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PRODUCTION AND EVALUATION OF HIGH-FIBRE BISCUIT

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***ABSTRACT**: In this study, wheat bran, corn bran; rice hull; orange peel; pea hull; soybean hull and sugar beet pulp were evaluated as raw materials and after modification by treating with alkaline hydrogen peroxide (AHP) at pH 11.5 followed by autoclaving to assess the effect of fibre modification on quality of high-fibre biscuit.*

Results showed that the addition of 4 and 8% replacement levels of raw and modified high-fibre sources to biscuit recipe resulted in similar weight of biscuit compared to control biscuit except for 4% raw orange peel, 4 and 8% raw pea hull, 4% modified pea hull, 4 and 8% modified soybean hull and 8% sugar beet pulp. The volume of all high-fibre biscuits was similar or higher compared to control biscuit except for biscuit containing 4% raw corn bran. The diameter and thickness of biscuit were affected by using 4 and 8% replacement levels of raw and modified high-fibre sources to biscuit recipe. Specific volume of biscuit was similar in all raw and modified high-fibre sources at 4 and 8% levels of replacement compared to the control.

Biscuit formulated to contain all raw and modified high-fibre sources at 4 and 8% levels of replacement were nearly similar to control biscuit in all biscuit quality measurements except for spread ratio.

Concerning sensory characteristics, raw and modified high-fibre sources can be used to replace up to 8% level for all high-fibre sources except for 8% raw pea hull, 8% raw rice hull and 8% raw sugar beet pulp to produce biscuit with acceptable sensory attributes.

***Key words**: High-fibre, dietary fibre, modification, , alkaline hydrogen peroxide, supplementation, replacement, incorporation, specific volume*

INTRODUCTION

Dietary fibre is resistant to the digestive secretions in the upper gastrointestinal tract. It has been proposed that amounts of dietary fibre in the diet is believed to decrease energy density for the purpose of controlling body weight (Mangeau et al, 1991). Accumulating evidence indicates that dietary fibre constituents have several important beneficial effects. Fibre is a well recognized remedy for constipation, but it also has prominent effects upon lipid and carbohydrate metabolism that might be of importance in the prevention of other sclerotic diseases (Dawoud, 1989; Gordon, 1989; Ellis and Dawoud, 1991; Abd El-Moniem and Yaseen, 1993; Larrauri et al, 1996; Atkinson, 1997; Larrauri et al, 1997). Production of foods containing bulk

without supplying calories by using materials such as gums, pectins and other dietary fibre sources is considered an important way for low-energy food production (Foda et al, 1987). Abd El-Magid et al (1985) indicated that the nitrogen fecal excretion of rats fed on biscuit supplemented with 10% potato peel was higher than that of rats fed with 10% wheat bran diet. Also they showed that apparent digestibility values of biscuits containing 5% and 10% potato peel or 10% wheat bran in diet were 84.5, 83.8 and 87.5% respectively.

Antinutritional effects of bran have been reported such as cation binding, which may result in decreased mineral availability and accelerated loss of certain body minerals. Historically, phytic acid is considered the major constituent in bran and whole wheat responsible for mineral deficiency disorders (Frolich and Asp, 1985; Kordonowy and Youngs, 1985).

The amount of brans and husk as by-products in cereal industry is quite large, traditionally has been used in animal feed, of relatively low cost, or has been disordered as waste. For those reasons, incorporating these by-products into biscuit may play a role in avoiding some nutritional disorders. Soybean hull, currently considered a by-product of soy processing, are used as fillers in animal diets and as a fibre supplement (Dawoud, 1998; Johnson et al, 1985; Laurikainen et al, 1998).

New food processing operations using heat (autoclaving, pressure, cooking, microwaving) or thermochemical treatments applied to vegetable or flour can modify the physico-chemical characteristics of fibres (Camire and Flint, 1991). Several processes have been developed to improve the degradability of ligno-cellulosic materials such as straw. For any process to be successful, it must not only increase the in vivo availability of nutrients, but also be economical to operate and free of pollution problems. Alkaline hydrogen peroxide treatment selectively removes about half of the lignin and a variable portion of the hemicellulose from plant cell walls (Gould et al, 1989; Jasberg et al, 1989a and Atia et al, 1995). Jasberg et al (1989b) indicated that alkaline hydrogen peroxide wheat straw can be used to replace a large portion of the flour normally present in cake formulation, reducing calories and increasing dietary fibre content. Alternatively the addition of low levels of alkaline hydrogen peroxide wheat straw to cake formulation can increase cake volume and allow to use of extra water.

