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To investigate the Effect of extrusion process conditions on the functional characteristics of expanded products Based on corn- almond

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ABSTRACT

In recent years, the demand for snacks with optimal functional and nutritional properties has a dramatic increased; hence researching in this regard is considered as an essential task. Almond, is one of the nuts kernel and an important source of nutrients, especially fats, fiber, antioxidants, vitamins and minerals such as iron and calcium. Using this seeds nut in expanded products not only improves the nutritional properties but also it causes to produce a product with optimal functional features. As the screw rate and humidity level have a great effect on the properties of extruded products. In this study, defatted almond flour –corn flour blends (20 - 80) were extruded in a co-rotating twin-screw extruder. Response surface methodology using a central composite design was used to evaluate the effects of independent variables, namely screw rate (120–220 rpm) and humidity level (12–16%) on functional properties (water absorption index, water solubility index and oil absorption index). Based on the process optimization maximum water absorption is 6.54085, water solubility is 25.6472 and oil absorption is 3.09778 that was belong to the production of screw rate 209.17 rpm and the 14% humidity.

Key words: Almond, functional properties, water absorption index, oil absorption index, and water solubility index.

Introduction

In recent years, the demand for snacks with optimal functional and nutritional properties has a dramatic increased and also the snacks that contain the products including protein and fiber are used as carriers to increase the nutritional features that mentioned above (Aguilar-Palazulos et al., 2012). Extrusion cooking is a process with high temperature and short time that has done with a combination of mechanical energy, temperature, pressure and humidity to produce a variety of fast foods and snacks (Lazou & krokida., 2010). It is used to produce a wide variety of expanded snacks, breakfast cereals, baby food, textured vegetable protein, animal feed. Advantages of extrusion are to improve functional properties and digestibility of cereals and reduce the level of antinutritional [Patel et al., 2016]. An optimal extrusion process depends on the functional properties of the product, such as water absorption, oil absorption and water solubility (Singh et al., 2007).Almond addition to the soluble and insoluble fiber, protein, iron, calcium, vitamin E and a high antioxidant, offers a very high ratio of fatty acid oleic, linoleic and linolenic [Ros., 2010]. It is a very good case for increasing nutritional and functional properties of food products, especially in the developing world [De pilli et al., 2008a]. In the use of nuts like peanuts, almonds and hazelnuts in snacks, and physical structure, texture, micro structure and complete starch-lipid, limited research has done by researchers like Asare (2004), Yağci and Göğüs (2009) and De pilli (2008a,b) but has not been investigating the functional characterization of this group of snacks. According to that the process conditions (humidity, screw rate, temperature of and pressure process) has a significant impact on the functional characteristics of products [Ding et al., 2006]. Response surface methodology (RSM) is an important statistical-mathematical method that uses quantitative data in an experimental design to determine the relationship between the response and the independent variables and optimize processes and products. The main advantage of RSM is reduced number of experimental runs needed to provide sufficient information for statistically acceptable result [Asare et al., 2004]. The aim of this study was to investigate the effects of process variables include screw rate and

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humidity level on the functional properties (water absorption index, oil and water solubility) of extruded products based on corn-almond and optimization of above effect by using response surface methodology.

Materials and Methods

Raw materials

Corn grits and almond was purchased from the local market of Mashhad and the humidity measurement and chemical tests were performed on them. The almond was defatted by cold press method and with the hammer mill was turned into flour. The defatted almond flour (17% fat) and corn grits ratio 20 to 80 were mixed together and according to desired humidity (12 -16%) of water was added to the formula and were prepared for extrusion cooking process.

Compositional analysis

Moisture, ash, protein, and fat analyses of corn grits and defatted almond flour were carried out using standard procedures of AOAC (2000). Carbohydrates were calculated by difference. The results of proximate composition analysis of the raw materials are presented in Table 1.

Table 1. Proximate compositions (g/100g) of defatted almond flour and corn flour

Component	Fat	Protein	Carbohydrate	Ash	Moisture
Defatted Almond flour	16.9	33.6	38.7	3.27	5.7
Corn Flour	2.8	6.89	75.5	0.65	11.3

extrusion cooking conditions

In this study, the twin-screw extruder direction DS56 model was manufactured by Jinan Saxin Company of China. The process variables of screw rate (120-220rpm) and humidity level (12-16%) on the properties of extruded sample contains of 20% fatted almond and 80% of corn grits were investigated. for drying Extruded products immediately after production were transferred to the oven 40 ° C for 2 hours, then after being cold placed inside the thick polyethylene plastic bags and are closed. All produced samples till the supplemental tests, was kept away from light, heat and humidity in room's temperature.

Functional properties

Water absorption index (WAI[1]) and water solubility index (WSI[2])

Put 0.2 grams of powdered product into 15 mL Falcon tube that has already been shed weight and weighing them. Then add 5 ml of distilled water and then stirred it for 2 minutes with Vertex it was centrifuged for 20 minutes at a speed of 700. Upon completion of the centrifuge supernatant is transferred into the petri dish and weighing the residual gel and water absorption properties was measured by equation (1)[Lazou & krokida., 2010].

