of SPF additions significantly affected the sensory evaluation of the product compared to the control. It seams that 10% of both soy and sweet potatoes is not different in overall acceptability from the control. The SPF level markedly affects the cooking quality.

Key words: Spaghetti; Fortification; Sweet potato flour; Low fat soy flour; Nutritional value; Quality parameters.

INTRODUCTION

One of the great challenges nowadays is to develop inexpensive foods of nutritionally superior and at the same time acceptable to the intended consumer. Wheat is abundant in some areas of the world and is one of the least expensive cereals available for creating fabricated foods high in nutrition. Pasta, whether it be in the form of flat noodles, elbow macaroni, or spaghetti, is consumed worldwide. It is also economically, easy to prepare, shelf stable, and serves in many different ways. Because pasta is extruded, additives can be easily blended into its formula. The amounts and types of additives that permitted in pasta are controlled by the U.S. Food and Drug Administration (FDA) as published in the **Federal Register (1980)**. Pasta, therefore can be used as a vehicle for production of novel formulated foods.

The changing food consumption patterns have forced many food-deficit countries to import large quantities of grain to meet local demand. There is now a renewed effort to broaden the food base in developing countries by certain varied new food products or improving tradi-

1- Food Technology Res. Institute, Agric. Res. Centre, Giza, Egypt.

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tional staple food products based on indigenous raw material such as sweet potato. Development of low-cost convenience food products may stimulate consumption and, hence, demand for this crop (**Collado and Corke, 1996**) . Pasta products are produced basically from semolina. The establishment of adequate conditions for the production of pasta products for raw native materials would be economic significance. In addition, because of their high popularity, these products could be a vehicle to improve the nutritive value of the habitual diets of most countries.

The variety of products from pasta has increased, in part, through addition of vegetable materials to the basic ingredient of wheat flour or semolina (**Banasik, 1975; Matsuo** ***et al*** **1972 and Molina** ***et al*** **1982).**

Such added ingredients provide different flavors, colors and often additional nutrients such as that may be found in spinach or carrot. Other materials offer potentially for instance as added ingredients to pasta products with sweet potato and soy flour. Both materials are relatively well known and readily available. Each has the potential to provide specific functionality to pasta, especially greater nutritional value.

Researchers use wheat sweet potato composite flour in the production of several types of products such as: Arabic bread **(Balady),** doughnuts, cup cakes, cookies, bread, noodles and spaghetti. **(Hamed,** ***et al*** **1973 a,b; Collins & Aziz 1982 and Collins & Pangloli, 1997).**

From the point of view of nutrition, the macaroni, produced from hydrated semolina, is a pasta product which is typically rich in carbohydrate, but not in protein. It is known to be deficient in essential amino acid lysine but at the same time contains an appreciable quantities of the amino acid methionine **(Seyam** ***et al*** **1983; Bahnassey, 1986 and Bahnassey,** ***et al*** **1986).** Some sorts of fortified pasta product with different sources of protein, e.g :edible legumes, soy protein concentrate, soy protein isolate and soy flour have been started earlier **(Nielsen** ***et al*** **1980; Molina** ***et al*** **1982; Collado & Corke 1996; Collins & Pangloli 1997 and Hussein, 2001).**

This study, have been designed to develop a fortified spaghetti with soy bean and partial sweet potato flour replacements. The various quality parameters of developed spaghetti were evaluated.

MATERIAL AND METHODS

Materials

Semolina was obtained from Sohag Milling Company , Egypt.
(wheat cultivar Sohag 2).

Low fat soy flour (LFS) was obtained from Food Technology Research Institute, Agricultural Research Center, Giza, Egypt.

Sweet potato roots of deep orange color was obtained from Vegetable Research department, Horticulture Research Institute , station at Kalubia, Ministry of Agriculture Egypt.

Methods

Preparation of sweet potato flour

Sweet potato roots were thoroughly washed, hand peeled and then sliced into 15.88mm (5/8 Inch). Slices were held in 1% citric acid solution for 30 sec, then blanched in boiling water for 3 minutes, cooled and spread onto trays and dried at 60°C for 4 hrs by using the air circulated oven, with drying continuing thereafter at 40°C until the material was dry enough for grinding. The dried sweet potato was ground in a cyclone sample mill into a flour to pass through a 60-80 mesh screen.