This research was designed to improve characteristics of some high-fibre sources and determine the differential effects of the incorporation of varying levels of raw and modified high-fibre sources on baking quality and sensory characteristics of biscuit.

MATERIALS AND METHODS

Materials:

Wheat flour (72% Extraction Rate) and wheat bran were obtained from the Middle and West Delta Milling Company, Shibin El-Kom, Egypt. Rice hull was obtained from North Alexandria Company for Rice Milling, Alexandria , Egypt. Pea hull was obtained by peeling pea seeds, then dried and milled. Orange peel powder was prepared as described by Abo El-Maati (1999). Wheat bran, corn bran, rice hull and soy bean hull were ground to fine powder. Sugar beet pulp was obtained from Beet Sugar Extraction Factory, El-Hamool, Kafr-El-Shiekh, Egypt, washed, dried and milled.

Methods:

Alkaline hydrogen peroxide treatment (AHP) followed by autoclaving of prepared samples.

Prepared samples were treated with a dilute alkaline solution of hydrogen peroxide (Gould et al. 1989). The treated sample was washed thoroughly with water and then was autoclaved for 15 min according to Chang and Morris (1990) and then dried in a forced-air oven at 60°C. The dried sample was ground using an electric grinder and stored at 4°C until use.

Biscuit making process

The following formula was used according to Youssef (1999).

Ingredient	%
Wheat flour 72% ER	100 - 92
Dietary fibre source	0 - 8
Sugar	10
Oil	20
Whole egg	30
Baking powder	3
Vanilla	0.2

Sugar and oil were creamed in a mixer for 2 min. also, whole egg and vanilla were blended in a mixer for 2 min, to which a creamed sugar and oil was added. A mixed flour blend containing the fibre source along with baking powder were gently mixed for 5 min. using a wooden rolling pin, the dough was sheeted to a uniform thickness of 4 mm. circular sheeted dough 6.0 cm in diameter was cut and baked for 12-15 min at 210°C. Biscuit was allowed to cool at room temperature, and stored for different measurements.

Baking quality measurements of biscuit

The following measurements of biscuit quality were taken in triplicate (i.e. three pieces from the same dough) according to Abd El-Moniem and Yaseen (1993): Biscuit weight (gm), Biscuit volume ((cm^3), Specific volume (cm^3/gm), diameter (cm), thickness (cm), spread ratio (cm) and spread ratio (± %).

Spread ratio (cm) and spread ratio (± %).were calculated as follow:

$$\text{Spread ratio (cm)} = \frac{\text{Diameter}}{\text{thickness}}$$

$$\text{Spread ratio } (\pm \%) = \frac{\text{Spread ratio of sample} - \text{spread ratio of control}}{\text{Spread ratio of control}} \times 100$$

Sensory evaluation of biscuit

Biscuit scoring was carried out subjectively using a score sheet for biscuit containing the following characteristics: shape, exterior colour, distribution of cell, interior colour, mouth feel, taste and odour. Twelve panelists were asked to give numerical values for these characteristics (Vecchionacce and Setser, 1980).

Statistical analysis

Baking properties and sensory evaluation data of high-fibre biscuit were statistically analyzed using analysis of variance and least significant difference according to SAS (1985). Significant differences were determined at the $P < 0.05$ level.

RESULTS AND DISCUSSION

Baking properties of high-fibre biscuit:

The results of the effect of raw and modified high-fibre sources on baking properties of biscuit are presented in Tables (1) and (2). Figs (1) and (2) show quality characteristics of control and high-fibre biscuits containing 4 and 8% levels of replacement.

The incorporation of all raw and modified high-fibre sources at 4 and 8% levels of replacement to biscuit recipe resulted in similar weight of biscuit compared to control biscuit except for 4% raw orange peel, 4 and 8% raw pea hull, 4% modified pea hull, 4 and 8% modified soybean hull and 8% sugar beet pulp.

