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SWEET POTATO PEEL: CHARACTERIZATION AND UTILIZATION AS A SOURCE OF FIBER IN WHITE PAN BREAD

Abou - Samaha, O. R.
Department of Food Science and Technology, Faculty of Agriculture, El-Shatby, Alexandria University, Alexandria, Egypt.

ABSTRACT

Sweet potato (*Ipomoea batata*.L, Lam) Mabrouka peel was prepared using three methods of peeling, namely, hand, abrasive and lye peeling. The proximate chemical composition, dietary fiber components, amino acids of protein content, physical and reological properties were studied. Also the functionality of sweet potato peel as a source of dietary fiber in white pan bread was investigated. The results showed that sweet potato peel was free of lipid and phytic acid. The sulfur containing amino acids were found to be limiting in peel's protein As the addition of sweet potato peel to baking blend was at 5, 10, 15 and 20% of flour weight. The higher levels of addition was markedly reduce the quality of bread produced, while the 5% addition gave a satisfying results The results showed that, lye peeling method was dominate the other methods of peeling regarding to the functionality of the resulted peels in white pan oread

Keywords. Sweet potato peel, chemical composition, physical properties, dietary fiber, baking quality, sensory evaluation

INTRODUCTION

The concern about fiber in the diet gave great attention to the vegetable source of dietary fiber which composed mainly of cellulose, hemicellulose, pectin and lignin. The dietary fiber components of food is important for the health of individuals and the public at large (Southgate *et al* 1978 and Marlett and Slavin, 1997). The decrease in consumption of plant fiber was related to an increase in certain diseases.

Dietary fiber acts as a bulking agent that increase intestinal motility and moisture content of feces (Mieh and Lilischkis, 1986). Some studies showed that plant fiber can lowered serum cholesterol and improve oral glucose tolerance in human (Tsia *et al*., 1976). Also, dietary fiber has found to be effective in reduction of constipation, ischemic heart disease, diverticular disease of colon, breast cancer, appendicitis, varicose veins obesity and gall stones (Baghurst *et al*., 1996) Dietary fiber was found effective in preventing the toxicity by heavy metals (Hg, Cd and Pb) as it can bind these toxic ion (Shiyi Ou. *et al*., 1999). As a consequence, the Nutrition Labeling and Education Act of 1990 requires food producers to report total dietary fiber on consumer product label (United States Congress, 1995) Wheat bran is a major source of dietary fiber, but considers as a rich source of phytate that can produce deficiency in some minerals. To avoid this effect of phytate, potato peels have been used as a source of fiber in some bakery products (Toma *et al*., 1979 and Orr *et al*., 1982)

In Egypt sweet potato is utilized as a supplemental food than a major stable vegetable, in spite of it's high production yield (24.6 tonnes/acre).

Recently, the Egyptian Ministry of Agriculture stated to encourage the industrial processing of such vegetables (Khalf, 1998). The use of sweet potato as a source of starch (Abou Samaha and El-Sahn, 1998) or as a raw material for different new products (Youssef and Rofael, 1997 and Khalf, 1998) have been reported.

According to our knowledge no work was found concerning the use of sweet potato peels Thus the purpose of this work was to study the physical, chemical and reological characteristics in addition to dietary fiber component of sweet potato peels from different peeling methods, and utilization as a potential source of dietary fiber in bread in order to maximize the utilization of such promising crop.

MATERIALS AND METHODS

Preparation of peels: Fresh sweet potato roots of (*ipomoea batata*. L. Lam, Mabrouka) were obtained from a private farm. AL-Mahmoudia, Egypt. The frish roots were stored at 16°C/ 85-90% RH for 15 days. The roots were soaked in running water for 15 min to soften the adhered materials, then washed under a stream of water and graded manually.

The washed graded sweet potato roots were peeled with the following methods:-

1-Hand peeling: With a hand-held vegetable peeler.

2-Abrasion peeling: With a Champion abrasive peeler for 25-30 sec. at 30 rpm with simultaneous washing with water.