Preparation of different blends

Different blends were prepared by partial replacement of semolina with 10% low fat soy flour (LFS) and 5, 10 and 15% level of sweet potato flour (SPF) replacement ratios as well as the control sample which was prepared with (100%) semolina for comparison. Table (1) summarize different blends compositions.

Spaghetti processing

Spaghetti was prepared from the above mentioned blends using a Demaco (De Francise Machine Corporation) semi commercial scale laboratory extruder, according to the method described by **Dexter, *et al* (1994).** Spaghetti samples were immediately packed in polyethylene bags and stored at room temperature (23-25°C).

Analytical Methods

A. The materials used in this study as well as the different prepared macaroni were chemically analyzed. Moisture, crude fiber, crude protein (N×6.25), fat and ash were determined according to the official methods of analysis **(A.O.A.C., 1995)**, total carbohydrates were calculated by differences. Minerals (Ca, Na, Mg, Mn, Fe, K and Zn) were determined using Atomic Absorption Spectrophotometer according to the method in **A.O.A.C. (1995)**. Total dietary fiber (TDF) was determined according to the method described by **Prosky *et al* (1985)**.

Amino acids were determined according to the method described by **Walter *et al* (1978)**, using Amino Acid Analyzer LC3000 recording integrator. The amino acid scores were calculated according to the protein reference pattern **(FAO/ WHO, 1989)**. Carotenoids were determined according to the method described in **A.O.A.C. (1995)**.

Physical properties

Color of macaroni was measured with a Hunter Lab Standard No. (2-1968) Model D25. A color and color difference meter Head lines were taken from L (lightness), a (« + » redness, « - » greenness) and b (« + » yellowness, « - » blueness) scales. The instrument was standardized on the white tile standard L = 77.1, a=-1.8 and b=+20.5 **(Hunter 1958)**.

Cooking quality

The increase in macaroni volume and weight were determined according to **Seyam, *et al* (1976) and Lorenz, *et al* (1979)**, cooking loss and optimal cooking time were carried out according to **A.A.C.C. (1983)**.

Sensory evaluation

The quality of cooked spaghetti macaroni were evaluated by ten panelists from the staff of Food and Technology Institute, Agriculture Research Center, Giza, Egypt. Cooked spaghetti samples were organolyptically evaluated for color, flavor, overall acceptability, stickiness

Table 1. Different blends of semolina partially substituted with sweet potato and low fat soy flours.

Sample	Semolina (%)	Sweet potato flour (%)	Low fat soy flour (%)
Control	100	-	-
Blends 1	85	5	10
Blends 2	80	10	10
Blends 3	75	15	10

and Tenderness (according to the method of **Dexter** ***et al*** **1994**). The maximum quality scores for the evaluation of cooked spaghetti were 20,20,20,25 and 15 for color, flavor, overall acceptability, tenderness and stickiness, respectively .

Statistical analysis

The collected data of sensory evaluation were statistically analyzed by the least significant differences L.S.D. at the 5% level of probability procedure according to **Snedecor and Cochran (1982)**.

RESULTS AND DISCUSSION

Chemical composition of raw materials

The composition (on dry basis) and β-carotene with retinol equivalent RE of the different raw flours used in this study (Semolina, low fat soy flour LFS and sweet potato flour SPF) were compared. Results are shown in Table (2). The results of moisture content was varied among the used flours. The highest percentage was recorded for semolina, meanwhile, the LFS gave the lowest percentage. The protein, ash, and total dietary fiber TDF of LFS recorded the highest values. Crude and total dietary fiber of LFS and SPF were higher than those of semolina flour. In case of the fat content and total carbohydrate values varied from flour to another. The SPF for instance recorded the lowest value of fat (1.16), followed by the semolina and LFS flours. Concerning the amount of total carbohydrate the most of which was found in semolina that reached (76.83%). These obtained results are coincidence with the previously reported chemical composition for semolina, low fat soy flour and sweet flours which were carried out by many investigators. In this respect, **Matsuo and Dexter** (1980), reported that semolina streams contain protein and ash from 11.2-14.3% and 0.49-1.10%, respectively, **Molina** ***et al*** **(1982)** mentioned that semolina flour contain 1.31 ether extract, 0.63 ash, and 2.93 nitrogen while defated soy flour contains 9.24, 1.76, 3.55 and 5.96 nitrogen, ether extract, crude fiber and ash. **Malcolmson** ***et al*** **(1993)** found that semolina is composed of 10.3-17.3% protein and 0.62-0.78% ash. **Collado and Corke** (1996) mentioned that SPF protein ranged from 2.6 to 3.2% and from 57.1 to 68.4% for total starch. Meanwhile, **Collins and Pangloli,** (1997) found that

