ENVIRONMENTAL AND CHEMICAL STUDIES ON SOME EXTRACTED ACTIVE COMPONENTS OF BARLEY

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ABSTRACT

β-Glucan is the effective naturally occurring compound that exists in the grains of *Hordeum vulgaris L* (barley). β-Glucan is a rich fiber fraction found as glucose polymer in the endosperm cell walls of barley and usually at a level of 2-8 of grain weight. Extraction treatment affected the yield of barley β-glucan (BBG) fiber fraction, and β-glucan recovery efficiency ($P \leq 0.05$). Its chemical composition and physical properties make it a functional ingredient which can be used in different healthy food products. Thus its health benefits are linked to its high viscosity and its nature as a soluble dietary fiber.

In this investigation different treatments to extract β-glucan from barley are examined. Functional properties of extracted β-glucan gum as solubility, viscosity, foaming properties, water hydration and fat absorption capacities are determined. These characteristics make it suitable as a fat replacer in food products. Since cake needs high fat to make, it was chosen and prepared by utilizing β-glucan as fat replacer with different levels, its physical and chemical properties are examined.

Keywords: β-glucan, grain weight, functional ingredients, fat replacer.

INTRODUCTION

Barley, *Hordeum vulgaris L,* is an ancient crop plant, and is also one of the world's most cultivated cereal crops. World production in 2000/2003 has been evaluated at approximately 134 million metric tons. Europe is one of the leading barley producers (51.659 Mt) followed by the Former Soviet Union (25.013 Mt), and Canada (13.172 Mt). In the UK barley has a particular importance as being the second most important crop, with approximately 6.2 million metric tons produced in 2002 (HGCA 2003).This year the United States Department of Agriculture (USDA) estimates that the World Barley Production 2015/2016 will be 144.81 million metric tons, around 0.2 million tons more than the previous month's production. Barley Production last year was 141.16 million tons. This year's 144.81 estimated million tons could represent an increase of 3.65 million tons or a 2.59% in barley production around the globe (USDA 2015).

Barley, which is a source of dietary fiber, β-glucan, and antioxidants, has been used as a staple food in several areas of the world for centuries (Ames *et al*., 2006 and Mahdi *et al*., 2008).

As a food source, barley contains starch (65-68%), protein (10-17%), b-glucan (4-9%), lipids (2-3%) and minerals (1.5-2.5%). These percentages vary depending on species, crop characteristics and soil environmental conditions (Quinde-Axtell and Baik, 2006).

β-Glucan is a trivial name for the glucose polymer found in the endosperm cell walls of barley and oats, and it consists of linear unbranched

polysaccharides of linked β-(1→ 3) - and β - (1→ 4) – D -glucopyranose units in a non-repeating but nonrandom order.

The extraction methodologies for barley and oat β-glucan were developed by Wood *et al*., (1977, 1978), who assessed particle size, temperature, pH and ionic strength on β-glucan yield at laboratory scale. These authors prepared an oat gum containing 78% β-glucan from oat bran at the pilot plant scale using hot alcohol deactivated oat bran (75% ethanol /4 hours) and a sodium carbonate extraction at pH 10 (Wood *et al.*, 1989).

The temperature and pH of extraction process also affects the recovery of β-glucan. Temelli (1997) illustrated that β-glucan content increased with temperature, but not pH. Burkus and Temelli (1998) further evaluated the effect of extraction conditions upon yield, composition, and viscosity stability of barley gum from regular barley (Condor) and a waxy cultivar blend. `Symons and Brennan (2004a) examining extraction procedures have also shown that extraction with thermo stable alpha-amylase yielded the purest β-glucan fraction.

β-glucan is used recently for substituting fat in foods and reducing the overall fat and energy intakes. These beneficial effects have been attributed to their gelling and viscosity increasing properties. The Food and Drug Administration in the U.S.A. has allowed a health claim reducing the risks associated with coronary heart diseases on food labels containing soluble β-glucan obtained from barley (Anon 2006).

β–glucan is the effectiveness compound of barley for healthy food products and medicinal uses, thus it is a soluble dietary fiber. The studies related to barley beta glucan were very few so the estimation and properties of beta glucan extracted from barley was tested in this investigation.

This investigation aims at studying the properties of β–glucan extracted from barley.