3-Lye peeling: By immersing the sweet potato roots in caustic sodium hydroxide (10%) at 83°C for 2 min. with agitation. The treated roots were then immediately soaked in tap water for 15 min. to remove alkali. Peels was then removed with a brush under water. Additionally. peel was tested for pH to assure removal of alkali residue.

Peels obtained from each method were collected on cheese cloth, rinsed with water and dried for 8 hrs at 55°C in a cabinet drier. The dried peels was ground in a Willey mill with 40 mesh sieves then packed in airtight glass containers and kept in a refrigerator until used.

Physical properties:

Density determination: A calibrated graduate cylinder was filled with peel, with slight shaking The content of the cylinder was weighted and the average of triplicate determinations was expressed as g/ml.

Bulk density: It was measured using a calibrated graduate syringe (open and packed with cotton) The syringe was filled with a known amount of sample. Pressure was applied manually until additional pressure would not further reduce the volume (Toma *et al.*, 1979). Water holding capacity was measured according to the method of Heller and Hackler (1979).

Chemical analysis:

Moisture, ash, protein, starch and crude fiber were determined according to the methods of AOAC (1990). Sodium potassium and calcium were

determined in ash solution using the Flame Photometer (Gallenkamp, FGA 330C). The iron content was measured colorimetrically by the orthophenanthroline reagent as in AOAC (1990). Phytic acid was estimated according to the method of Wheeler and Ferrel (1971). Amino acid content (except tryptophan) was determined in the protein hydrolysate by the method of Spackman *et al.* (1958) using Beckman Amino Acid Analyzer (Model 119CL) Neutral detergent fiber (NDF) was measured by the method of Van Soest and Wine (1967), modified to include an α-amylase starch digestion step (Approved method of AACC. 1978). Cellulose and lignin were determined by the acid detergent fiber method (ADF) of Van Soest (1963) as modified by Holst (1973)

Flour blends and baking: Wheat flour 72% extraction was blended with 5, 10, 15 and 20% sweet potato peel powder from each of the peeling method. The baking formula was based on flour weight as follow: 100g flour, 2g salt, 1g sugar, 3g shortening, 3g compressed yeast and water as required by farinograph test. Bread was prepared by the straight dough procedure. Fermentation was 3hrs, proof period at 30°C was 55 min. and the baking time was 25 min at 230°C .

Baking characteristics: Loaf weight, loaf volume and specific volume carried out by the standard methods of AACC (1969) after one hour of baking

Organoleptic evaluation of baked bread: Pan bread quality parameters were tested according to the method of Matz (1960), using 10 panelist of Food Science and Technology Dept., Alexandria Univ., and the results were statistically analyzed according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Chemical analysis of sweet potato peels: As shown in Table (1) the moisture content of the sweet potato peels from different methods were quite close (7.12 to 8.93%) The protein content of lye peeled (6.17%) was lower than that of abrasive peeled (7.52%) or the hand peeled (8.36%). On the other hand all these values were lower than that reported for wheat bran 14.3% (AACC, 1967). This may contributed to the lower protein content of sweet potato which had the lowest protein content among the root crop (Salvador *et al.*, 2000). The data showed that, the sweet potato peel was almost free of lipids and this may because of the lower lipids content of sweet potato root as reported by many investigator (Khalf, 1998). Also, the peels were found free of phytic acid, which considered, as a positive parameter when using this peel in a food product especially, from the bioavailability of minerals view point

Various measures of fiber illustrated in Table (2). Crude fiber has been used as a measure of fiber content for many years, but is not suitable for dietary fiber estimation because the harsh treatment with strong acid and base remove major amounts of gums, pectins, hemicellulose and even important amount of cellulose.

Table (1): Physical characteristics and chemical analysis of sweet potato peels (as dry wt basis).