Table 2. Chemical composition of semolina low fat soy flour LFS and sweet potato flour SPF on dry basis

Component	Semolina	Low fat soy flour	Sweet potato flour
Moisture	12.40	4 80	10.80
Protein %	14.90	48.21	5.82
Ether extract %	1.22	5.86	1.16
Ash %	1.13	5.91	4.22
Crude fiber	1.12	4.50	5.70
Total dietary fiber	4.80	16.20	15.52
* Total carbohydrate	76.83	19.33	67.60
β-carotein (mg/100g)	2.90	0.33	53.11
** R.E.	484.30	55 11	8869.37

* Calculated by difference

** R.E.: Retinol equivalent = 0.167 × μg β-carotein.

the proximate composition of SPF were: 5.2%, 5.8-6.1%, 0 8%, 2.5%, 16.0% and 74.6% for moisture, protein, fat, ash, TDF and carbohydrates, respectively.

They also mentioned that defatted soy flour composition was 2.7%, moisture, 50.9-52.3% crude protein, 0.8% fat, 6.7% ash, 17.4 TDF, and 22.8% carbohydrates. Our results were also confirmed with that of **Hussein, (2001)**. He mentioned that the main chemical composition of SPF was 5.82%, 1.26, 4.13, 5.57, 83.22 and 12.38% for protein, fat, ash, crude fiber, total carbohydrate and moisture, respectively.

β-carotene in raw material

Concerning the β-carotene content of the different raw materials, results in Table (2) indicated that the sweet potato flour recorded the highest amount of β-carotene, 53.11 mg/100gdw of retinol equivalent of 8869.37 compared with semolina and LFS which recorded the lowest values 0.33 mg/100 dw and 55.11. These results in accordance with those obtained by **Collins and Pangloli (1997)**, they mentioned that the SPF, DFS recorded 55.06, 0.02 mg/100g dwb and Retinol equivalent (RF) 9, 176, 4 RE/100g, respectively. In this concern, **Collado *et al* (1997)** mentioned that yellow pigment as carotenoids (μg/g of SPF) ranged from 2.9 to 150.6 with a mean of 13.80. **Oke (1990)** reported that the selected deep yellow sweet potato varieties are rich source of pro-vitamin A in the form of the pigment β-carotene.

Regarding to the β-carotene in semolina, our value is in harmony with the results of **Borrelli, *et al* (1999)**. Their mean value of β-carotene content (ppm/dmb) in semolina was in the range of 2.67-4.87 in six cultivars during 1994-1995 in three location of southern Italy.

In summary, the high content of protein in LFS and β-carotene in SPF besides the ash and fiber both in LFS and SPF is supporting the possibility of using this material as fortified pasta products with relatively high nutritive value.

Chemical composition of different blends of spaghetti

Different blends of spaghetti macaroni were prepared by partial replacement of semolina with levels of 5, 10 and 15% sweet potato flour SPF and 10% of low fat soy flour LFS. All blends were chemically, analyzed for protein, fat, ash crud fiber, total dietary fiber TFD, total carbohydrate and β-carotene, as shown in Table (3).

Results in Table (3) show that addition of SPF and LFS to semolina has increased protein, ash, fat, fiber, β-carotene and retinol equivalent. Therefore the total carbohydrate was decreased. The protein content was raised up to be 17.77 in spaghetti with 10% LFS and 5% SPF, while original spaghetti had the lowest protein value of 14.80%. The protein content decrease with increasing the addition of SPF but all blends were higher than the control. On contrary, ash, fiber, β-carotene and R.E. were increased with increasing the levels replacement of SPF. Concerning TDF content of control spaghetti recorded the lowest value 4.80 compared with the fortified spaghetti with SPF and LFS, which ranged between 6.52-7.58%. These results mean that such fortified spaghetti would provide an important dietary fiber of contribution to prevention against some diseases (**Dreher, 1987**). Food and Drug Administration regulation provide for Daily Recommended values (DRV's) of 25g dietary fiber/day/2 00 Kcal diet (**Fedderal Register 1993**). The obtained results in Table (3), also indicated that the fortified spaghetti with SPF and LFS contained enough amounts of pro-vitamin A, expressed in retinol equivalent RE. In this concern, the samples which contained 5% SPF provided 858 RE/100g, about 85% of the RE recommended for an adult male or about 106.9% recommended for an adult female (**N.R.C, 1989**). This means that the spaghetti samples which contained 10 or 15% SPF besides 10% (LFSF) would provide more than the (RDA) of RE for both adults man and women. Concerning the total carbohydrate values, it is noticed that the control spaghetti contains the highest value (76.83%) which decreased with added SPF and LFS.

