PRODUCTION OF SNACKS DIGESTIBILITY PROTEIN FROM BARLEY AND TOMATO WASTES.

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ABSTRACT

Prepared mixtures of barley flour with different ratios of tomato wastes from the tomato industry are (zero, 5, 10, 15 and 20%) to take advantage of their high content from fiber, antioxidants, and minerals, as well as to raise their economic value, for the production of snacks using extrusion at 180 °C and 200 rpm. Also, we studied the effect of these ratios on the chemical composition, phenolic compounds and physical properties (expansion, bulk density, water absorption, hardness, breaking strength, and color) of products as well as, organoleptic properties. The study showed that increasing the ratio of tomato wastes decreased each of the protein ratio, β-glucan and increased each of fiber ratio and mineral elements. Total phenolic compounds also increased by increasing the proportion of waste but decreased by extrusion. Also, affected the increase a ratio of tomato wastes on the physical properties of the outputs extrusion process, where decreased each of expansion ratio and water absorption. On contrast that, increased each of hardness, hardness, bulk density and color values. Sensory evaluation showed that the best ratio addition of tomato wastes were 15% and 20%. These results indicate that possibility of using tomato wastes mixing with barley flour of production snacks with high nutritional value.
Keywords: Production; Snacks; Extrusion; Barley; Tomato wastes.

INTRODUCTION

Extrusion cooking is an important and popular food processing technique classified as a high temperature/short time process to produce fiber-rich products (Gaosong and Vasanthan, 2000 and Vasanthan, *et al.* 2002). In the extruder, the food mix is thermo mechanically cooked to high temperature, pressure and shear stress, which are generated in the screw-barrel assembly. The cooked melt is then texturized and shaped in the die (Arhaliass *et al.* 2003). The thermo mechanical action during extrusion brings about gelatinization of starch, denaturation of protein and inactivation of enzymes, microbes and many anti-nutritional factors; all this occurs in a shear environment, resulting in a plasticized continuous mass (Bhattacharya and Prakash, 1994).

Barley is the fourth most important cereal in the world in terms of total production after wheat, rice and corn (Jadhav *et al.* 1998), only a small amount of barley is used for human consumption. Taste and appearance factors along with its poor baking quality have limited the use of barley in human foods. However, in recent years there has been a growing research interest for the utilization of barley in a wide range of food applications (Bhatty, 1999; Bilgi and Celik, 2004 and Koksel *et al.* 1999). The mixed linkage $(1\rightarrow3)(1\rightarrow4)$-β-D-glucans (β-glucan) from the endosperm of cereal grains are valuable industrial hydrocolloids and have been shown to be important, physiologically active dietary fibre components (Wood, 2001). β-

glucans are water-soluble, linear, high molecular-weight polysaccharides (Autio *et al.* 1987; Autio *et al.* 1992 and Doublier and Wood, 1995). They give viscous, shear thinning solutions even at low concentrations. The viscosity is related to the molecular weight and is strongly dependent on concentration (Autio, 1995 and Wood *et al.* 2000).

Barley β-glucan has shown to have cholesterol-lowering effects in humans (Newman *et al.,* 1989) rats (Hecker *et al.,* 1998) and chicks (Wang *et al.*, 1992).

Proposed mechanisms of action are, e.g. increased excretion of cholesterol (Lia *et al.* 1995) and stimulation of the reverse cholesterol transport (Bourdon *et al.*, 1999). In a study with golden hamsters. Delaney *et al.*, (2003) concluded that the cholesterol lowering effect of β-glucan is more or less similar whether it is isolated from oat or barley. Barley β-glucan has been shown to lower also postprandial glucose and insulin response in humans (Hallfrisch *et al.*, 2003).

Tomato *(Lycopersicon esculentum)* is one of the most popular vegetables and an integral part of human diet worldwide. Significant amounts are consumed in the form of processed products such as juice, paste, puree, ketchup, sauce and salsa.

During tomato, processing a by-product, known as tomato pomace, is generated. This by-product represents, at most, 4% of the fruit weight (Del Valle *et al.*, 2006).