Characteristic	Constitute			
	Hand peeled	Abrasion peeled	Lye peeled	Wheat bran [a]
Moisture (%)	8.93±0.02	7 12±0 02	8.45±0 02	10.40
Crude protein (N x 6.25) (%)	8.36±0 02	7.65±0 02	6.17±0 02	14.30
Crude fat (%)	AF [b]	AF [b]	AF [b]	5.20
Crude fiber (%)	10.17±0 28	16 82±0.31	14.57±0.33	8.90
Starch (%)	8.46±0.10	6.98±0.13	5.48±0 14	23 90
Ash (%)	7 35±0.12	5 76±0 14	5.24±0 11	5 12
Minerals (mg/g)				
Na	0.50±0 01	0.60±0 01	0.50±0 01	1.00
K	20 0±0 23	12.70±0.25	6 45±0 25	10.00
Ca	14.80±+0.18	29 80±0 18	26.70±0.22	12.00
Fe (ppm)	200 0±1 14	350.00 ±1.25	360.00±1.18	122.00
Neutral detergent fiber (NDF)	22.33±0.18	43 12±0 23	30.17±0 34	41.00
Acid detergent fiber (ADF)	15 98±0.36	36.75±0.34	26.38±0.28	12.00
Hemicellulose	6.35±0 18	6.36±0.21	3.79±0.23	29.00
Cellulose	7 12±0 23	16.94±0 28	13 42±0 26	8 00
Lignin	5 86±0 18	9.81±0.21	12 96±0.24	3 30
Other fiber [d]	62.85±0.22	52 86±0 38	56 73±0 34	40 00
Dietary fiber [e]	75 83±0.32	79 61±0 34	83.11±0 39	52 00
Phytic acid (mg/g)	ND [c]	ND [c]	ND [c]	3 39
Density (mg/ml)	462.48±0.45	287.37±0 41	395 82±0 45	4 39
Bulk density (g/cc)	1.39±0 01	0 92±0.01	1.13±0 01	0.509
Water holding capacity (mg/g)	11.34±0 13	7.12±0 08	9.38±0.12	9.50

a – Official AACC white wheat bran R07-3691/1976. b – Almost free
c – Not detected. d – Other fiber = 100- (cellulose + lignin +starch +fat +protein + ash)
e – Dietary fiber = other fiber + cellulose +lignin

Table (2): Amino acid composition of sweet potato peels (g amino acid/ 100g protein)

Amino acid	Hand peeled	Abrasion peeled	Alkali peeled	FAO/WHO/UNU 1985
Aspartic	11 32	13.05	13.14	
Threonine	4.25	4.49	4 73	3.40
Serine	5.29	4.35	3.09	
Glutamic	13 76	16.75	15 28	
Proline	2 91	2.63	3.52	
Glycine	4.02	4.59	4 63	
Alanine	5 79	5 64	5 79	
Cystine	-	-	-	
Valine	6 51	5.98	6 08	3.50
Methionine	0.35	0.58	0 51	2 50
Isoleucine	6 48	5.03	5 42	2.80
Leucine	5 57	6.12	5.92	6.60
Tyrosine	4 42	3.51	3.87	
Phenylalanine	5.18	5 39	5.41	
Histidine	2 39	2 17	2.61	1 90
Lysine	6 89	6 08	5 84	5 80
arginine	8 12	7 32	7.76	

The ADF method is often used to measure cellulose and lignin, even though, it may remove portions of cellulose in some cases The NDF method is considered to mainly measure of cellulose, lignin and non soluble

hemicellulose. In this study we calculated the other fiber as named by Toma *et al.* (1979) as following:
100-(cellulose +lignin + ash +fat + starch +protein), which considered a possible indication of pectins, gums and NDF soluble hemicellulose, as the recent researches, revealed that the sweet potato peel contained higher amount of pectic substances and low molecular weight sugars (Salvador *et al.*, 2000). As shown from the results in Table (2) the crude fiber content of potato peels (10.17 to 16.82) was higher than that reported for wheat bran (8.9%). At the same time, the abrasion peeled has the highest value while the hand peeled has the lowest. This may because of the amount of pulp associated with the peels in hand peeled method. Both acid detergent fiber (ADF) and neutral detergent fiber content were differ according to peeling method. NDF was 43.12, 30.17 and 22.23%, while ADF was 36.75, 26.38 and 15.98% in abrasion, lye and hand peeled, respectively. The other fiber value of wheat bran was less than the value of sweet potato peels. This suggests that soluble hemicelluloses, gums or pectins are major components of dietary fiber in sweet potato peels but not in wheat bran. A little difference were noticed in dietary fiber content of peels resulted from different methods of peeling.