MATERIALS AND METHODS

Hull less barley grains were obtained from Crops Research Institute, Agriculture Research Center, Giza, Egypt. All Chemicals used in this study were of analytical grade

1. Preparation of barley flour and bran:

Hull- less barley (naked) was moistened to 14% moisture for 24 hours and then milled by hammer mill to whole barley flour. Portion of this stayed as it is, and the other portion of flour was sieved through 0.5 mm sieve to obtain barley bran.

2. Analytical procedures of raw materials and extracted β-glucan:

Moisture, ash, starch, crude protein (N×6.25), crude fiber and ether extract were determined according to the standard methods described by AACC (2010). Total carbohydrates were calculated by difference. Minerals content were determined according to the method described by Jackson (1976) using Atomic Absorption Spectrophotometer (3100). β-glucan was determined enzymatically according to the method described by Carr et al (1990). Total dietary fiber (TDF), insoluble dietary fiber (IDF) was determined according to the method described by Prosky et al. (1985, 1988).

3. Extraction of β-glucan:

Extraction of β-glucan from cereals (barley bran or whole barley flour) is a challenge, as it involves at least three stages:

(1)Pre-treatment of raw material, (2) Extraction of β-glucans

and (3) purification/isolation step.

Pre-treatment stage can pursue different objectives: first, to deactivate the endogenous enzymes (β-glucanases) responsible for the depolymerization of β -glucans. A second purpose is to facilitate the later extraction stage, increasing the overall yield of the process. In this case physical treatments, such as sonicating, could be considered. And finally a third group of pre-treatments include milling processes: special milling of the barley can be done in order to produce milling fractions enriched in β-glucans (bran), increasing the amount of β-glucans extracted. All pre-treatments enhance the performance of the β-glucan extraction process.

Extraction of β-glucan from barley bran was carried out according to three methods described by

1- Water extraction (Benito *et al.* (2009)
2- Aqueous-alkaline extraction (Wood *et al.* 1978, Wood *et al.*, 1989, Temelli 1997)
3- Enzymatic extraction (Bbatty (1993)

(1). Water extraction: this method involves the following steps:

1. Endogenous enzyme deactivation by the use of ethanol as previous step to the extraction. Barley bran sample was suspended in ethanol (80% v/v) and boiled under reflux for two hours with continuous stirring. After the treatment, the barley bran and the ethanol were separated by filtration.

Barley bran was dried at 60ºC and, subsequently, extraction process was carried out, according the procedure described in section 2.

2. Batch procedure for extraction of β-glucans:

Extraction was carried out in a 1L jacked vessel. In each experiment, 25g of barley bran were mixed vigorously (500rpm) with 200 ml deionized water for 3 hours at 55ºC. After the extraction, the mixture was centrifuged for 10 minutes at 5000 rpm. Solid material was discarded, while liquid extract was kept at 4ºC. All the extraction experiments were carried out in duplicate. β-Glucan precipitation was done by adding an equal volume of ethanol (96%, v/v) to the liquid extract. The white solid obtained was separated from liquid by vacuum filtration, and set at 60ºC overnight. Once dried, gum was milled and kept in a sealed glass tube until the moment of being analysed.

(2). Aqueous-Alkaline extraction: In this method, the following procedure was followed:

Water (500 ml) was added to barley bran (50 g), and the suspension was immediately adjusted at pH 7 with sodium carbonate (20% w/v) and stirred vigorously for 0.5 hr at 45ºC. The mixture was centrifuged (15 min at 15,000 ×g, 4ºC), the residue retailed for further extraction, and the cooled supernatant adjusted to PH 4.5 with 2M-HCl and centrifuged (20 min at 21,000 ×g, 4ºC). This residue was discarded and the cold supernatant made 50% with respect to 2-propanol (IPA), which was added slowly with vigorous stirring. The precipitate was allowed to settle overnight, collected by centrifugation, resuspended in (IPA) and the rubbery pellet disintegrated in a Vertis homogenizer. The sample was washed with IPA on a suction filter and

air-dried with gentle warming to prevent moisture condensation and the development of a horny texture to the gum. The residue from the initial extraction was subjected to further extraction under the same conditions as the first. Routinely, three extractions were carried out, giving three extracts combined together before the step of acidification with 2M HCl. The gum was isolated as described before by 2-Propanol precipitation

(3). Enzymatic extraction:

After two extractions of β-glucan by 1N NaOH, the pH of the combined extracts was adjusted first to 6.5 with hydrochloric acid and calcium chloride added to enhance α- amylase activity. After incubation with α-amylase the pH of the extract was adjusted at 4.5 to precipitate the protein (Bbatty, 1993).