Tomato pomace consists of the dried and crushed skins and seeds of the fruit (Tadeu-Pontes *et al.*, 1996). The skin, important component of pomace, is source of lycopene. Lycopene is an excellent natural food color and serves as a functional ingredient with important health benefits beyond basic nutrition (Kaur *et al.* 2005). A diet rich in lycopene is related to a decreased risk of certain cancers, particularly cancers of the digestive tract, prostate cancer and pancreatic cancer due to protective effect of lycopene against oxidative damage (Johnson, 2000). It also was found that tomato pomace significantly reduced cholesterol level in liver and heart by 15% and 18%, respectively (Bobek *et al.* 1998). The use of tomato processing by-products could provide gaining valuable substances and at the same time reduce the waste disposal problem. In recent years, there is an increasing demand for conversion of fruit and vegetable wastes into useful products. The primary motivation is to minimize environmental impact of these by-products and to utilize valuable constituents that remain, such as lycopene and dietary fiber. One viable method for utilization of fruit and vegetable by-products into useful products is extrusion processing due to its versatility, high productivity, relative low cost, energy efficiency and lack of effluents. Successful incorporation of tomato pomace into extruded products that deliver physiologically active components represents a major opportunity for food processors providing the consumer a healthy barley-based product to choose from which is currently lacking in the marketplace (Aylin *et al.*, 2008).

The objective of this research was to investigate process ability of production of snacks digestibility protein from barley and tomato waste. The effect of the variables such as tomato skin content, extrusion die temperature

and screw speed on system parameters and physical properties of extrudates were evaluated by using response surface methodology. Sensory properties were determined in terms of color, texture, taste, off-odor and overall acceptability for selected extrudate samples.

MATERIALS AND METHODS

Materials:

Hull-less whole barley grain (*Hordeum apertum – Giza 130*) samples used in this study were obtained from Barley Research Department, Sakha Agricultural Research Station, (A R C), Egypt. Tomato wastes *(Lycopersicon esculentum)* (processing by-product) was obtained from the Company Kaha for Preserved Foods located in Kaha, Qlliopih Governorate, Egypt.

Methods:
Sample preparation:

Barley flour was prepared using a Super Mill 1500 (Newport Scientific, Australia). Barley flour was stored at 4 ⁰C until use. Tomato wastes, obtained from the paste line, had a moisture content of 46.4% (w.b.). It was dried at 50 ⁰C overnight in a forced-air drier (Model # R-4, Commercial Dehydrator System, Inc., Eugene, OR, USA). The dried tomato wastes was coarsely ground and passed on sieve with size of 20 mesh. Then, the sieved tomato wastes was finely ground and stored in polyethylene bags at -20 ⁰C for further usage. The moisture content of dried tomato wastes was 2.43 ±0.2% (w.b.). Blends were prepared by mixing barley flour and tomato wastes in the ratios of 100:0, 95:5, 90:10, 85:15 and 80:20 on a dry-to-dry weight basis.. The blended samples were conditioned to 21–22% (w.b.) moisture by spraying with a calculated amount of water and mixing continuously at medium speed in a mixer (Model F-30T, Blakeslee, Chicago, IL, USA) (Aylin *et al*., 2008). The samples were put in buckets and stored at 4 ⁰C overnight. The feed material was then allowed 3 hours to equilibrate at room temperature prior to extrusion. This preconditioning procedure was employed to ensure uniform mixing and hydration and to minimize variability in the state of the feed material. Moisture content of samples was determined by halogen moisture analyzer (Model HR83 and HR83P، Mettler-Toledo GmbH, Greifensee, Switzerland) at 105 ⁰C.

Extrusion cooking:

All products were made using a Clextral BC21 twin-screw laboratory scale extruder (Clextral, Firminy Cedex, France). The screw diameter, (L/D) ratio and die diameter was 25 mm 16 and 6 mm, respectively. The feed rate (20 kg/h) and screw speed (200 rpm) were kept constant. The extrusion was carried out at 180 °C, the temperature of different barrel zones was 50, 100، 140 and 180 °C. The terminal section was heated by an induction heating belt and the feeding section of barrel was cooled with running water (Aylin *et al*., 2008).

Proximate analysis:

Moisture, ash, lipid and protein contents were determined according to the standard AACC (1995) procedures. The fiber contents (total, soluble and insoluble fiber) were measured using the Megazyme total dietary fiber analysis kit (Prosky *et al.* 1985). β-glucan content was determined using the mixed-linkage β-glucan assay procedure kit of Megazyme Ltd. (McCleary and Glennie, 1985).