The volume of all high-fibre biscuits was similar or higher compared to control biscuit except for biscuit containing 4% raw corn bran. No significant differences ($P > 0.05$) in specific volume of biscuits were found between all high-fibre biscuits and control biscuit.

The diameter and thickness of biscuit were affected by using 4 and 8% replacement levels of raw and modified high-fibre sources to biscuit recipe. Specific volume of biscuit was similar in all raw and modified high-fibre sources at 4 and 8% levels of replacement compared to the control. This observation agree with that reported by Abd El-Moniem and Yaseen (1993).

Also, data show that the dough containing 4 and 8% of raw and modified high-fibre sources could not spread well compared to control.

In general, the results of baking quality of biscuit showed that raw and modified high-fibre sources can be used to replace up to 8% of the wheat flour with no perceptible difference in biscuit characteristics. Addition increments of high-fibre sources progressively reduced spread ratio of resulted biscuit compared to control biscuit.

Table (1) : Objective measurements of biscuits prepared by addition of raw high-fibre sources at different levels of replacement.

Biscuit type	Level* %	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Diameter (cm)	Thickness (cm)	Spread ratio (cm)	Spread ratio (±%)
Control (72% ER)	0	13.03	24.00	1.84	5.60	1.23	4.55	0.00
Raw Corn Bran	4	12.25	22.25	1.82	5.20	1.25	4.52	-0.66
	8	13.25	23.75	1.79	5.48	1.25	4.38	-3.74
Raw Orange Peel	4	14.10	26.25	1.86	5.60	1.35	4.15	-8.79
	8	13.75	24.75	1.80	5.35	1.30	4.12	-9.45
Raw Pea Hull	4	14.10	25.75	1.83	5.45	1.60	3.41	-25.05
	8	14.18	25.50	1.80	5.68	1.48	3.84	-15.60
Raw Rice Hull	4	13.08	24.75	1.89	5.58	1.33	4.20	-7.69
	8	12.75	24.00	1.88	5.53	1.48	3.74	-17.80
Raw Soybean Hull	4	14.08	25.50	1.81	5.55	1.35	4.11	-9.67
	8	14.00	25.25	1.80	5.43	1.38	3.93	-13.63
Raw Sugar beet Pulp	4	13.55	25.00	1.85	5.60	1.33	4.21	-7.47
	8	13.73	24.25	1.77	5.25	1.40	3.75	-17.58
Raw Wheat Bran	4	12.63	24.75	1.96	5.65	1.35	4.19	-7.90
	8	13.30	24.50	1.84	5.48	1.43	3.83	-15.82
LSD		1.02	1.14	0.28	0.16	0.34	0.98	