Physical properties of sweet potato peels: Table (1) shows some physical properties of sweet potato peels. Densities (direct and bulk) of hand, lye and abrasion peeled were (462.48 mg/ml, 1.39 g/cc), (395.82 mg/ml, 1.13 g/cc) and (287.37 mg/ml, 0.92 g/cc), respectively. The different content of fibers in the peels may behind this difference in densities.

Amino acid composition of sweet potato peels: Table (2) illustrate the amino acid composition of sweet potato peels. Although most of the amino acid present in abundance, sulfur containing amino acid leucine are limited. The amino acid in cereal protein, as wheat, may compensate such deficiency when introduce these peels in bakery products.

Functionality of sweet potato peel in pan bread baking: Table (3) showed farinograph data for doughs prepared from flour containing sweet potato peels. The addition of sweet potato peel caused a general increase in water absorption of the flour, which increased as the level of peel substitution, increased from 5 to 20%. The lye peeled showed higher values of water absorption at all levels of addition. This trend may explained by the higher components of dietary fiber in sweet potato peels than wheat flour, as these components have high affinity to hold water.

The data presented in Table (4) also showed that the addition of sweet potato peels led to increase the dough development time from 3.5 min. to 10.5, 11.5 and 13.5 min in hand, abrasive and lye peeled at 20% substitution, respectively. It was obvious that increasing the addition level increased the dough development time. The data in the same table showed that all the doughs containing peels exhibited a weakening of the farinograph curve as appeared from the value of tolerance index.

Table (4) illustrate that loaf volume as well as specific volume were markedly reduced when the sweet potato was added at higher levels (15 and 20%). The lye peeled exhibited the lower reduction in either loaf volume or the specific volume when compared with other types of peels. The

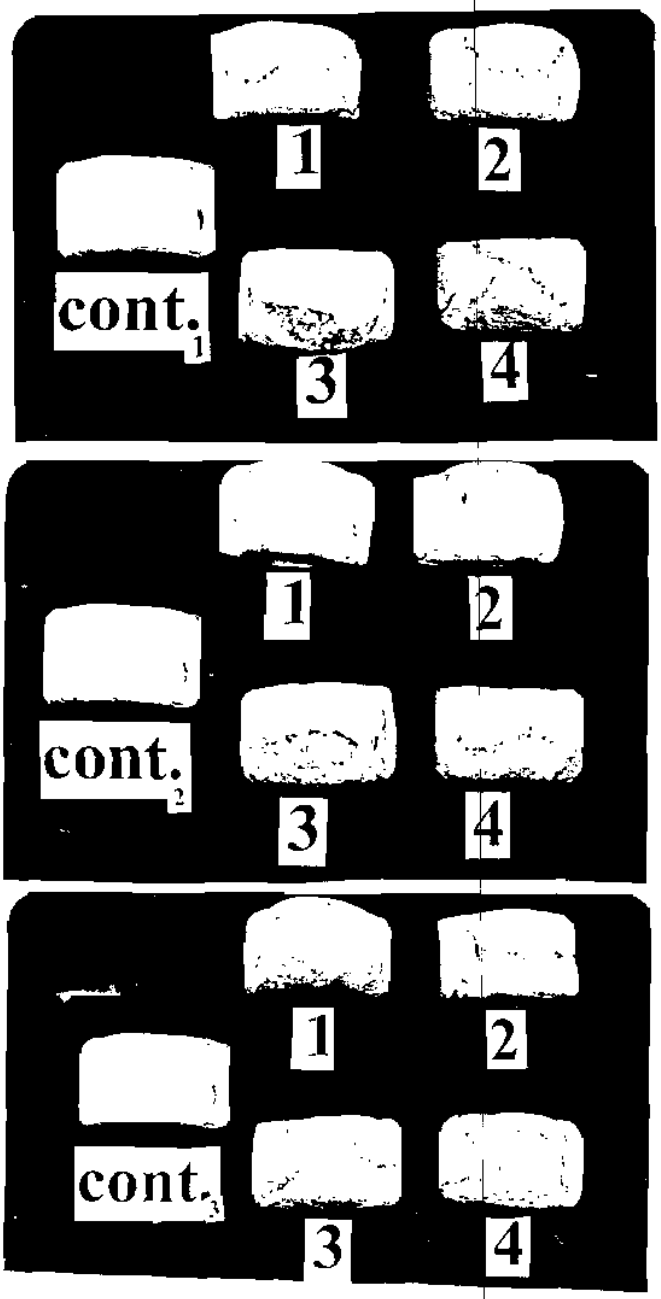
addition of 5% sweet potato peels to the flour was found suitable level of substitution. The higher percentage addition of peels i.e., 15 and 20%, were greatly affected the quality attributes of pan bread as shown in Table(5) and Fig (I A,B; II A, B; III A, B). On the other hand, the lye peeled at lower level of addition 5 and 10% was found the best regarding the quality of the bread fortified with different sweet potato peels.