Total phenolic content (TPC):

The total phenolic content (TPC) was determined according the Folin–Ciocalteu specterophotometric method (Sharma and Gujral, 2010). Samples (200 mg) were extracted with 4 ml acidified methanol (HCl/methanol/water, 1:80:10, v/v/v) at room temperature (25 ºC) for 2 h. An aliquot of extract (200 ll) was added to 1.5 ml freshly diluted (10-fold) Folin–Ciocalteu reagent. The mixture was allowed to equilibrate for 5 min and then mixed with 1.5 ml of sodium carbonate solution (60 g/l). After incubation at room temperature (25 ºC) for 90 min, the absorbance of the mixture was read at 725 nm (Shimadzu, UV-1800, Japan). Acidified methanol was used as a blank. The results were expressed as l g of ferulic acid equivalents (FAE) per gram of sample.

Physical properties:

Expansion: Extrudate expansion was determined as sectional expansion. A digital caliper was used to measure the width and thickness of extrudates. The average of ten measurements of extrudate was used to calculate sectional expansion index (SEI). SEI was calculated by dividing the cross-section area of extrudate by the cross section area of the slit die as given in Eq. (1) (Alvarez-Martinez *et al.* (1998):

$$SEI = \frac{S_e}{S_d} = \frac{W_e \times H_e}{W_d \times H_d} \qquad (1)$$

where S_e and S_d are the cross-sectional areas of the extrudate and the die. W_e and H_e are the width and thickness of the extrudate and W_d and H_d are the width and thickness of the die, respectively.

Bulk density: A volumetric displacement method by using glass beads with a diameter in the range of 1.00–1.18 mm as a displacement medium was used to determine bulk density of extrudates (Hwang and Hayakawa, 1980). Bulk densities (PD) of the extrudates were calculated by using Eq. (2):

$$P_d = \frac{W_{ex}}{W_{gb}} \times P_{gb} \qquad (2)$$

where P_d, is the bulk density using glass bead displacement method (g/cm3); W_{ex}, is the extrudate mass (g); W_{gb}, is the mass of glass beads displaced (g) and P_{gb}, is the bulk density of the glass beads (g/cm3). The values were average of three measurements.

Water absorption and solubility indices: The water absorption index (WAI) is the weight of gel obtained per gram of dry ground sample. The WAI of extrudates was determined according to the AACC methods, (1995). The ground extrudate was suspended in water at room temperature. After standing for 10 min, gently stirred during this period, samples were

centrifuged for 15 min at 1000 x g (AllegraTM 6 Centrifuge، Beckman Coulter Inc., Palo Alto, CA, USA). The supernatant was decanted and WAI was calculated as the weight of sediment obtained after removal of the supernatant per unit weight of original solids as dry basis. Three determinations were conducted for each extrudate.

Texture*:* The hardness (H) and breaking strength (BS) of samples were measured with a TA-XT2i Texture Analyzer (Texture Technologies Corp., Scarsdale, NY, USA). Hardness (as N) was determined by measuring the maximum force required to break the extruded samples using three point break test (Singh *et al.*, 1994 and Mathew *et al.*, 1999) with a sharp-bladed probe (55 mm wide, 40 mm high، 9 mm thick). BS (as N/mm^2) was determined by dividing the maximum force by cross-sectional area of the product. Extrudate sample was cut into ~42 mm length and a single piece was placed on the two support bars perpendicular to the probe.

The width (20.3-22.0 mm) and height (2.5–3.3 mm) of samples were changing according to the extrusion processing. The distance between two supports was 22 mm and the probe was lowered on to the extrudate at a pretest speed of 1 mm/s and test speed of 2 mm/s. A force-time curve was recorded and analyzed by Texture Exponent 32 software program (version 3.0). Six measurements were performed on each sample.

Color: HunterLab LabScan II (Hunter Associates Laboratory, Inc., Reston، VA, USA) was used to determine color values of the raw materials and ground extruded in terms of the Hunter *L*, a and b. The *L* value represents the lightness/darkness of the sample and ranges between 0 for black to 100 for white sample. The *a* and *b* values represent redness/greenness and yellowness/blueness of sample. The measuring head was equipped with 51 mm diameter viewing port and used the system of diffuse illumination with 10° viewing geometry. The illuminant was D65. The extrudates were ground in a laboratory grinder and passed through a 60 mesh sieve prior to color analysis (Mensah, 1997).. For each sample, three measurements were taken and averaged. The total color change (*ΔE*) was calculated as:

$$\Delta E = \sqrt{(L - L_0)^2 + (b - b_0)^2 + (a - a_0)^2} \qquad (3)$$

where the subscript '*o*' indicates initial color values of the raw material.

Sensory evaluation:

A semi-trained panel of 28 panelists evaluated the extruded snacks for color, texture, overall acceptability, taste and off-odor on a 7- point hedonic scale (from 1 = extremely dislike to 7= extremely like). Panelists rinsed their mouths with water after tasting each sample Rickard and Thompson, (1997).