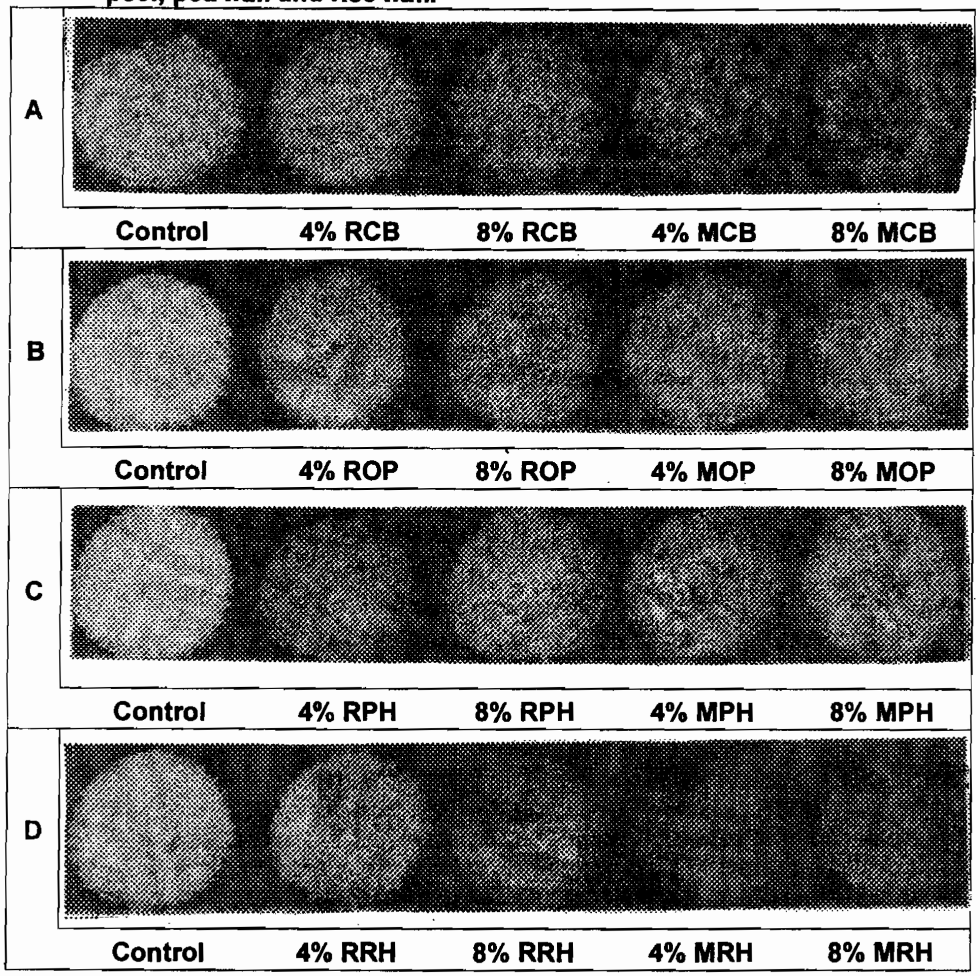
*- Levels of replacement of wheat flour

Table (2): Objective measurements of biscuits prepared by addition of modified high-fibre sources at different levels of replacement.

Biscuit type	Level* %	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Diameter (cm)	Thickness (cm)	Spread ratio (cm)	Spread ratio (±%)
Control (72% ER)	0	13.03	24.00	1.84	5.60	1.23	4.55	0.00
Modified Corn Bran	4	13.35	24.25	1.82	5.58	1.35	4.13	-9.23
	8	13.95	25.50	1.83	5.45	1.50	3.63	-20.22
Modified Orange Peel	4	13.78	25.25	1.83	5.40	1.30	4.15	-8.79
	8	13.78	25.00	1.81	5.43	1.38	4.05	-10.90
Modified Pea Hull	4	14.18	26.00	1.84	5.60	1.48	3.78	-16.92
	8	13.88	25.00	1.80	5.70	1.50	3.80	-16.48
Modified Rice Hull	4	13.10	24.75	1.89	5.53	1.50	3.69	-18.90
	8	13.38	25.75	1.92	5.35	1.50	3.57	-21.54
Modified Soybean Hull	4	14.13	26.01	1.84	5.38	1.55	3.47	-23.74
	8	14.15	25.50	1.80	5.30	1.60	3.31	-27.25
Modified Sugar Beet Pulp	4	13.63	24.75	1.82	5.48	1.35	4.06	-10.77
	8	14.20	26.00	1.83	5.40	1.50	3.60	-20.88
Modified Wheat Bran	4	13.45	26.00	1.93	5.73	1.43	4.01	-11.87
	8	13.53	25.50	1.88	5.38	1.55	3.47	-23.74
LSD		1.02	1.14	0.28	0.16	0.34	0.98	