3.1. Identification and Quantitative Determination of isolated β- glucan by HPLC:

High-Performance Liquid Chromatography HPLC [HEWLETT PACKARD HP1047IR, HEWLETTPACKARD HP1047 (pump), HEWLETT PACKARD HP1047 computer monitor] was used for the determination of the extracted β-glucan by using the method described by Wood et al., (1991).

4. Physicochemical properties of β-glucan:

4.1. Solubility of β-glucan samples:

The solubility of β-glucan (unpurified) in the native flours (primary solubility) was determined according to the method of Gaosong and Vasanthan (2000). 100 mg of flour was mixed with 10 ml distilled water. The mixture was subjected to continuous shaking for 2 hr. at room temperature (25;C) followed by centrifugation at 10.000 rpm for 5 min β-glucan content

in an aliquot (0.1 ml) of the supernatant was determined. The solubility was calculated as a percentage of the total β-glucan content in the flour.

4.2. Foaming property: Whip ability (foaming capacity) and foam stability were measured according to Lin *et al*. (1974) by dispersing ca. 2.5 g gum (extracted β-glucan) in 100 mL water, whipping for 2 min using a hand-held food mixer at high speed (350 rpm) in a stainless steel bowl with straight sides and measuring volumes before and after whipping. Whip ability was reported as the percentage increase in volume due to whipping. Foams were slowly transferred to a 1000 ml graduated cylinder and allowed to set at room temperature (~21°C) for 2h. Volume of foam after 2h as a percentage of original volume was reported as foam stability

4.3. Fat absorption capacity:

Fat absorption capacity was determined according to Bhatty (1986). One gram of sample was mixed with 10 ml corn oil. The mixture was allowed to stand at room temperature for 30 min and then centrifuged at 1890 xg for 25min. The free oil was measured and percent oil absorption was calculated.

4.4. Water hydration capacity (WHC):

WHC of Extracted β-glucan: was determined applying the procedure described by Robertson et al., (2000)

5. Determination of Viscosity:

The rheological behavior was characterized by preparing aqueous dispersions of (1.5, 3.0, 4.5 and 6.0) % (p/v) of the extracted β-glucans at 80° C (1 h), followed by continuous agitation for 2 h at room temperature. This procedure guaranteed complete hydration and dispersion without forming

clumps. The rheological measurements were obtained with a rotational rheometer (Brookfield Engineering Laboratories model RVDV-III Ultra, Stoughton, MA, USA) with concentric cylinders spindle ULA, and the results obtained were processed through the Rheocalc_ 32(version 2.5) software. The intervals of shear rate: 30, 50, 70, 90 rpm at room temperature (25±5˚C) were applied, fitted with spindle Lv No. 1. The results were automatically recorded as centipoises (cp.). This method was described by (Limberger-Bayer et al., 2014) but with some modifications was done.

6. Preparation of Cake:

White cakes were prepared according to the method described by William (1988) using the following components. Flour 100g, sugar 100g, salt 1.7g, milk powder 9.1g, shortening 45.5g, water 36.4g, egg whites 68.4g, baking powder 5.7g, vanilla 2.3g. Different cake blends with extracted β-glucan as partial substitute of fat were formulated.

The physical properties of cakes, height (cm), weight (gm), volume (cm^3), specific volume (cm^3/g) and density (gm/cm^3) were measured according to the methods described by AACC (2010). Specific gravity of the batter of cake was measured by method 10-14 (AACC 1983). The pH of the batter was determined by direct immersion of a pH electrode in the batter at room temperature (25˚C) using a Digital pH meter (Jenway, Model 3020, Dunmow, Essex, UK).

7. Statistical analysis:

The results obtained were analyzed by Analysis of Variance using General Linear Model (GLM) procedure within a package program of

Statistical Analysis System (SAS, 1987). Means were separated using Least Significant Difference (LSD) test at a degree of significance ($P \leq 0.05$).

