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ACCEPTABILITY OF NOVEL SNACKS MANU-FACTURED BY PARTIALLY CORN SUBSTITUTION WITH UNTRADITIONAL FOODSTUFFS

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ABSTRACTS

The attractive colors of many red and yellow fruits and vegetables are attributable to their carotenoid contents. Therefore, a child lovely food form (extrudate as snacks) was formulated by partially introduction of ß-carotene rich foodstuffs (carrot, pumpkin and sweet potatoes). The tested materials were individually blanched, in water, 5% citric acid or 1% sodium metabisulfite, cooled, dried and milled. The milled products were subjected to extrusion process and these produced extrudates were put under investigation.

It was found that the chemical constituents, except the ether extract, in the extrudate products was higher in samples blanched in water compared to those blanched in the other blanching solutions. The same trend was also found in case of water and oil retention of the sweet potatoes and pumpkin extrudates. On the contrary, the higher values were noticed in the carrot extrudate samples blanched in sodium metabisulfite followed by those blanched in citric acid and water. ß-carotene of the extrudate samples blanched in citric acid or sodium metabisulfite was superior than the other tested materials including the control extrudate sample (corn). There was a minor change in color indicator (L, a and b) of all samples during the storage period at ambient temperature. The sensory evaluation of the extrudate samples reveals that the blanching treatment enhanced the tested attributes scores to be higher than the corn extrudate.

Keywords: Carrot, sweet potatoes, pumpkin, extrudate, sensory evaluation.

INTRODUCTION

It is now becoming increasingly apparent that Vitamin A Deficiency (VAD) is responsible for a wide variety of disorders. So, it is of importance to be interest in a relatively uncommon blinding disease of children, happening as a result of VAD, that was primarily the responsibility of ophthalmologists and pediatricians which has expanded in recent years to include a concern about one of the major public health factors in developing countries threatening survival and well-being in young children and other vulnerable groups (Zeitoun, 2000 and Omaye *et al.*, 1996). The potential role of antioxidant nutrients could be assigned in the prevention of major chronic diseases such as cancer and coronary heart disease (McLaren and Frigg, 2001). Carotenoids appear to be involved in the protection against singlet and triplet oxygen. Singlet oxygen is known to be capable of damaging DNA (Beutner *et al*, 2001).

Carrots, beside the pleasant taste, contribute to the intake of carotene, minerals and dietary fibers, therefore, are extensively utilized in the food industry, domestic and world markets (Kaminski *et al.*, 1986). As a crop, sweet potatoes combating the food shortages and malnutrition that may increasingly occur as a result of population growth and pressure on land utilization. The sweet potatoes could be considered a staple or vegetable food, a sweet dessert, fast food chips, a snack (crisps) a multi purpose flour, a starchy industrial raw material and has a number of outstanding nutritional characteristics, which could make it a valuable tool for solving certain severe and widespread nutritional problems in the developing world (El-Said, 2000). Pumpkin, also, is rich in ascorbic, nicotinic, pantothenic and folic acids, and is an industrial raw material for carotene production. It is also, particularly used in alleviate cardiovascular diseases and constipation of stomach or intestines, good diuretic and used in treatment of diabetes, rheumatism, eczema and burns as well as against warms and other parasites (Vucetic *et al.*, 1989). Pumpkin, as all other deep yellow vegetables, is an excellent source of vitamin A. Half a cup (125 g) provides 7840 International Units of the vitamin (Anon, 1975). Local Egyptian varieties of carrots, sweet potatoes and pumpkin possessed detectable amounts of protein, fat, ash, crude fibers and total carbohydrates, and minor components, vitamins and minerals (Anon, 1996). Therefore, it could be considered a good source of such components for children especially, when served in a lovely form.

Blanching is a vital process for most vegetables since it usually causes microorganisms destruction, enzyme inhibition, improves the texture, color, flavor and nutritional quality stability (Williams *et al.*, 1986). For many years ago, sulfur dioxide (SO_2) has been used as antioxidative and preservative agents to maintain the color of processed fruits and vegetables. The maximum allowable sulfite residue concentration for carrot products in US is 200 PPM (Zhao and Chang 1995). Extrusion is a large-scale food processing technique and a standard procedure for the manufacturing of many snack foods (Lee *et al.*, 2000). It is a continuous high temperature short time that using both temperature and pressure for expansion. Treating the materials containing starch and protein leads to changes in properties of the extrudate depending upon the type and amount of energy transferred, the used machine and the raw materials (Mathew *et al.*, 1999).