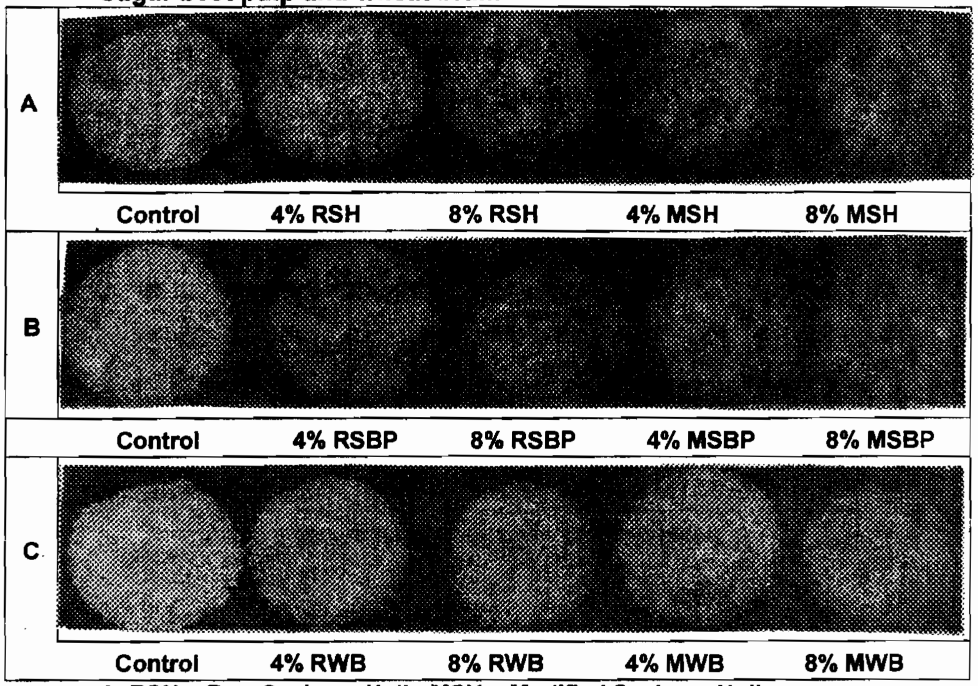
*- Levels of replacement of wheat flour

Fig. (1) Quality characteristics of control and high-fibre biscuits containing 4 and 8% (level of replacement) of raw and modified corn bran, orange peel, pea hull and rice hull.



A. RCB = Raw Corn Bran; MCB = Modified Corn Bran.
B. ROP = Raw Orange Peel; MOP = Modified Orange Peel.
C. RPH = Raw Pea Hull; MPH = Modified Pea Hull.
D. RRH = Raw Rice Hull; MRH = Modified Rice Hull.

Fig. (2) Quality characteristics of control and high-fibre biscuits containing 4 and 8% (level of replacement) of raw and modified soybean hull, sugar beet pulp and wheat bran.



A. RSH = Raw Soybean Hull; MSH = Modified Soybean Hull.
B. RSBP = Raw Sugar Beet Pulp; MSBP = Modified Sugar Beet Pulp.
C. RWB = Raw Wheat Bran; RWB = Modified Wheat Bran.

Sensory characteristics of high-fibre biscuit:

Means of the sensory evaluation of biscuits prepared using 4 and 8% levels of raw and modified sources are presented in Tables (3) and (4).

It could be observed that as the level of all fibre sources increased, scores of shape decreased except for modified corn bran, modified rice hull and modified wheat bran. Biscuits containing 8% raw corn bran, 8% raw orange peel, 4 and 8% raw pea hull, 8% raw rice hull, 8% modified soybean hull, 8% raw sugar beet pulp, 8% modified sugar beet pulp and 8% raw wheat bran had significant ($P < 0.05$) effects on scores of shape compared to control biscuit, but the other levels have no significant ($P > 0.05$) effects.

Addition of raw and modified high-fibre sources seemed to affect exterior color of biscuit. Biscuits containing 4 and 8% raw corn bran, 8% modified corn bran, 4% raw orange peel, 4% modified orange peel, 4 and 8% modified pea hull, 4% modified rice hull, 4% raw soybean hull, 4% raw sugar beet pulp, 4% modified sugar beet pulp, 4% raw wheat bran and 4 and 8% modified wheat bran had no significant ($P > 0.05$) effects on exterior color of biscuits compared to control biscuit, but the other levels were significantly ($P < 0.05$) lower than the control biscuit.

No significant ($P > 0.05$) differences in distribution of cell were found between control biscuit and biscuit containing 4% raw corn bran, 4 and 8% modified corn bran, 4% raw orange peel, 4 and 8% modified orange peel, 4% modified pea hull, 4 and 8% modified rice hull, 4% soybean hull, 4% raw sugar beet pulp, 4% modified sugar beet pulp, 4% raw wheat bran and 4 and 8% modified wheat bran, while other levels of raw and modified high-fibre sources had significant ($P < 0.05$) differences on distribution of cell.