Statistical analysis

Analysis of variance (ANOVA) was carried out using Microsoft Excel software and Fishers least significant difference (LSD) test was used to describe means with 95% (p < 0.05) confidence. The Pearson correlation coefficients were calculated by SPSS statistical software (SPSS Inc., Chicago, Illinois, USA) at a probability level of p < 0.05**.**

RESULTS AND DISCUSSION

Proximate analysis of the raw ingredients of extrudates:

The composition of the raw mixtures were shown in Table (1). It was observed that increasing the percentage of tomato wastes in the mixtures did not have a significant effect on the moisture content, while, led to significant decreasing of lipids from 2.25 to 1.16%, proteins from 14.27 to 11.47% and β-glucan from 4.91 to 3.58%. On the contrary, it was found that the percentage of ash, carbohydrates and fiber increased by increasing tomato waste in mixtures were from 1,89 to 2,76%, 69,88 to 72,68% and from 6,77 to 10,03%, respectively. These results are due to replacement barley flour by tomato wastes, which contain a high amount of fiber and minerals. Similar findings have been reported previously (Aylin *et al.,* 2008 and Del Valle *et al.,* 2006).

Table 1: Proximate analysis of the raw ingredients of extrudates (% as dray weight).

Mixtures *	Moisture	lipids	Protein	Ash	Carbohydrates	Fiber	β-glucan
100:00	11.71[a]	2.25[a]	14.27[a]	1.89[bc]	69.88[b]	6.77[e]	4.91[a]
95:05	11.41[a]	2.04[ab]	13.58[ab]	2.09[b]	70.88[b]	7.43[d]	4.66[ab]
90:10	11.33[a]	1.73[bc]	12.64[bc]	2.27[ab]	72.03[a]	7.99[c]	4.28[bc]
85:15	11.15[a]	1.50[cd]	12.04[cd]	2.55[a]	72.76[a]	8.62[b]	3.91[cd]
80:20	11.93[a]	1.16[d]	11.47[d]	2.76[a]	72.68[a]	10.03[a]	3.58[d]

* **(Barley flour: Tomato wastes).**
Means with the same letter within a column are not significantly different by least significant difference (LSD) analysis (P> 0.05).

Effect of extrusion and mixing ratio on total phenolic content (TPC):

Total phenolic content of mixtures before and after extrusion were shown in Table (2). The total phenolic content in all the mixtures decreased significantly upon extrusion as compared to their corresponding control (unextruded) samples. These results are also consistent with previous study carried out by Delgado-Licon *et al.* (2009) on the extrusion of bean–corn mixture. The phenolic compounds are heat labile (Sharma and Gujral, 2010) and are less resistant to the heat, and heating over 80 °C may destroy or alter their nature (Zielinski *et al.*, 2001). While, increasing 20% of tomato wastes led to the increase total phenolic content 1747 μg FAE/g for unextruded and 1901μg FAE/g for extruded. The differences in the total phenolic content can be attributed to differences in high content of antioxidants in tomato waste as lycopene. These results are also consistent with previous study carried out by (Madhujith and Shahidi, 2009; Sharma and Gujral, 2010) reported TPC value ranging from 2.63 to 4.51 mg of ferulic acid equivalents (FAE)/g in barley.

Table 2: Total phenolic content of mixtures before and after extrusion.

Mixtures *	Total phenolic content (µ g FAE/g)	
	Unextruded	**Extruded**
100:00	3642^{eA}	2561^{eB}
95:05	4077^{dA}	3112^{dB}
90:10	4578^{cA}	3560^{cB}
85:15	4906^{bA}	3942^{bB}
80:20	5389^{aA}	4462^{aB}

* **(Barley flour: Tomato wastes).**

FAE = ferulic acid equivalents.

a, b, c, d and e superscripts are significantly (p < 0.05) different within a column for different extrudates and A and B superscripts are significantly (p < 0.05) different within a row for each extrudates.