The obtained results are in agreement with those observed by **Abo-El-Naga (1995), Kamal, (1998)** and **Collins and Pangloli, (1997)** who mentioned that the carbohydrate level of control nodel decreased with added sweet potato and defatted soy flour.

Minerals content of prepared blend of spaghetti

Minerals content of semolina, SPF, LFS and different prepared spaghetti samples were determined and the results are summarized in Table (4). From these data, it could be observed that the mineral content (mg/100g samples) of semolina was as follows: 15.80 Ca, 4.69 Na, 142 K, 62.13 mg, 0.80 Mn, 1.60 Fe, and 1.30 Zn. It is noticed that SPF contains the

Table 3. Chemical composition of spaghetti produced from semolina partially replaced with (LFS)* and (SPF) **

Component	Control *** spaghetti	Spaghetti with 10% LFS +		
		5% (SPF)	10% (SPF)	15% (SPF)
Protein %	14.80	17.77	17.42	16.86
Ether extract %	1.22	1.59	1.56	1.53
Ash %	1.11	1.21	1.39	1.57
Crude fiber	1.12	1.68	1.91	2.12
Total dietary fiber	4.80	6.52	7.05	7.58
Total carbohydrate	76.83	71.47	70.15	69.79
β-carotein (mg/100g)	2.72	5.14	7.66	10.16
**** R.E.	454.27	858.38	1279.22	1696.72
Moisture	12.84	12.42	11.99	11.45

* LFS = Low fat soy flour
** SPF = Sweet potato flour
*** Control = Spaghetti made from 100% semolina
**** R.E. = Retinol equivalent = 0.167 X μg β-carotein.

highest values of K (1220) and Na (130) mg/100g. when compared with semolina and LFS Meanwhile, the LFS recorded the highest values which were 124, 20, 13.5, and 8.5mg/100g dw. for Ca, Mg, Fe and Zn, respectively. Consequently, we could observe that the spaghetti fortified with SPF and LFS contained higher amounts of minerals especially K, Ca, Na, Mg and Fe compared with control spaghetti (100% semolina). This means that the fortified spaghetti with SPF and LFS contains an increment of Ca (2.2 - 4.9%), Na (1.80-2.25%). K (1.2 - 1.16%), Mg (1.88%), Fe(1.84-1.88%) and was 1.6% in Zn .In general mineral shifts for K, Na, Ca increased with the increment of SPF levels from 5 to 15%. **Bahnassey *et al* (1986)**, found that the minerals content of legumes flour or protein concentrates and fortified spaghetti was considerably higher than the semolina or control spaghetti. The results are closer to that reported by **Hussein (2001).**

Amino acids composition in different blends and spaghetti

The amino acid content of different blends and prepared spaghetti were determined and results are presented in Table (5) as relative percentage. The essential amino acids were compared to the protein reference pattern **(FAO/WHO, 1989)**. Comparing the amino acids of semolina with those of LFS and SPF indicating that semolina showed higher values for glutamic acid (32.99%), the

Table 4. Mineral content of different blends of spaghetti (mg/100g) dwb

Minerals (mg/100g dw)	Semolina	SPF	LFS	Different blends of spaghetti with 10% LFS			
				Control	+ 5% SPF	+ 10% SPF	+15% SPF
Ca	15.80	124.00	192.00	15.62	37.00	40.00	43.00
Na	4.69	130.00	28.30	4.57	10.50	16.90	23.10
K	142.00	1220.10	350.20	140.00	261.00	265.00	315.00
Mg	62.13	22.00	209.00	62.11	75.00	73.00	72.00
Mn	0.80	2.50	3.40	0.70	0.85	0.92	0.97
Fe	1.60	2.10	13.50	1.52	2.81	2.84	2.86
Zn	1.30	0.24	8.50	1.24	1.98	1.90	1.85