Table (3): Farinograph data for dough prepared from flour containing sweet potato peels.

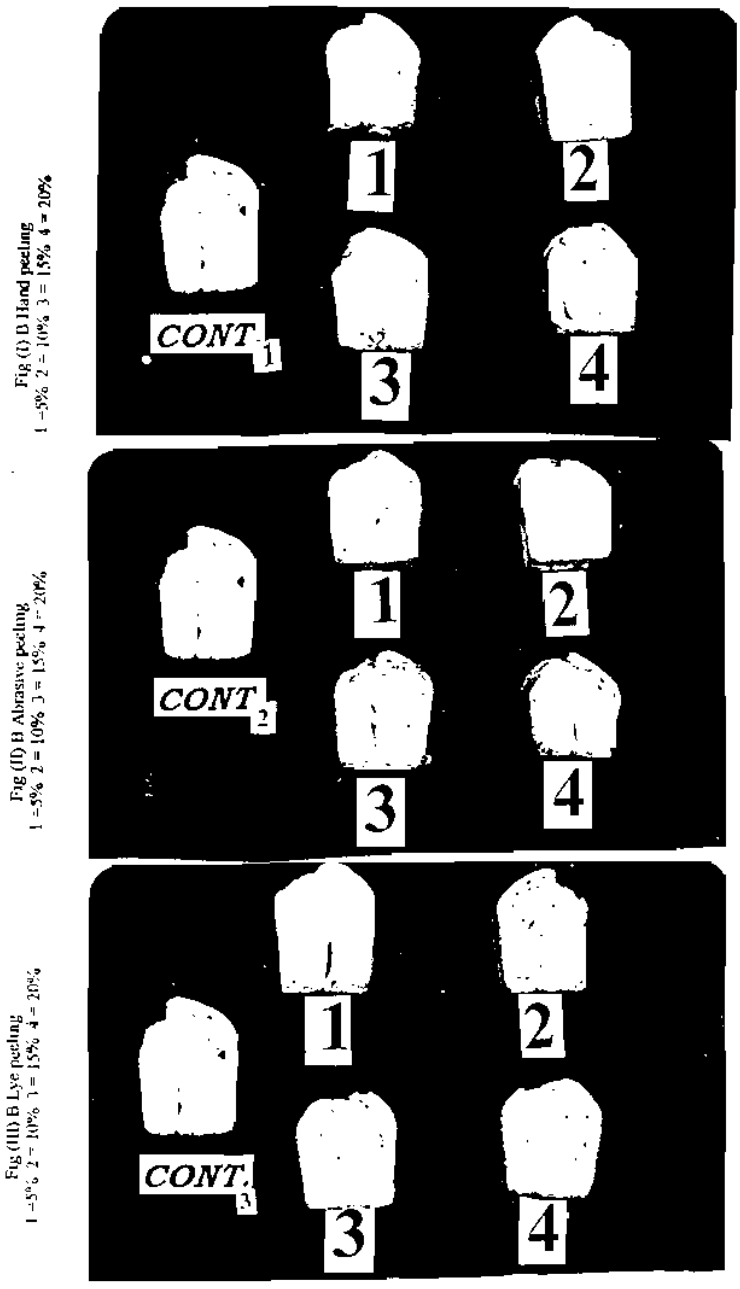
Percent sweet potato peel added	Absorption %	Dough development (min)	Tolerance index (BU)
Hand peeled			
0 0	61 2	3 5	25
5	64.8	4 5	45
10	68 1	7 5	40
15	69 9	9 0	40
20	71.4	10 5	40
Abrasion peeled			
0.0	61.2	3 5	25
5	65.9	5.0	45
10	69 4	8 0	40
15	71 9	9 5	40
20	74 3	11 5	30
Lye peeled			
0 0	61 2	3 5	25
5	67.6	6 0	40
10	71 6	9.5	35
15	73 8	10.5	35
20	75.2	13 5	30