The objective of the present study is a trail to manufacture a highly acceptable snack food by partially using some untraditional processed ß-carotene rich foodstuffs compared to that produced from the traditional corn.

MATERIALS AND METHODS

Materials:

Carrots (*Daucus carota L.*), sweet potatoes (*Ipomoea batatas L.*) and pumpkin (*Curcubita pepo L.*) samples were obtained from the local market at Giza Governorate, Egypt.

Preparation methods:

Vegetables were washed, drained, hand peeled and cut into slices. The fleshes of each type were treated in one of three boiling blanching solutions, water, 5% citric acid or 1% sodium metabisulfite in (1:4 v/v) ratio for 3 min. The different samples groups were cooled drained and dried in a forced air oven at 60°C. for about 6 hr. The dried samples were ground and kept in plastic pouches until the extrusion process had been carried out.

Extrusion process:

10% of the whole milled yellow corn (the control) were substituted by the ground samples and individually used to produce the snacks through extruding these materials in the Al Rabaela for Foods Industries Factory, The

Industrialized Zone at Al Obour City. The extrusion process was carried out using a Barabender Laboratory single-screw extruder, 186401, type 832400, equipped with a feeding screw AEV 300, No 141923, type GNF 1014h, a speed control of feeding device, temperature regulators for two extruder zones and a die head. The extrusion process conditions for the three zones temperatures were 90°, 130° and 200°C., for the screw speed was 249 min^{-1} and for the feeding screw speed was 160 min^{-1}. The tested materials were conditioned in the first step of processing by adding appreciated amount of water and oil (1:2 ratio, v/v) to be adjusted to 18%. The water and oil amount were slowly added during stirring using a laboratory mechanical stirrer. The conditioning product was extruded in the second step under the conditions previously mentioned. The spices were dissolved in oils then sprayed on the extrudate product in the third step of processing. The resultant extrudates were directly dried in an air forced dryer oven at 110°C for 5 min and left to equilibrate with the room temperature.

Chemical analysis:

Moisture, protein, ether extract, ash and crude fibers contents of the manufactured snacks (corn and tested materials) were determined according to the AOAC (1990). The total carbohydrates were calculated by difference. ß-carotene was determined using High Performance Liquid Chromatography (HPLC), Hewllet Packard (HP) 1050 model provided with HP pump, HP degasser, HP autosampler and HP Variable Wavelength Detector, in the unextrudated and extrudated samples according to the method of Pupin *et al.*, (1999).

Water and fat retention ratios were measured according to the method of Mudhar *et al.*, (1989), with a minor modification, by placing one g of the tested sample before and after extrusion process with amount of water or fat (10 ml) in centrifuge cups and stirring at 1000xg for 15 min. The precipitated material was filtered, drained, weighed and the water as well as fat retention ratio was calculated by dividing the drained sample weight by the original weight sample (1 g) and multiplied by 100.

The color stability of the snacks, extrudate corn as a control and the extrudates of different treated samples of carrot, sweet potatoes and pumpkin, was measured according to the method of Hunter (1958) using a color differences meter instrument (Hunter Lab model D25). Samples were put in a 90 and 12 mm height and diameter, respectively, glass Petri dish. The instrument was standardized by adjusting to the white standard value (L=92.5, a=+1.0 and b=+0.6). The dish was completely filled with no space or air bubbles between the cover and the sample and the L, a and b values were recorded within a storage period of 16 days at ambient temperature.