Effect of mixing ratio on physical properties of extrudates:

Table (3) shown an effect the mixing ratio on physical properties of extrudates. Sectional Expansion Index (SEI) is an important physical attribute for the extruded snacks that greatly affects consumer acceptability. SEI of products ranged between 286.24% and 232.14%. As expected, incorporation of tomato wastes reduced the expansion values of up to 18.9% compared to the controls. Bulk densities (PD) of products varied between 112.22 and 289.32 kg/L. The density of the extruded products to which 20% of tomato waste was added, was about twice that of extruded products containing flours only due to the presence of sugars and soluble fiber in the tomato wastes that absorb moistures. The water absorption index (WAI) measures the volume occupied by the granule or starch polymer after swelling in excess water. While the water soluble index WSI determines the amount of free polysaccharide or polysaccharide released from the granule after addition of excess water (Sriburi and Hill, 2000). The WAI ranged from 7.54 to 6.01 g/g for the barley flour–tomato wastes extrudates. The WAI decreased significantly as the percentage of tomato wastes increased. This may be attributed to relative decrease in starch content with addition of tomato wastes and competition of absorption of water between wastes and available starch. This result is in agreement with those of (Artz *et al.,* 1990). They reported a decrease in water holding capacity when the ratio of fiber/corn starch increased in extrusion of corn fiber and corn starch blend.

Table 3: Physical properties of extrudates.

Mixtures *	SEI (%)	PD (kg/L)	WAI (g/g)	H (N)	BS (N/mm^2)
100:00	286.24^a	112.22^d	7.54^a	5.71^e	0.305^e
95:05	275.13^{ab}	167.39^{cd}	7.14^{ab}	10.46^d	0.540^d
90:10	260.82^{bc}	204.27^{bc}	6.75^{bc}	14.98^c	0.783^c
85:15	245.44^{cd}	248.44^{ab}	6.44^{cd}	19.23^b	1.012^b
80:20	232.14^d	289.32^a	6.01^d	23.31^a	1.245^a

Means with the same letter within a colum are not significantly different by least significant difference (LSD) analysis (P> 0.05).

* (Barley flour: Tomato wastes).

SEI = sectional expansion index; PD = Bulk densities; WAI = water absorption index; H = hardness and BS = breaking strength.

Hardness (H) was obtained from the maximum force required to fracture the products by the Kramer shear cell. Hardness correlates with the bite hardness that could be expected from eating the product. Hardness varied between 5.71 and 23.31 N (Table 3) among our products. Products made with the flours alone were much less hard than that of tomato wastes (Table 3).Fiber interferes with air bubble formation and increases air cell wall thickness (Altan *et al.*, 2008) resulting in a harder product.

During extrusion, it was noticed that the foam structure from products containing skin was much finer than that for the other products. Substituting starch for finely divided skin fiber also reduces the proportion of materials capable of forming a melt in the extruder and this would be expected to reduce the foam volume and increase hardness. The breaking strength (BS) results were in line with hardness results. The breaking strength of barley extrudates was in the range of 0.305–1.245 N/mm^2 (Table 3). The low value of breaking strength was found for barley extrudates that produced from alone barley flour. The higher Sectional Expansion Index (SEI) and the lower the bulk density, the lower hardness and breaking strength was found in our study. The results were in agreement with study of (Choudhury and Gautam, 1998).

Effect of mixing ratio on color parameters of raw and extrudates materials:

Color is an important quality factor directly related to the acceptability of food products, and is an important physical property to report for extrudate products.

Table 4 shows color parameters of raw materials and extrudates. The non-extruded blend of barley flour and tomato wastes with a percentage of 0, 5, 10, 15 and 20 tomato wastes had color values of the ranges: *a*: 1.25–4.639 *b*: 9.03–0.94 and *L*: 45.93–64.60; whereas the barley flour–tomato wastes extrudates had color values of the ranges: *a*, 3.81–6.54; *b*, 16.73–1.78 and *L*, 73.68–92.57 (Table 4). Among the color parameters, the *L* and *a* values showed marked changes due to addition of tomato wastes only. An increase in tomato wastes level decreased the *b* value of the samples and increased the *a* value of samples as expected due to the lycopene pigment in the tomato pomace (Table 4). Similar result was found by (Ilo and Berghofer, 1999).

Table 4: Color parameters of raw and extrudates materials.

Raw mixtures (Barley flour: Tomato wastes)	Hunter color value			
	a	*b*	*L*	*ΔE*
100:00	1.25^e	9.03^a	45.93^e	-
95:05	1.97^d	6.01^b	50.32^d	-
90:10	3.02^c	3.91^c	55.17^c	-
85:15	3.74^b	2.05^d	59.56^b	-
80:20	4.63^a	0.94^e	64.60^a	-
Extrudates mixtures	*a*	*b*	*L*	*ΔE*
100:00	3.81^d	16.73^a	73.68^e	14.67^e
95:05	4.51^{cd}	12.71^b	78.41^d	16.25^d
90:10	5.18^{bc}	8.91^c	83.12c	19.07^c
85:15	5.85^{ab}	4. 05^d	87.54^b	21.42^b
80:20	6.54^a	1.78^e	92.57a	23.72^a

a, redness, greenness; *b*, yellowness, blueness; *L*, whiteness and **ΔE** the total color change.
a, b, c, d and e superscripts are significantly (p < 0.05) different within a column for different extrudates.