Table (4): Effect of addition of sweet potato peels on the quality of pan-bread

Peel substitution %	Quality characteristics		
	Loaf weight (g)	Loaf volume (cm^3)	Specification volume (cm^3/g)
Hand peeled			
0.0	160±1 80	453±2 20	2.83±0 03
5	159±1 66	401±2 30	2.52±0 02
10	159±1.75	382±2 10	2.40±0.02
15	159±1 45	349±2 30	2 19±0.02
20	158± 84	335±2 50	2 12±0 02
Abrasion peeled			
0 0	160±1 80	453±2.20	2 83±0 03
5	160±1 53	402±2 40	2 51±0 01
10	160±1 81	389±2 10	2.43±0.03
15	159±1.90	353±2 30	2.22±0.02
20	158±2.10	336±2.30	2.13±0 01
Lye peeled			
0 0	160±1.80	453±2 20	2.83±0.03
5	160±1.50	406±2 40	2.54±0 03
10	159±1.40	398±2 30	2 50±0 02
15	159±1 60	373±2 50	2 35±0 03
20	158±1 80	345±2 30	2.21±0.01



External appearance of bread from different wheat flour-sweet potato peel blends.



Internal appearance of bread from different wheat flour-sweet potato peel blends

Table (5): Sensory evaluation data of ban bread containing sweet potato peels

Substitution level of sweet potato peel %		General appearance									
		Shape	Break shred	Crust colour	Crust appearance	Crumb colour	Crumb grain	Crumb texture	Odour	Taste	Total
Hard peeling	0	9.10^{A}	9.40^{A}	9.50^{a}	9.40^{a}	9.40^{A}	9.30^{a}	9.40^{a}	9.60^{A}	9.60^{A}	84.50^{a}
	5	8.70^{B}	9.20^{B}	8.75^{b}	8.50^{b}	8.70^{B}	8.60^{bc}	8.60^{c}	9.00^{B}	9.20^{B}	78.95^{cd}
	10	8.55^{B}	9.00^{C}	8.35^{c}	8.30^{b}	8.30^{C}	8.40^{c}	8.50^{c}	8.90^{B}	8.90^{C}	77.20^{e}
	15	7.90^{C}	8.80^{D}	7.50^{d}	7.80^{c}	6.70^{D}	6.60^{f}	6.50^{f}	8.50^{C}	8.50^{D}	69.20^{h}
	20	7.05^{D}	8.10^{E}	6.60^{e}	6.30^{de}	6.35^{E}	6.50^{f}	6.50^{f}	8.50^{C}	8.50^{D}	64.30^{i}
Abrasive peeling	0	9.00^{A}	9.40^{A}	9.40^{a}	9.40^{a}	9.40^{A}	9.30^{a}	9.40^{a}	9.60^{A}	9.60^{A}	84.50^{a}
	5	8.75^{B}	9.00^{B}	8.60^{b}	8.45^{b}	8.70^{B}	8.70^{b}	9.00^{b}	9.00^{B}	9.10^{B}	79.30^{c}
	10	8.70^{B}	9.00^{B}	8.25^{c}	8.40^{b}	8.50^{C}	8.35^{c}	8.50^{c}	9.00^{B}	9.00^{B}	77.90^{de}
	15	7.95^{C}	8.95^{B}	7.55^{d}	7.90^{c}	7.00^{D}	7.00^{e}	7.05^{e}	8.70^{C}	8.60^{C}	70.30^{g}