Sensory properties:

Sensory attributes of the tested samples were organoleptically estimated by a well trained staff Food Technology Research Institute. These quality attributes were scored on a scale of 10 points for the excellent degree as recommended by Notter *et al.*, (1959). The mean attribute scores were statistically analyzed for ranking and detecting the significant differences *through the determination of analysis of variance and least significant* differences (LSD) by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Chemical constituents of the extrudated products:

Data presented in Table (1) show that the moisture content of sweet potatoes and pumpkin snacks blanched in citric acid or sodium metabisulfite were very close to the moisture content of the control snack sample (manufactured by corn). On the other hand, there was a detectable increment in the moisture content of the sweet potatoes and pumpkin partially substituted extrudate blanched in water. However, moisture content of all partially substituted extrudate carrot samples was higher than those of two extrudate materials and the control sample (extrudate corn). It could be regarded to that the moisture content in raw samples of carrots is higher than in sweet potato, 89.18 and 74.89%, respectively, as reported by El-Said (2000) and the influences on the processed product yield during dehydration (Toul and Popisilova, 1963). Protein content exhibited the largest variation in corn, whereas, the protein content in all other extrudates seemed to be in a narrow amount. These may be due to the variation in protein content of the initial materials reported by Bao and Chang (1994). The highest amount of ether extract of all extrudate samples, corn and other samples, was regarded to the conditioning step by oil and water (2:1, v/v) in the first step of manufacturing and the oil spraying in the third step of snack production as previously explained. The different extrudate sorts of sweet potatoes possessed the highest amount of ether extract than the other foodstuffs extrudates and control, whereas, the pumpkin extrudate has the highest content of crude fiber.

Table (1): Chemical composition of the different extrudate products (% on dry weight basis).

Materials	Moisture Content	Protein content	Ether extract	Fiber	Ash	Carbohydrates
Corn	3.33	8.10	23.00	2.50	2.12	60.95
The 10% substituted extrudate samples blanched in water						
Carrot	6.23	6.51	18.56	4.00	3.55	61.15
Sweet potatoes	4.66	6.00	25.12	5.11	4.00	55.11
Pumpkin	4.82	6.92	18.15	5.88	5.50	58.73
The10% substituted extrudate samples blanched in Citric acid						
Carrot	4.39	5.63	20.11	3.68	3.23	62.96
Sweet potatoes	3.67	5.23	26.00	4.72	3.86	56.52
Pumpkin	3.65	5.82	21.62	5.23	5.07	58.61
The 10% substituted extrudate samples blanched in sodium meta bisulfite						
Carrot	5.12	5.00	22.00	3.52	3.00	61.36
Sweet potatoes	3.33	4.92	24.52	4.64	3.25	59.34
Pumpkin	3.33	5.15	23.17	5.15	4.98	58.22

The same trend of fiber content could be found in case of ash content, but the different extrudate carrot products and corn possessed the highest amount of total carbohydrates (Table, 1). It showed also that the 10% substitution of the tested foodstuffs increased the fiber contents, which are higher in such materials as reported by Anon, (1996) and El-Said (2000). It could be also reported that the novel extrudates were more nutritious than the traditional products with respect to their contents of fiber and minerals which possess an nutrition impact on the consumer health. However, the differences in each constituent could be summarized, as previously mentioned, in the variation in the original amount of each components and the effect of the processing treatments.

ß-carotene is a useful component, as provitamin A, in preventing cancer, higher dietary and blood level of ß-carotene predict a lower prevalence of lung and gastrointestinal cancers (Meydani *et al.*, 1994; Zhang *et al.*, 1992 and Zeegler, 1989). Therefore, ß-carotene content in the tested products was estimated in relative to the control sample content and the results are illustrated in Table (2). It shows that citric or bisulfite blanched carrot possessed the highest ß-carotene amount followed by sweet potatoes and pumpkins blanched in bisulfite and the corresponding samples blanched in citric acid. It simply means that the ß-carotene carrot samples were more sensitive to blanching in bisulfite solution than citric acid. On contrary, both of sweet potatoes and pumpkin were more sensitive to blanching in citric acid than in bisulfite solution. With respect to the extrudated samples, a dramatically reduction in ß-carotene was noticeable. It could be regarded to that the expected ß-carotene amount should be as the 10%, the replacement percent, of the blanched one.

Table (2): ß-carotene of the tested blanched materials and the extrudate 7products (µg/100g on dry weight basis).