Sensory evaluation:

Five extrudate samples were selected out of 20 extrudate samples with respect to textural property and different tomato wastes level for sensory evaluation. The mean values of sensory panel ratings of extrudates are presented in Table (5).

Extrudates with different level of tomato wastes had better score than that of extrudate with 0%. Extrudate with 15% tomato wastes had the highest level of acceptance for color. Extrudates 10% and 15% had higher preference values for the parameter of texture. The overall acceptability of the barley flour and tomato wastes extrudate ranged lowest (4.23) in extrudate zero and highest (5.87) in extrudate15% (Table 5). These results were agreement with Altan *et al.*, (2008).

Table 5: Sensory evaluation scores of extrudates.

Sensory properties	Extrudates				
	100:00	95:05	90:10	85:15	80:20
Color	3.43^c	3.82^{bc}	4.37^a	4.93^a	4.21^{ab}
Texture	4.22^b	4.27^b	5.63^a	5.84^a	4.42^b
Taste	3.62^{cd}	4.23^d	4.86^c	5.63^b	6.15^a
Off-odor	2.86^d	3.92^c	4.72^b	4.35^b	5.26^a
Overall acceptability	4.23^c	4.25^c	4.93^b	5.87^a	5.17^b

Means within raw with different superscripts are significantly different (P < 0.05).

Conclusion

The system parameters and product responses were found to be most dependent on tomato wastes level. The results showed that varying levels of tomato wastes could be incorporated into an extruded barley snack

depending on the desired texture of the final product. Extrudates with 15% and 20% tomato wastes levels extruded at 180 °C and 200 rpm had higher preference levels for parameters of color, texture, taste and overall acceptability. Such extrusion would also provide another avenue for tomato wastes utilization.

REFERENCES

Altan, A.; McCarthy, K. and Maskan, M. (2008). Evaluation of snack foods from barley–tomato pomace blends by extrusion processing. Journal of Food Engineering, 84(2), 231–242.

Alvarez-Martinez, L.; Kondury, K. and Harper, J. (1998). A general model for expansion of extruded products. Journal of Food Sciences 53, 609–615.

American Association of Cereal Chemists (AACC) (1995). Approved methods of the AACC. St Paul, MN: The Association.

Arhaliass, A.; Bouvier, J. and Legrand, J. (2003). Melt growth and shrinkage at the exit of the die in the extrusion-cooking process. Journal of Food Engineering, 60, 185–192.

Artz, W.; Warren, C. and Villota, R. (1990). Twin screw extrusion modification of corn fiber and corn starch extruded blend. Journal of Food Science, 55, 746– 750.

Autio, K.; Myllym.aki, O. and Malkki, Y. (1987). Flow properties of solutions of oat β -glucans. Journal of Food Science, 52, 1364–1366.

Autio, K.; M.alkki, Y.and Virtanen, T. (1992). Effects of processing on the microstructure of oat (*Avena sativa*) bran concentrate and the physicochemical properties of isolated b-glucans. Food Structure, 11, 47–54.

Autio, K. (1995). Functional aspects of cell wall polysaccharides. In A.-C. Eliasson (Ed.), Carbohydrates in food (pp. 227–264). New York: Marcel Dekker.

Aylin A., Kathryn L. McCarthy and Medeni M. (2008). Evaluation of snack foods from barley–tomato pomace blends by extrusion processing. Journal of Food Engineering 84, 231–242.

Bilgi, B. and Celik, S. (2004). Solubility and emulsifying properties of barley protein concentrate. European Food Research and Technology,218,437–441.

Bhatty, R. (1999). The potential of hull-less barley. Cereal Chemistry, 76(5), 589–599.

Bhattacharya, S. and Prakash, M. (1994). Extrusion of blends of rice and chick pea flours: A response surface analysis. Journal of Food Engineering, 21, 315–330.

Bobek, P.; Ozdin, L. and Hromadova,M. (1998). The effect of dried tomato grape and apple pomace on the cholesterol metabolism and antioxidative enzymatic system in rats with hypercholesterolemia. Nahrung, 42, 317–320.