Table 5. Amino acid composition and amino acid score of raw flours and different prepared spaghetti

Amino acids (g/100g)	Semolina		Sweet potato flour		Low Fat Soy Flour	
	A.A*	A.A.S**	A.A*	A.A.S**	A.A*	A.A.S**
Essential						
Lysine	1.47	26.72***	3.10	56.36	4.52	82.18
Threonine	2.42	60.50	5.80	145.0	5.60	140
Valine	3.14	62.80	5.20	104.0	3.52	70.40
Methionine + Cystine	3.15	90.00	1.95	55.71***	1.80	51.43***
Isoleucine	2.19	54.75	4.10	102.5	4.20	105
Leucine	5.5	79.57	4.00	57.14	8.30	118.5
Phenylalanine	4.96	88.57	5.80	103.5	4.66	83.21
Non-Essential Histidine	2.10		3.70		2.30	
Arginine	3.50		3.80		5.50	
Serine	6.19		3.60		5.20	
Aspartic	3.80		17.40		12.6	
Glutamic	32.99		11.30		21.2	
Glycine	6.16		4.60		4.80	
Alanine	3.47		5.40		4.95	
Tyrosine	1.18		4.00		2.47	
Proline	13.92		5.20		5.21	

Table 5. Cont.

Amino acids (g/100g)		Different blends of spaghetti with 10% LFS						FAO/ WHO 1989
		+5% SPF		+10% SPF		+15% SPF		
		A.A*	A.A.S**	A.A*	A.A.S**	A.A*	A.A.S**	
Essential								
	Lysine	1.87	34.00***	1.97	35.82***	2.06	37.45***	5.50
	Threonine	2.91	72.75	3.07	76.75	3.25	81.25	4.0
	Valine	3.28	65.60	3.38	67.60	3.49	69.80	5.0
	Methionine + Cystine	2.99	85.43	2.96	84.57	2.93	83.71	3.5
	Isoleucine	2.48	62.00	2.58	64.50	2.67	66.75	4.0
	Leucine	5.51	78.57	5.45	77.85	5.38	76.85	7.0
	Phenylalanine	5.25	93.75	5.37	95.89	5.48	97.86	4.7
Non-Essential	Histidine	2.20		2.28		2.36		
	Arginine	3.72		3.73		3.75		
	Serine	6.06		6.03		6.00		
	Aspartic	5.36		6.04		6.72		
	Glutamic	30.72		29.64		28.55		
	Glycine	6.56		6.68		6.77		
	Alanine	3.85		3.92		4.10		
	Tyrosine	1.44		1.58		1.72		
	Proline	12.61		12.17		11.74		

A.A * = amino acid , A.A.S** = amino acid score , *** = chemical score = the lowest value of amino acid score sulfer containing amino acids methionine and cystine (3.15%) but not in lysine (1.47%). On the other hand, the LFS and SPF contain more than 3.1% and 2.4% times as much lysine as semolina, and for therionine 2.3, Isoleucine 1.9 respectively. The SPF recorded the highest values of valine (5.2%) and phenyl- alanine (5.80%) compared with semolina and LFS. Concerning the data of chemical score of different flours, we could observe that the first limiting amino acid in semolina was lysine, meanwhile in SPF the first limiting amino acid, was methionine and cystine. The obtained data also indicated that the first limiting amino acid in LFS was methionine and cystine. The results indicate that LFS and SPF are capable of fortifying spaghetti with more protein and essential amino acids. The major non essential amino acid in LFS was found to be glutamic acid (21.20%) followed by aspartic acid (12.60%) while the major non essential amino acid in SPF is aspartic (17.40%) flowed by glutamic (11.30%). The highest value of glutamic acid was in semolina (32.99%). The obtained results were in coincidence with (**Seyam *et al* 1983; Bahnassey, *et al* 1986**). **Luis *et al* (1998) and Hussein, (2001)** reported that the major essential amino acid in defatted soy bean was leucine 8.44% followed by thereonine 6.77%, Lysine 4.77% then phenyalanine, isoleusine and valine.

They also mentioned that the metheoine was found to be the limiting sulfer amino acid.