The extrudate corn	17.0		
The non extrudate sample	**Blanched in**		
	Water	**Citric acid**	**Sodium meta bisulfite**
Carrot	ND	31410.8	2177.0
Sweet potatoes	ND	135.2	244.9
Pumpkin	ND	14.0	241.9
The 10% substituted extrudate sample	**Blanched in**		
	Water	**Citric acid**	**Sodium meta bisulfite**
Carrot	90.3	138.3	9.7
Sweet potatoes	19.8	5.7	ND
Pumpkin	8.5	8.2	7.2

ND Not determined

This decrement may also be the result of extrusion process in all the tested samples compared to the sample produced before extrusion. It could be demonstrated by learning that the blanching process is a simple heating only and it resulted in a lower reduction (reached 20-30% as reported by Rogers *et al.*, 1993). On the other hand the severe effect may be regarded to the extrusion process including high severe temperature and pressure (as previously mentioned by Lee *et al.*, 2000 and Mathew *et al.*, 1999). It could also be found that ß-carotene destruction may be due to the heat treatments through the preparation and manufacturing methods (Hamed, 1980).

Physical properties of the extrudated products:

With respect to the water and fat retention, Table (3) reveales that the water holding capacity of all the tested samples, blanched in the different solutions, is higher than the fat holding capacity of the corresponding samples. This simply refers to that the blanched samples in all the different solutions were more related to the water than to the oil phase. On the other hand, the water retention values of the samples blanched in water were higher than the corresponding samples blanched in the other solutions. However, no specified pattern could be detected with respect to the fat retention of all the tested samples. The changes in fat and water retention confirm the observation of Williams *et al.*, (1986) being related to the blanching process effect on the tissues expansion and the variation may be due to the widespread differences in the nature of the tissue and the blanching solution type. The extrusion process showed a varied effect on the water and fat retention, however, both characteristics in case of the water blanched sample of the pumpkin partially substituted extrudates were higher than the other materials, including the blanched samples only. These results are confirmed by the observation of El-Said (2000). The increment may be due to the higher fiber amount in the partially substituted materials and due to the degradation or dextrinization of starch as a result of extrusion process (Likimani *et al.*, 1991).

Table (3): Water and fat holding capacity (%) of the tested blanched materials before and after extrusion process.

The non extrudate corn	Water holding capacity			Fat holding capacity		
	144			128		
The non extrudate sample	Blanched in					
	Water		Citric acid		Sodium meta bisulfite	
	Water	Fat	Water	Fat	Water	Fat
Carrot	428	84	306	106	284	122
Sweet potatoes	378	114	306	108	298	84
Pumpkin	316	110	282	82	212	98
The extrudate corn	Water			Fat		
	264			410		
Substituted extrudate sample	Blanched in					
	Water		Citric acid		Sodium meta bisulfite	
	Water	Fat	Water	Fat	Water	Fat
Carrot	342	220	228	350	170	374
Sweet potatoes	328	214	332	326	322	316
Pumpkin	420	286	314	260	306	126

Color of the extrudate samples (Table 4) were estimated by monitoring the "L" (lightness graded from 0 to 100, darker to whiter), "a" (redness to greenness) and "b" (yellowness to blueness).

These parameters varied from one snack to another. It may be due to the different impact of the extrusion process. It could be noted that the control sample was lighter than the other products, regardless the blanching solution.

The "a" parameter value, which referred to that the redness color, was lower in the control sample than the other extrudated samples under investigation. The "b" parameter value of the control sample was closest to the carrot values, but was lower in the other tested extrudated samples confirming that the yellowness of the other samples were greater than the control one (tend to be blueness).

Table (4): Color stability (L, a and b)* of the tested extrudate products within 16 days of storage at ambient temperature.