	20	6.85^{D}	8.00^{C}	6.70^{e}	6.20^{e}	6.50^{E}	6.50^{f}	6.50^{f}	8.70^{C}	8.60^{C}	64.45^{i}
Lye peeling	0	9.00^{A}	9.40^{A}	9.35^{a}	9.40^{a}	9.40^{A}	9.30^{a}	9.40^{a}	9.60^{A}	9.60^{A}	84.50^{a}
	5	8.90^{B}	9.20^{B}	9.10^{b}	9.20^{a}	9.10^{B}	9.30^{a}	9.25^{ab}	9.50^{A}	9.50^{A}	82.95^{b}
	10	8.75^{B}	9.00^{C}	8.55^{c}	8.50^{b}	8.60^{C}	8.60^{bc}	8.50^{c}	9.30^{b}	9.30^{B}	79.75^{f}
	15	7.95^{C}	9.00^{C}	7.80^{d}	8.00^{c}	7.45^{D}	7.50^{d}	7.40^{d}	8.70^{C}	8.70^{C}	72.65^{i}
	20	6.90^{D}	8.05^{D}	6.70^{e}	6.50^{d}	6.80^{E}	6.70^{f}	6.65^{f}	8.70^{C}	8.70^{C}	65.55^{i}

* Small letters indicate significance difference between substitution levels within different peeling methods

** Capital letters indicate significance difference between substitution levels within each peeling method at p< 0.01

CONCLUSION

The results obtained in this study with other researches concerning the use of sweet potato in production of starch and it's derivatives, or using sweet potato in different types of food products may encourage the utilization of this promising crop in food processing.

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قشور البطاطا: توصيفها والاستفادة منها كمصدر للألياف فى الخبز الأبيض

أسامة راشد أبو سماحه

قسم علوم وتكنولوجيا الأغذية- كليه الزراعة- جامعة الإسكندرية- الشاطبى

تم تحضير قشور البطاطا باستخدام ثلاثة من طرق التقشير وهى التقشير اليدوى, التقشير بالاحتكاك والتقشير بالقلوى. تمت دراسة التركيب الكيماوى التقريبى, مكونات الألياف الغذائية ومحتوى البروتين من الأحماض الأمينية, الخصائص الفيزيقية والريولوجية. أيضا تمت دراسه توظيف هذه القشور كمصدر للألياف الغذائية فى الخبز الأبيض. وأوضحت النتائج ان قشور البطاطا خاليه من الدهن وحمض الفيتيك. كما وجد أن الأحماض الأمينية الكبريتية ناقصة فى بروتين القشور. وحيث كانت إضافة القشور بنسب ٥, ١٠, ١٥, ٢٠% من وزن الدقيق فإن مستويات الإضافة المرتفعة أدت إلى خفض جودة الخبز الناتج بدرجة ملحوظة بينما الإضافة بنسبة ٥% أعطت نتائج مرضيه. أظهرت الدراسة تفوق طريقه التقشير بالقلوى على الطرق الأخرى من حيث الخصائص الوظيفية للقشور الناتجة منها فى الخبز الأبيض.