RESULTS AND DISCUSSION

1. Phytochemical investigations of barley flour and bran:

The results of these Phytochemical investigations are shown in Table (1). It is clear that, all the constituents of barley bran are higher than whole barley flour itself except total carbohydrates and moisture. But, the content of minerals of bran are lower than flour except Mg and K. According to Helm and De Francisco (2004) the protein contents in six Brazilian hull-less barley varieties are 12.55 to 15.92% d.m. and that described by Žilic *et al.*, (2011) for hull-less barley genotypes are 12.59 to 16.91% d.m. the protein contents determined here are in agreement with them results. Helm and De Francisco (2004) also concluded that crude fat 2.91 to 4.00%, ash 1.51 to 2.27% and crude fiber 5.95 to 7.12% and the result of the present study fall within the ranges reported by these investigators. Concerning the barley bran, Bhatty (1993 and 1995) reported that, the protein content of barley bran ranged between 13.60 -18.70%, fat 2.70 to 3.8 % and the starch 51.0 to 57.1 %.

Mangan *et al.*, (2015) stated that among 33 Tibetan barley grain samples the Fe and Zn contents are: 29-65 and 20-55 mg kg^{-1} respectively. Our results are in agreement with these results, but disagreement with Kan, (2015) who reported that barley cultivars from Turkey have K (635), Ca (48.7), Mg (166.7) and Na (12.4) gm/100g. This might be due to the variation in genetic

material, as well as, agronomic and environmental conditions experienced by the tested material.

Table (1): Chemical composition of raw material of barley flour and barley bran (dry weight basis)

Constituents	Barley flour	Barley bran
Protein (%)	14.69	15.96
Ash (%)	2.20	2.65
Ether Extract (%)	2.45	3.30
Crude Fiber (%)	3.83	6.35
Total carbohydrates*	76.83	71.83
Minerals contents (mg/100g sample)		
Fe	6.58	5.89
Ca	17.23	6.75
Zn	6.38	4.64
Mg	307.8	495.8
K	222.6	232.1
Na	1001.0	898.6

*Calculated by difference. Moisture content for barley flour 10.20 and for barley bran 10.5.

The total dietary fibre, total β-glucan of raw materials are listed in Table (2). It is obvious that the values of β-glucan and dietary fiber of barley bran are higher than barley flour. These results are in good agreement with those of previous investigators (Holtekjolen *et al.,* 2006; Izydorczyk *et al.,* 2003; Bhatty, 1999; Zheng *et al.,* 2011 and Sudha *et al.,* 2007).

Table (2): Total, Soluble and Insoluble dietary fibre and β-glucan of used raw materials (dry weight basis).

Sample	Dietary fibre %			β-glucan %		
	Total	**Soluble**	**Insoluble**	**Total**	**Soluble**	**Insoluble**
Barley flour	12.86	6.13	6.73	4.81	3.68	1.13
Barley bran	16.56	7.93	8.63	7.36	5.65	1.71

In earlier studies the variations in TDF, SDF and IDF contents of barley flour have been reported to range from 7.5 to 16.8%, 5.6 to 6.4%, and 1.9 to 10.4%, respectively in barley (Helm and De Francisco, 2004; Vasanthan *et al.*, 2002). The results obtained in the present study are similar to these values.

2. Isolation and characterization of β-glucan:

β-Glucan was extracted from barley flour (whole) and barley bran by the methods described before (cf. the experimental part). The yield of β-glucan from the three methods and its recovery percentage values are listed in Table (3). The yield of gum (extracted β-glucan) product represents the weight of gum obtained from 100 g of flour.

The results of table (3) indicate that there is no significant difference ($p \leq 0.05$) between the extracted values of β-glucan from flour by methods 2, 3 a significant increase in the value of β-glucan from b-bran in method 3. Efficiency of β-glucan extraction was determined by dividing, g β-glucan in 100 g fraction by g β-glucan in 100 g bran or flour. In this investigation the recovery percentage was significantly different at $p \leq 0.05$ for extraction value from b-bran and b-flour and high values from b-bran because ß-glucans

are usually concentrated in the outer layers, internal aleurone and subaleurone endosperm cells walls (Demirbas, 2005 and Holtekjolen *et al.*, 2006). Lower efficiency by hot water extraction method was observed, also by Symnons and Brennan, (2004) who ascribed this to the β-glucan cleavage by β-glucanase enzyme. The recovery values ranged from 58.18 to 79.35 %, which are lower than those reported by Vizhi and Many, (2012). Previous studies showed a recovery of 60–76% β-d-glucan (Ahmad *et al*., 2009). The higher recovery in enzymatic process in the present study may be attributed to a prior treatment with ethanol and the use of appropriate enzymes that reduce the intermolecular association of β-d-glucan with other components of oat that resulted in high extractability of β-d glucan. Similar observations were recorded by Xu *et al.*, (2007).