Corn (control)	L			a			b		
	72.38			+11.70			+19.30		
Substituted extrudate sample	**Blanched in**								
	Water			Citric acid			Sodium meta bisulfite		
	At zero time								
	L	a	b	L	a	b	L	a	b
Carrot	66.22	+12.41	+18.33	63.38	+10.18	+18.80	64.72	+11.91	+19.33
Sweet potatoes	62.79	+8.41	+15.50	60.84	+9.35	+16.03	61.32	+9.50	+15.62
Pumpkin	61.30	+7.18	+11.30	58.33	+8.42	+13.41	56.44	+8.30	+12.21
Substituted extrudate sample	**After 4 days of storage**								
	L			a			b		
Corn	72.18			+11.33			+19.35		
Substituted extrudate sample	L	a	b	L	a	b	L	a	b
Carrot	61.30	+12.30	+18.24	63.30	+10.15	+18.72	60.62	+11.72	+19.28
Sweet potatoes	62.77	+8.10	+15.50	60.80	+9.30	+16.00	61.33	+9.50	+15.61
Pumpkin	61.26	+7.05	+11.26	58.24	+8.31	+13.38	56.32	+8.26	+12.17
The extrudate sample	**After 8 days of storage**								
	L			a			b		
Corn	72.06			+11.10			+19.28		
Substituted extrudate sample	L	a	b	L	a	b	L	a	b
Carrot	61.23	+12.23	+18.13	63.10	+10.20	+18.51	60.54	+11.63	+19.10
Sweet potatoes	62.64	+8.06	+15.32	60.61	+9.17	+15.54	61.10	+9.32	+15.50
Pumpkin	61.18	+6.92	+11.15	58.10	+8.25	+13.11	56.24	+8.10	+12.03
The extrudate sample	**After 12 days of storage**								
	L			a			b		
Corn	71.84			+10.94			+19.03		
Substituted extrudate sample	L	a	b	L	a	b	L	a	b
Carrot	61.02	+12.02	+17.98	62.74	+10.08	+18.33	60.15	+11.42	+18.95
Sweet potatoes	62.31	+7.85	+15.14	60.30	+8.99	+15.21	60.92	+9.13	+15.22
Pumpkin	60.79	+6.85	+11.01	57.84	+8.10	+12.99	56.04	+7.94	+11.92
The extrudate sample	**After 16 days of storage**								
	L			a			b		
Corn	71.52			+10.51			+18.80		
Substituted extrudate sample	L	a	b	L	a	b	L	a	b
Carrot	60.72	+11.84	+17.75	62.51	+9.61	+18.14	59.84	+11.13	+18.62
Sweet potatoes	62.06	+7.45	+15.08	60.09	+8.62	+15.01	60.43	+9.08	+15.10
Pumpkin	60.30	+6.32	+10.84	57.57	+7.92	+12.80	55.81	+7.51	+11.75

* (L) Lightness (a) Redness or greenness
(b) Yellowness or blueness

The variation of these parameter values is, as previously mentioned, due to the differences in the original used foodstuffs and the variation in the blanching solution effect. The same table shows minor changes in the tested parameters with the storage period (around 16 days at room temperature) suggesting that the sample color was more stable due to the blanching process, especially in citric acid or sodium meta bisulfite. These observations are in accordance with that found by Zhao and Chang (1995).

Sensory properties of the extrudated products:

One of the limiting factors for consumer acceptability is the sensory evaluation of the different attributes. Therefore, the organolyptic test of the samples attributes were estimated to measure the acceptability of such products and revealed a final judge on the preferences of the newest products in relation to the control sample (Table 5).

With respect to the color preference, no significant differences could be detected among all the different snack products, including the control and snacks, except sweet potato and pumpkin replacement snacks, which seemed to be closest to the control sample, and carrots, blanched in water, citric acid or bisulfite solution, respectively. The most preferable sample, with respect to taste, was the sweet potatoes blanched in water which completely differed than the corresponding carrot sample.

Table (5): Sensory properties of the different extrudate products.