The results in Table (6) were confirmed by those of **Ravindran *et al* (1995)**. They mentioned that the amounts of most essential amino acids in sweet potato tubers confirmed to the reference protein pattern recommended by **NAS/NRC (1988)**, except for sulfur containing amino acids plus lysine and leucine.. **Purcell *et al*** (1972) also reported that sulfur containing amino acids and lysine was found to be first and second limiting amino acids in sweet potato, respectively.

Bradbury *et al* (1985), found that in addition to these amino acids, leucine was limiting in some cultivars. In general, aspartic acid, glutamic acid, alanine and proleine were higher in the low protein cultivars, and phenyl-alanine, lysine, threonine, and cystine were higher in the high protein cultivars (**Ravindran *et al* 1995**).

The amino acid composition of spaghetti fortified with LFS and replacement of 5, 10 and 15% SPF was also evaluated, as shown in Table (6). These results gave the same trend as in the raw flours compared with the control spaghetti made with 100% semolina. The spaghetti made from LFS-SPF blends had a much better AA balance especially in the essential amino acids, particularly; lysine, therionine, valine, isoleucine and phenylalanine (**Bahnassy *et al* 1986**).

The higher values of amino acids were found in spaghetti contained 10% LFS and 10% or 15% SPF. Moreover, the chemical score of different fortified spaghetti were higher than control sample. Therefore, blending semolina with LFS and SPF can enhance nutritional quality.

Physical properties of macaroni blends
Color

Added SPF and LFS affected the Hunter L, a and b values of different spaghetti samples compared to control at 100% semolina as shown in Table (6). It was found that the added SPF and LFS

Table 6. Hunter color measurements of different blends of spaghetti

Treatments	Color parameters		
	whiteness L	redness a	yellowness b
- Control Spaghetti *	70.52	+2.30	16.8
- Spaghetti (with 10%) LFS			
and 1. 5% SPF	61.20	+3.00	18.20
2. 10% SPF	59.50	+3.40	22.30
3. 15% SPF	57.80	+3.90	23.40

* Control spaghetti (100% semolina)

negatively affect the lightness Hunter (L) of spaghetti, producing darker pasta compared with control sample. With each increasing of SPF level lightness tended to decrease. On the contrary, the Redness values (a_L) increased with higher levels of SPF, to be 3.9 in sample No.3. Also, yellowness (b_L) values increased with increasing levels of SPF. Spaghetti prepared with 15% SPF had yellower color than the other samples. These results were closer to those of **Collado & Corke, (1996); Collado *et al* (1997) and Collins & Pangloli (1997).** They mentioned that noodles produced from composite flours were generally darker in color, and the redness (yellowness) (Hunter a_L, b_L) values increased with additive of SPF. Meanwhile, the DFS had no effect on redness and produced some lowering the Hunter b_L value.

Cooking quality of prepared spaghettis

Cooking quality of different cooked spaghetti were evaluated (weight and volume increase) after cooking for 20 min as well as the cooking loss (% T.S.S.). Results are shown in Table (7). Addition of sweet potato and LFS increased the percentages of weight, volume increased and cooking loss. These percentages increased with increasing the replacements of (SPF). So, the blends contain 10% LFS with 15% SPF recorded the highest percentages of weight, volume as well as the cooking loss compared with control and other samples. These results were in agreement with those of **Collins and Pangloli (1997).** They found that cooking loss at 10% DFS addition was 1.8 times that of control, and they also mentioned that cooking loss increased with increasing the levels of SPF to 15%. Similar data were reported earlier **(Bahnassey & Khan, 1986); Breen *et al* 1977 and Singh *et al* 1989).** Moreover, **Hussein, (2001),** found that macaroni contained sweet potato powder and pumpkin had higher values for cooking loss, weight and volume increase compared with control. Also, **Dexter *et al* (1994)** reported that good quality macaroni products should absorb water at least

Table 7. Cooking quality of different blends of spaghetti

Treatments	Weight increase (%)	Volume increase (%)	Cooking loss %T.S.S
- Control Spaghetti *	220.10±1.12	215.20±1.73	7.50±0.14
- Spaghetti (with 10%) LFS			
and 1. 5% SPF	224.30±2.30	220.50±1.15	7.67±0.57
2. 10% SPF	235.20±1.43	245.10±2.88	8.28±0.57
3. 15% SPF	247.10±1.15	290.30±5.77	10.32±1.15

* Control spaghetti (100% semolina).