Table (3): Percentage of Recovery of β-glucan content (%)

Treatments (methods)	Yield-extracted β-glucan % from bran	β-glucan content (%) in barley bran	Percentage of Recovery (%)		Yield-extracted β-glucan % from flour	β-glucan content (%) in barley flour	Percentage of Recovery (%)
(1)Water Extraction	4.68 ± 0.005^{c}		63.59 ± 0.7^{c}		2.79 ± 0.1^{b}		58.18 ± 1.7^{b}
(2)water-Alkaline Extraction	5.41 ± 0.005^{b}	7.36 ± 0.05	73.51 ± 0.7^{b}		3.05 ± 0.15^{a}	4.81 ± 0.1	68.33 ± 2.5^{a}
(3)Alkalin Enzymatic Extraction	5.84 ± 0.005^{a}		79.35 ± 0.7^{a}		3.44 ± 0.06^{a}		71.43 ± 1.0^{a}

Means in the same column with different letters are significantly different ($p \leq 0.05$)**.**
Means ± SE (stander error)

*For the next part of the study the water-alkaline extracted fraction from methd (2) was selected (without pre-treatment step), as being the most stable, safety and economical β-glucan containing fraction, for inclusion into bakery products.

The extracted β-d-glucan was quantified and identified by HPLC analysis which gave retention time 10.1 min, β-glucan recovery value (75.229 %) and pentosan (3.61 %) was detected. The extracted β-d-glucan sample was subjected to complete analysis. The results are listed in Table (4).

Table (4): Proximate analysis of extracted β-glucan gum pellet

Constituents	**(g/100g) %**
Moisture	9.25
Protein	4.15
Ash	1.67
Ether extract	2.27
Crude Fiber	0.53
Starch	2.30
pentosan	3.61
(β-glucan)	76.22
Total Dietary Fiber	82.15
Minerals contents (mg/100g sample)	
Ca	5.85
K	97.43
Na	812.55
Mg	473.5
Zn	4.29
Fe	6.04

The above results are in good agreement with those reported by Ahmad *et al.,* (2010) and Burkus and Temelli (2005).

3. Functional properties of extracted β-glucan gum pellets:

Solubility, Water-hydration capacity (WHC), Fat absorption capacity (FAC) and Foaming capacity of β-glucan gum was investigated and listed in Table (5).

Table (5): Functional properties of beta-glucan pellet

Property	g/ 100g (%)
Solubility	53.11
Water-hydration capacity WHC	315
Fat absorption capacity FAC	365
Foaming capacity	155
Foam stability	60.6

The results obtained in our study (c.f. Table 5), are comparable with those obtained by previous investigators (Gaosong and Vasanthan 2000; Vizhi and Many 2012 and Bae *et al.,* 2009).

Foaming capacity and stability are the two important factors when the beta-glucan is used as a functional ingredient Vizhi and Many (2012). High foaming capacity and stability show more desirable characteristics in the preparation of cakes and batter. Proteins in the gum obtained at low pH/low temperature conditions may be expected to have better functionality. Thus, proteins must make a significant contribution to whippability (Foaming capacity) and foam stability.

The effect of different concentrations of extracted β-glucan and different shear rates on viscosity of extracted β-glucan were determined (c.f. Table 6). Examination of the values obtained reveals that the viscosity is increased with increasing the concentration of β-glucan. On the other hand, increasing the shear rates caused an observed decrease in β-glucan viscosity. At concentrations (> 0.2 %) the high molecular weight β-glucan molecules start to entangle and form viscus and pseudo-plastic behavior solutions (Doublier and wood 1995).

Table (6): The effect of different concentrations of extracted β-glucan and different shear rates on viscosity of extracted β-glucan.

Shear rates	Concentrations of β-glucan %			
	1.5	3.0	4.5	6.0
30	180.11	195.41	215.56	235.18
50	135.65	165.18	186.45	204.17
70	96.88	123.56	146.95	186.87
90	73.81	101.15	125.36	165.22

4. The use of extracted β-glucan as fat replacer in cake production:

After physical properties and chemical studies of extracted β-glucan, it was of interest to the authors to use it as partial substitute of fat in making healthy cakes. Low calories white layer cake blends were prepared with a study of their physical properties (batter and cake) and chemical composition. The results obtained are listed in Tables 7and 8.