The interior color of the biscuits was observed to be affected by using all fibre sources at 4 and 8% levels of substitution. Increasing level of fibre sources decreased the acceptability of the biscuit interior color except for modified corn bran, modified rice hull, modified soybean hull and modified wheat bran.

Mouth feel was scored as most acceptable in the biscuit substituted with 4 and 8% raw and modified corn bran, 4% raw orange peel, 4 and 8% modified orange peel, 4% modified rice hull and 4 and 8% modified sugar beet pulp.

As the level of all fibre sources increased the acceptability for taste was decreased except for modified corn bran, modified pea hull and modified rice hull.

All odor scores were significantly ($P < 0.05$) lower than the control biscuit except for 4 and 8% raw corn bran and 4% modified corn bran.

There were no significant ($P > 0.05$) differences in overall quality score between control biscuit and 4% raw corn bran, 4 and 8% modified corn bran, 4% raw orange peel and 4% modified orange peel.

It is obvious from results that biscuits containing 4 and 8% raw and modified corn bran, 4% raw orange peel, 4 and 8% modified orange peel, 4% modified pea hull, 4% modified sugar beet pulp and 4% modified wheat bran did not affect the sensory scores of all biscuit characteristics, i.e no significant ($P > 0.05$) differences were found between these biscuit types and control biscuit. These results are in agreement with that obtained by Atia et al (1995) who found that addition of sugar cane baggas-alkaline hydrogen peroxide fibres at the level of 15% to wheat doughs had a good effect on dough of cake and cookies. Jasberg et al (1989b) showed that alkaline hydrogen peroxide wheat stalks can replace up to 40% of the flour in a cake formulation without adversely affecting either baking performance or taste panel score. In some batter systems, such as pancake, as much as 50% of the flour can be replaced without deterioration of baking or sensory performance.

Generally, replacement could be achieved up to 8% level for all high-fibre sources except for 8% raw pea hull, 8% raw rice hull and 8% raw sugar beet pulp before the biscuit quality become unacceptable. The data presented in this paper suggested that AHP treatment followed by autoclaving may be a useful method for improving the functionality of raw high-fibre sources for use in biscuit formulations.

Table (3): Sensory evaluation of biscuits prepared by addition of raw high-fibre sources at different levels of replacement.

Biscuit type	Level* %	Shape (15)	Exterior color (20)	Distribution of cell (10)	Interior color (10)	Mouth feel (10)	Taste (20)	Odor (15)	Overall quality score (100)
Wheat Flour (Control)	0	13.4	18.0	8.1	8.5	8.4	17.8	14.5	88.7
Raw Corn Bran	4	13.8	18.3	8.0	8.3	8.6	18.1	14.4	89.5
	8	11.9	17.9	7.0	8.1	8.5	17.8	14.1	85.3
Raw Orange Peel	4	13.3	18.1	8.0	8.1	8.5	17.5	13.2	86.7
	8	11.2	17.1	6.8	7.1	7.1	13.4	13.0	75.7
Raw Pea Hull	4	8.1	13.3	6.9	4.1	7.3	14.3	11.9	65.9
	8	8.5	11.3	4.9	3.6	5.9	13.8	8.9	56.9
Raw Rice Hull	4	13.9	17.1	7.0	6.9	6.8	13.6	8.3	73.6
	8	8.6	13.6	5.5	5.1	4.6	9.9	6.6	53.9
Raw Soybean Hull	4	13.4	17.6	7.9	5.1	5.0	12.3	10.3	71.6
	8	12.9	17.0	7.9	5.0	3.4	9.5	9.1	64.8
Raw Sugar beet Pulp	4	13.3	17.8	6.9	6.3	5.9	10.0	10.8	71.0
	8	12.4	16.8	5.7	5.8	6.9	8.0	8.1	63.7
Raw Wheat Bran	4	13.3	18.3	7.9	8.0	7.6	15.4	13.2	83.7
	8	9.5	13.1	6.0	5.9	6.9	12.3	9.6	63.3
LSD		0.9	0.8	0.7	0.7	0.6	1.0	0.9	4.6

*- Levels of replacement of wheat flour

Table (4): Sensory evaluation of biscuits prepared by addition of modified high-fibre sources at different levels of replacement.