Table 8. Sensory acceptability and texture intensity of different blends of spaghetti

Treatments	Acceptability			Texture intensity	
	Color	Flavour	Overall	Tenderness	Stickness
1. Control Spaghetti (100% semolina)	18.37^{a}	18.62^{a}	18.62^{a}	24.37^{a}	18.75^{a}
2. Spaghetti (10%) LFS					
and 5% SPF	10.50^{c}	11.12^{c}	11.12^{c}	19.25^{b}	14.37^{b}
: 10% SPF	15.38^{b}	15.63^{b}	18.37^{a}	19.37^{b}	18.50^{a}
: 15% SPF	10.87^{c}	14.62^{b}	14.87^{b}	19.25^{b}	14.75^{b}

Mean have the same letter are not significant twice of their original volume. They also mentioned that the cooked weight and volume of substituted spaghetti were higher than those of control. In this concern, **Abo-El-Naga (1995)** found that the increased dietary fiber in substituted spaghetti samples increases cooked weight and volume of spaghetti.

Sensory characteristics of different cooked spaghetti

Cooked spaghetti prepared with different blends were organoleptically examined for color, flavor, overall acceptability, tenderness and stickiness. Results are shown in Table (8). Regarding all parameter of sensory evaluation, significant differences were observed. The highest scores were in the control spaghetti followed by spaghetti replaced with both 10% of LFS and SPF. The Spaghetti replaced with 10% LFS and 15% SPF were ranked as the lowest score. The spaghetti replaced by 10% LFS and 10% SPF were the most favorable in color, flavour overall acceptability and texture intensity among the three tested samples. These results were confirmed to those previously obtained by **Hussein, (2001)** with some exceptions. He mentioned that the statistical analysis indicated that significant difference was found between control sample and supplemented samples with respect to odor and taste of macaroni containing 10 and 15 %SPF yellow sweet potato powder, respectively. These samples, however, were found to be insignificantly differ than control for overall acceptability. Our results were confirmed by the results of **Collins and Pangloli, (1997)**.

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مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس ، القاهرة ، م٤٨ ، ع(١)، ٢٢٥-٢٤١ ، ٢٠٠٣

القيمة الغذائية للاسباجيتى المدعمة بدقيق الصويا منخفض الدهن ودقيق البطاطا

[١٧]

سحر محمد زكى[١] - إيمان محمد سالم[١] - فتحية كمال سليمان[١]

١- معهد تكنولوجيا الأغذية - مركز البحوث الزراعية - جيزة - مصر

إن معدل الإستهلاك العالى للمكرونة كأحدى أشهر الوجبات الغذائية العالمية يفرض ضرورة هذا المنتج من الناحية الغذائية . تم تجهيز الأسباجيتى من دقيق السيمولينا بنسبة (١٠٠%) كعينة قياسية ، وكذلك استبدال دقيق السيمولينا بدقيق البطاطا بنسبة ٥ ، ١٠ ، ١٥% بالإضافة إلى ١٠% من دقيق الصويا المنخفض الدهن . تم تقييم كل من الخواص الكيماوية والطبيعية والحسيه للإسباجيتى . وجد أن استبدال السيمولينا بكل من دقيق البطاطا ودقيق الصويا المنخفض الدهن أدى إلى زيادة القيمة الغذائية للإسباجيتى . هذه المكونات أدت إلى زيادة نسبة البيتاكاروتين (مولد فيتامين) وزيادة البروتين والأحماض الأمينية والأملاح وكذلك الألياف . كما وجد أن إضافة البطاطا والصويا قد أثر على قيم قياس اللون بجهاز الهنتر وهى L, a, b وبالمثل وجد أن النسب المرتفعة المضافة من دقيق البطاطا قد أثر بصورة معنوية على التقييم الحسى للمنتج مقارنة بالعينة القياسية . وقد أتضح أن إضافة نسبة ١٠% لكل من دقيق الصويا والبطاطا لم تختلف فى درجة قبولها عن العينه القياسية . كذلك أثرت نسبة إضافة دقيق البطاطا على خواص الطبخ .

تحكيم: أ.د رمضان محمد محمود
أ.د علـى إبراهيـم سيد