Bourdon, I.; Yokoyama, W.; Davis, C.; Backus, R.; Richter, D.; Knuckles, B. and Schneeman, B. (1999). Postprandial lipid, glucose, insulin, and cholecyst okinin responses in men fedbarley pasta enrichedwith beta-glucan. American Journal of Clinical Nutrition, 69, 55–63.

Choudhury, G.and Gautam, A. (1998). Comparative study of mixing elements during twin-screw extrusion of rice flour.Food Research International 31, 7–17.

Delaney, B.; Nicolosi, R.; Wilson, T.; Carlson, T.; Frazer, S.; Zheng, G.-H.; Hess, R.; Ostergren, K.; Haworth, J. and Knutson, N. (2003). Beta-glucan fractions from barley andoats are similarly antiatherogenic in hypercholesterolemic Syrian golden hamsters. Journal of Nutrition, 133, 468–
495.

Del Valle, M.; Camara, M. and Torija, M.-E. (2006). Chemical characterization of tomato pomace. Journal of the Science of Food and Agriculture, 86, 1232–1236.

Delgado-Licon, E.; Ayala, A.; Rocha-Guzman, N.; Gallegos-Infante, J.; Atienzo- Lazos, M. and Drzewiecki, J. (2009). Influence of extrusion on the bioactive compounds and the antioxidant capacity of the bean/corn mixtures. International Journal of Food Sciences and Nutrition, 60, 522–532.

Doublier, J. and Wood, P. (1995). Rheological properties of aqueous solutions of (1→3)(1→4)-β-D-glucans from oats (Avena sativa L.). Cereal Chemistry, 72, 335–340.

Gaosong, J. and Vasanthan, T. (2000). The effect of extrusion cooking on the primary structure and water solubility of b-glucans from regular and waxy barley. Cereal Chemistry, 77, 396–400.

Hallfrisch, J.; Schofield, D. and Behall, K. (2003). Physiological responses of men andwomen to barley and oat extracts (Nu-trimX). II. Comparison of glucose andinsulin responses. Cereal Chemistry, 80, 80–83.

Hwang, M. and Hayakawa, K. (1980). Bulk densities of cookies under going commercial baking processes. Journal of Food Science 45, 1400–1402.

Hecker, K.; Meier, M.; Newman, R. and Newman, C. (1998). Barley β-glucan is effective as a hypocholesterolaemic ingredient in foods. Journal of the Science of Food and Agriculture, 77, 179–183.

Ilo, S. and Berghofer, E. (1999). Kinetics of color changes during extrusion cooking of maize gritz. Journal of Food Engineering, 39, 73–80.

Jadhav, S.; Lutz, S.; Ghorpade, V. and Salunkhe, D. (1998). Barley: chemistry and value-added processing. Critical Reviews in Food Science, 38(2), 123–171.

Johnson, E. (2000). The role of lycopene in health and disease. Nutrition in Clinical Care, 3, 35–43.

Kaur, D.; Sogi, D.; Gary, S. and Bawa, A. (2005). Flotation on sedimentation system for skin and seed separation from tomato pomace. Journal of Food Engineering, 71, 341–344.

Koksel, H.; Edney, M. and Ozkaya, B. (1999). Barley bulgur: effect of processing and cooking on chemical composition. Journal of Cereal Science, 29, 185–190.

Lia, A.; Hallmans, G.; Sandberg, A.; Sundberg, B.; Aman, P. and Andersson, H. (1995). Oat beta-glucan increases bile acid excretion and a fibre-rich barley fraction increases cholesterol excretion in ileostomy subjects. American Journal of Clinical Nutrition, 62,p1245–1251.

McCleary, B. and Glennie-Holmes, M. (1985). Enzymic quantification of (1→3), (1→4)-β-D-glucan in barley and malt. Journal of the Institute of Brewing, 91, 285 295.

Madhujith, T. and Shahidi, F. (2009). Antioxidant potential of barley as affected by alkaline hydrolysis and release of insoluble-bound phenolics. Food Chemistry, 117, 615–620.

Mathew, J.; Hoseney, R. and Faubion, J. (1999). Effects of corn sample, mill type، and particle size on corn curl and pet food extrudates. Cereal Chemistry 76، 621– 624.

Mensah, P., (1997). Fermentation the key to food safety assurance in Africa? Food Control 8, 271–278.

Newman, R.; Newman, C. and Graham, H. (1989). The hypocholesterolemic function of barley b-glucans. Cereal Foods World, 34, 883–886.