Materials	Color	Taste	Odor	Crispness	After taste	GA*
Corn	7.70 ^{bc}	6.90 ^{cd}	6.93 ^{b}	7.53 ^{bc}	6.57 ^{c}	7.43 ^{cd}
The extrudate samples blanched in water						
Carrot	8.90 ^{ab}	3.77 ^{e}	5.23 ^{c}	3.13 ^{f}	3.83 ^{d}	9.03 ^{ab}
Sweet potatoes	6.93 ^{c}	9.43 ^{a}	8.60 ^{a}	9.27 ^{a}	9.43 ^{a}	6.38 ^{e}
Pumpkin	8.70 ^{ab}	7.67 ^{bc}	8.67 ^{a}	7.17 ^{c}	8.57 ^{ab}	8.67 ^{ab}
The extrudate samples blanched in Citric acid						
Carrot	8.60 ^{ab}	7.47 ^{bc}	8.50 ^{a}	7.03 ^{cd}	8.27 ^{b}	8.53 ^{ab}
Sweet potatoes	8.60 ^{ab}	8.57 ^{ab}	8.57 ^{a}	9.10 ^{a}	8.37 ^{b}	8.83 ^{ab}
Pumpkin	7.10 ^{c}	5.77 ^{d}	6.93 ^{b}	6.00 ^{de}	6.43 ^{c}	7.13 ^{de}
The extrudate samples blanched in sodium meta bisulfite						
Carrot	5.23 ^{d}	8.57 ^{ab}	8.80 ^{a}	8.80 ^{a}	8.43 ^{b}	5.13 ^{f}
Sweet potatoes	9.10 ^{a}	6.23 ^{d}	7.13 ^{b}	5.67 ^{e}	6.53 ^{c}	9.46 ^{a}
Pumpkin	8.53 ^{ab}	8.57 ^{ab}	8.43 ^{a}	8.47 ^{ab}	8.60 ^{ab}	8.20 ^{bc}

*** General appearance.**
Values, within the same column, followed by the same letter are insignificant at 0.05 level.

The odor possessed no pattern in significance differences, but most of the snacks seemed to be more preferable than the corn sample (control). Crispness and after taste characteristics of the products were enhanced in sweet potatoes blanched in water or citric acid to be more preferable than the control sample. However, the general appearance which could be considered as the integration of the whole attributes confirmed that the blanching process before the extrusion process enhanced most of the foodstuffs attributes suggesting that blanching step is a critical step in the production line, especially in case of using water or citric acid as a blanching solution.

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درجة القبول لبعض الأغذية الخفيفه الجديده التى تم تصنيعها عن طريق الاستبدال الجزئى للذره ببعض الأغذية غير التقليديه

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تعزى الألوان الجذابة لعديد من الخضر والفاكهة الحمراء والصفراء إلى احتوائها على صبغات الكاروتينويدات ولهذا فقد تم تصميم نموذج غذاء للأطفال (منتج غذائي خفيف في شكل بثق حراري) بالاحلال الجزئي لبعض المواد الغذائية الغنية في محتواها من بيتا كاروتين (الجزر – البطاطا – القرع العسلي) بدلا من الذره. حيث تم تجهيز المواد الخام بتعريضها لعملية السلق، في الماء أو ٥٪ حمض ستريك أو ١٪ صوديوم ميتا بيسلفيت ثم تبريدها، وتجفيفها وطحنها. ثم إجراء البثق الحراري للناتج المطحون ثم القيام بدراسة المنتج النهائي.

وقد لوحظ أن كل المكونات الكيميائية، فيما عدا المستخلص الأثيري في ناتج البثق الحراري كانت مرتفعة في العينات التي تم سلقها في الماء عن تلك التي تم استخدام محاليل السلق الأخرى. كما لوحظت نفس العلاقة في حالة القدرة على امتصاص الماء أو الدهن لناتج البثق الحراري للبطاطا والقرع العسلي. على النقيض من ذلك، فقد لوحظ ارتفاع القيم في عينات البثق الحراري للجزر المعرض للسلق فى محلول ميتا بيسلفيت يليه العينات التي تم سلقها في حمض الستريك أو الماء. كذلك فان كمية بيتا كاروتين لعينات البثق الحراري التي تم سلقها في حمض الستريك أو ميتا بيسلفيت كانت أعلى من العينات الأخرى بما فيها العينة غير المعالجة بالسلق (الذرة). كما لوحظ وجود تغير طفيفا في دلائل قياس اللون (b, a, L) لكل العينات على مدار مدة التخزين على درجة حرارة الغرفه. كما لوحظ أن قيمة درجات صفات التقييم الحسي للمعاملات المعرضة للسلق كانت أعلى من تلك التي تم إجراء عملية البثق الحراري لها.