It is clear from the data of Table (7) that there are significant differences between 50% substitution and control, 75% substitution at ($p \leq 0.05$). 50% Substitution gave higher values than the others in height, volume, weight and specific volume but gives lower values in specific gravity, pH and density. This indicates that 50% substitution of fat by β-glucan gives a cake of high quality.

Table (7): Batter characteristics as influenced by fat replacer (β- glucan) levels and physical properties of low calories cake prepared with different fat replacer levels.

Property	Replacer level			$L.S.D_{0.05}$
	0% (control)	50%	75%	
Batters				
Specific gravity	0.95^{a}	0.92^{b}	0.94^{a}	0.1
pH	7.11^{a}	$6.86.5^{a}$	6.73^{c}	0.1
Cakes				
Height (cm)	5.0^{c}	6.5^{a}	5.5^{b}	0.32
Volume (cm^3)	420^{c}	470^{a}	440^{b}	8.00
Weight (gm)	160.76^{c}	168.7^{a}	164.69^{b}	3.13
Specific volume (cm3/gm)	2.61^{c}	2.79^{a}	2.67^{b}	0.01
Density (gm/cm^3)	0.38^{a}	0.35^{b}	0.37^{a}	0.01

Means in the same row with different letters are significantly different ($p \leq 0.05$) for each effect.

$L.S.D_{0.05}$ least significant differences at ($p \leq 0.05$)

It is clear from the data of Table (8) that there was no significant difference ($p \leq 0.05$) in crude protein. But there are high significant differences in total fat and total calories, both decreasing by increasing the level of β- glucan.

Table (8): Chemical composition of low calorie white layers cakes prepared with different fat replacer levels by β- glucan (on dry weight basis).

Constituents	Replacer level			$L.S.D_{0.05}$
	0% (Control)	**50%**	**75%**	
Crude protein	8.87[a]	8.92[a]	8.96[a]	0.41
Total fat	20.73[a]	14.60[b]	10.66[c]	1.06
Total ash	1.78[c]	1.91[b]	2.13[a]	0.07
*Total carbohydrate				
Moisture	68.62[c]	74.57[b]	78.25[a]	2.13
**Total Calories	23.24[ba]	24.82[a]	24.31[a]	1.20
	496.53[a]	465.36[b]	444.78[c]	11.20

*Calculated by difference. **calculated

Means in the same row with different letters are significantly different ($p \leq 0.05$) for each effect

CONCLUSION

The results of this study show clearly that the use of barley and beta - glucan extracted from it as naturally functional ingredients gave food products of acceptable nutrition value. In addition, the wide range of therapeutic uses of these naturally occurring components might represent another benefit for using them in food.

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دراسات كيميائية وبيئية على بعض المكونات الفعالة المستخلصة من الشعير

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المستخلص

يعد البيتاجلوكان أهم المواد الفعالة الموجودة طبيعيا فى حبوب نبات الشعير. البيتاجلوكان هو الياف غذائية ومكون من وحدات جلوكوز عديدة مرتبطة طبيعيا (بوليمر) ويوجد فى جدار خلايا الإندوسبيرم (الطبقة تحت الأليرون) حيث تتراوح نسبته بين ٢–٨ % من وزن الحبة. كمية البيتاجلوكان المستخلصة تتأثر بطريقة الإستخلاص وبالتالى النسبة المئوية لكفاءة الإستخلاص. التركيب الكيميائى للبيتاجلوكان والخواص الطبيعية له جعلته مركب وظيفى يستخدم فى انتاج اغذية صحية. تنشأ فائدة البيتاجلوكان الصحية من لذوجته العالية وكونه من الألياف الغذائية القابلة للذوبان.

يتضمن هذا البحث دراسة على استخلاص مادة البيتاجلوكان من حبوب الشعير العاري بطرق إستخلاص مختلفة ومعرفة كفاءة انتاجيته بهذه الطرق. والتعرف عليها بدراسة خواصها الفيزيائية والكيميائية . كما تم استخدام تللك المادة المستخلصة كبديل للدهن فى تحضير بعض عجائن الكيك.

وقد استلزم ذلك دراسات كيميائية وفيزيائية على كل من حبوب الشعير ومادة البيتاجلوكان المستخلصة وكذلك عجائن الكيك المنتجة للتعرف على تراكيبها الكيميائية ومن ثم قيمها الغذائية.

الكلمات الدالة: بيتاجلوكان، حبوب الشعير، عجائن الكيك، الخواص الفيزيائية والكيميائية.