Prosky, L.; Asp, N.; Furda, I.; De Vries, J.; Schweizer, T. and Harland, B. (1985). The determination of total dietary fibre in foods and food products: collab- orative study. J. Association Official Anal. Chem. 68, 677-679.

Rickard, E. S. and Thompson, L. U. (1997). Interactions and effects of phytic acid In F. Shahidi (Ed.), Antinutrients and phytochemicals in food (pp. 294–313.(Washington, DC: American Chemical Society.

Singh, J.; Hoseney, R. and Faubion, J. (1994). Effect of dough properties on extrusionformed and baked snacks. Cereal Chemistry 71, 417–422.

Sharma, P. and Gujral, H. (2010). Milling behavior of hulled barley and its thermal and pasting properties. Journal of Food Engineering, 97, 329–334.

Sharma, P.; Gujral, H. and Rosell, C. (2011). Effects of roasting on barley β-glucan, thermal, textural and pasting properties. Journal of Cereal Science, 53, 25–30.

Sriburi, P. and Hill, S. (2000). Extrusion of cassava starch with either variations in ascorbic acid concentration or pH. International Journal of Food Science and Technology, 35, 141–154.

Tadeu-Pontes, M.; Carvalheiro, F.; Roseiro, J. and Amaral-Colloc_o, M. (1996). Evaluation of product composition profile during an extrusion based process of tomato pomace transformation. Agro-Food- Industry Hi-Tech, May/June, 39– 40.

Vasanthan, T.; Gaosong, J.; Yeung, J. and Li, J. (2002). Dietary fiber profile of barley flour as affected by extrusion cooking. Food Chemistry, 77, 35–40.

Wang, L.; Newman, C. and Hofer, P. (1992). Barley beta-glucans alter intestinal viscosity and reduce plasma cholesterol concentrations in chicks. Journal of Nutrition, 122, 2292–2297.

Wood, P.; Beer, M. and Butler, G. (2000). Evaluation of the role of concentration and molecular weight of oat b-glucan in determining effect of   viscosity on plasma glucose and insulin following an oral glucose load. British   Journal of Nutrition, 84, 19–23.

Wood, P. (2001). Cereal b-glucans: Structure, properties andhealth claims. In B. V. McCleary, & L. Prosky (Eds.). Advanced dietary fibre technology (pp. 315– 318). Oxford: Blackwell Science Co.

Zielinski, H.; Kozlowska, H. and Lewczuk, B. (2001). Bioactive compounds in the cereal grains before and after hydrothermal processing. Innovative Food Science and Emerging Technology, 2, 159–169.

إنتاج أغذية خفيفة ذات بروتين سهل الهضم من الشعير ومخلف الطماطم.

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تم إعداد خلطات من دقيق الشعير مع نسب مختلفة من مخلفات تصنيع الطماطم هي (صفر و٥ و١٠و ١٥ و٢٠٪) للاستفادة من محتواها المرتفع من الألياف، ومضادات الأكسدة، والعناصر المعدنية، وكذلك لرفع قيمتها الاقتصادية، لإنتاج وجبات خفيفة باستخدام جهاز البثق الحراري على ١٨٠°م و ٢٠٠ لفة/دقيقة. أيضاً تم دراسة تأثير هذه النسب على التركيب الكيميائي للخلطات، والمركبات الفينولية الكلية، والخصائص الطبيعية للمنتجات مثل (الانتفاش والكثافة الظاهرية ونسبة التشرب والقابلية للذوبان والصلابة واللون) وكذلك الخواص الحسية. أوضحت الدراسة أن زيادة نسبة مخلفات الطماطم أدت إلى تقليل نسبة كل من البروتين والبيتا جلوكان وزيادة نسبة كل من الألياف والعناصر المعدنية. المركبات الفينولية الكلية ازدادت أيضاً بزيادة نسبة المخلفات ولكنها انخفضت بفعل عملية البثق الحراري. كذلك أثرت زيادة نسبة المخلفات على الخصائص الطبيعية لنواتج عملية البثق حيث خفضت نسبة الانتفاش والقدرة على امتصاص الماء، وعلى النقيض من ذلك ازدادت صلابة والمقاومة للكسر والكثافة الظاهرية واللون. التقييم الحسي أظهر أن أفضل نسبة إضافة من مخلفات الطماطم كانت ١٥% و٢٠%. وتشير النتائج إلى إمكانية استخدام خلط مخلفات الطماطم مع دقيق الشعير فى إنتاج أغذية خفيفة ذات قيمة غذائية عالية.

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