Biscuit type	Level* %	Shape (15)	Exterior color (20)	Distribution of cell (10)	Interior color (10)	Mouth feel (10)	Taste (20)	Odor (15)	Overall quality score (100)
Wheat Flour (Control)	0	13.4	18.0	8.1	8.5	8.4	17.8	14.5	88.7
Modified Corn Bran	4	13.0	17.0	7.9	8.0	8.1	17.0	14.0	85.0
	8	13.4	17.9	8.1	8.0	8.5	17.0	13.1	86.0
Modified Orange Peel	4	14.0	18.1	8.4	8.3	8.4	17.8	13.5	88.5
	8	13.9	15.1	8.3	8.1	8.5	17.6	13.3	84.8
Modified Pea Hull	4	13.8	18.3	7.9	6.8	7.6	13.9	12.8	81.1
	8	13.2	17.6	6.9	4.6	6.8	14.4	12.6	76.1
Modified Rice Hull	4	12.9	18.0	8.0	7.9	7.8	16.1	12.0	82.7
	8	13.4	17.1	8.0	7.9	7.5	16.1	12.0	82.0
Modified Soybean Hull	4	12.8	17.1	8.0	7.0	6.7	16.5	12.5	80.6
	8	12.3	13.6	8.0	7.0	6.3	15.9	11.6	74.7
Modified Sugar beet Pulp	4	12.9	17.3	7.9	7.8	7.8	17.1	13.4	84.2
	8	11.8	16.3	7.0	5.9	7.9	15.8	11.9	76.6
Modified Wheat Bran	4	13.2	17.4	7.9	8.1	7.6	17.0	13.5	84.7
	8	13.6	17.3	8.4	8.1	7.4	15.0	10.0	79.8
LSD		0.9	0.8	0.7	0.7	0.6	1.0	0.9	4.6

*- Levels of replacement of wheat flour

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إنتاج وتقييم البسكويت العالي في الألياف

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الملخص العربي

في هذه الدراسة استخدمت مصادر متعددة للألياف وهى ردة القمح ، ردة الذرة ، سرسة الأرز، قشر البرتقال، قشر البسلة، قشر فول الصويا ولب بنجر السكر. وتم تقييم هذه المصادر كمواد خام وبعد تعديلها بالمعاملة بفوق أكسيد الهيدروجين في وسط قلوي ثم بالأوتوكلاف من حيث تأثيره على جودة البسكويت المضافة إليه. وقد أظهرت النتائج أن إضافة هذه المصادر من الألياف إلى مكونات البسكويت بنسب إحلال ٤ ، ٨٪ أدى إلى إنتاج بسكويت مماثل للكنترول في الوزن فيما عدا نسبة ٤٪ من قشر البرتقال الخام و ٤ ، ٨٪ قشر البسلة الخام و ٤٪ قشر البسلة المعدل و ٤ ، ٨٪ قشر فول الصويا المعدل و ٨٪ لب بنجر السكر المعدل. وأوضحت النتائج أيضا أن حجم البسكويت العالي في الألياف كان مماثلا أو أعلى من حجم البسكويت العادي باستثناء البسكويت المحتوى على ٤٪ ردة الذرة الخام. وقد تأثرت صفتي القطر والسمك للبسكويت الناتج عند استخدام ٤ ، ٨٪ من الألياف الخام أو المعدلة بينما لم يتأثر الحجم النوعي باستخدام نفس المواد وبنفس النسب. وكانت جميع أنواع البسكويت المنتجة والمحتوية على معدل إحلال ٤ ، ٨٪ من جميع مصادر الألياف الخام والمعدلة مشابهة للبسكويت العادي في جميع صفات الجودة عدا نسبة الانتشار.

وفيما يتعلق بالصفات الحسية فيمكن القول أن استبدال دقيق القمح بالألياف الخام والمعدلة حتى نسبة ٨٪ تعطى بسكويت ذو صفات حسية مقبولة في كل الأنواع ماعدا البسكويت المحتوى على ٨٪ من الألياف الخام لكل من قشر البسلة وسرسة الأرز ولب بنجر السكر.