(1) $$WAI = \frac{m_g}{m_s}$$

Mg: the weight of the remaining gel (g)

m_s : sample weight (g)

To measure water solubility, the supernatant that was transferred after centrifugation into a weighed petri dish moved into the hot air oven to heat and dry matter remaining to be weighed. The solubility in water were calculated by equation 2 [Lazou & krokida., 2010].

(2)

$$WSI = \frac{m_{ds}}{m_s} \cdot 100$$

M_{ds}: oven-dry weight of investment supernatant after centrifugation (g)

m_s : sample weight (g)

Oil absorption index (OAI[3]*)*

5.0 grams of powdered product transferred into the Falcon 15 ml that was weighted before and then add 3 ml of refined corn oil were added to the vortex and stirred it for 1 minute and put it away for 30 minutes. And then was centrifuged for 20 minutes at a speed of 700. Oil absorption was calculated by equation [Lazou & krokida., 2010].

(3)

$$OAI = \frac{V_{oil}}{m_s}$$

V_{oil}: volume of oil absorbed per milliliter

M_s: weight in grams

Statistical analysis

The effect of the independent variables on the functional properties of extruded snack based on corn-almond was studied using response surface methodology. Design Expert 7.1.6 software was used to analyze data and charts related to the response surface method. The independent variables considered were screw rate level (X1) and humidity level (X2). The coded and actual levels are summarized in Table 2

Table 2. Coded levels for the experimental design

Component	**Code**	Variable Level Codes		
		-1	**0**	**+1**
Screw Rate(rpm)	$\mathbf{X_1}$	120	170	220
Feed Moisture Content (%)	$\mathbf{X_2}$	12	14	16

Results and Discussion

The ANOVA, regression coefficients and mean values of functional properties of extruded snack are summarized are summarized in Table 3. Models for all parameters were significant, and none of the models showed significant lack of fit (P > 0.01).

Table 3. Coefficient of variables in the suggested model for response variables

Parameter Term	WAI	WSI	OAI
X_1 Screw Rate	0.0114	0.0001	0.6942
X_2 Feed Moisture Content	0.0001	0.0001	0.0001
x1 x 2 Feed Moisture Content ×Screw Rate	0.0004	0.2595	0.0033
x_1^2 Screw Rate ×Screw Rate	0.2472	ns	0.0862
x_2^2 Feed Moisture Content ×Feed Moisture Content	0.3661	ns	0.0569
model			
F Value	0.0001	0.0001	0.0003
R_2	0.89	0.91	0.94
Adjust R_2	0.82	0.88	0.85
Lack of fit	0.4756	0.2192	0.4037

The effect of screw rate and humidity level on water absorption index

WAI measures the water holding by the starch after swelling in excess water [Lazou & krokida., 2010]. The optimal model was proposed by design expert software. As for water absorption index average polynomial was statistically significant (p<0.05). ANOVA for the model as fitted (Table 3) shows high significance (P < 0.001) with a correlation coefficient (R_2) and adjusted R_2 value of 0.89 and 0.82, respectively.According to analysis of variance result in table3, meaningful model includes humidity and screw rate as well as the interaction between the screw rate and humidity (p<0.001). In Figure 1, the independent effect of humidity and screw rate variables on the water absorption index is shown. Accordingly, humidity increasing leads to an increase in the water absorption index, while increasing the screw rate reduces water absorption index. When the screw speed increases, it leads to further fragmentation and degradation of amylose and amylopectin and thus reduces the water absorption index [Gupta et al., 2008]. Water absorption index show the absorbed water by the gelatinized starch and is an important factor to investigate the undamaged starch and gelatinized [Lazou & krokida., 2010]. In addition, the starch-lipid complex formation reduces the starch gelatinization during extrusion; followed by that water absorption index is also reduced [De pilli 2008a,b]. Viscosity decreases with increasing humidity, mixing in the extruder was better to more gelatinized starch and thereby increasing the water solubility [Sibel et al., 2008]. In, Lazou & krokida (2010), Yağci and Göğüs (2008) and Ding (2006) researches, the highest rate of water absorption with high humidity has been reported in the above samples.

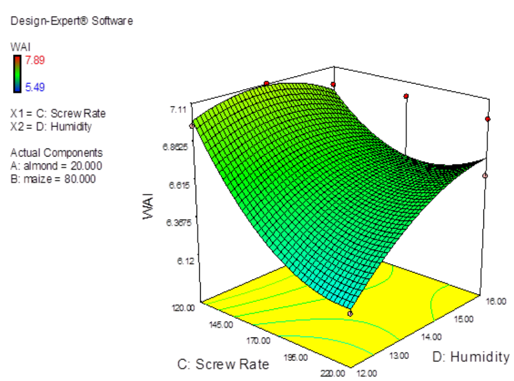

Figure 1: Effect of humidity and the screw rate on the water absorption index

The effect of screw rate and humidity level on the water solubility index

The optimal model was proposed by design expert software. As for water solubility index binomial model was statistically significant ($p<0.05$). The response was analyzed using ANOVA and the data are presented in Table 3. The regression model had a coefficient of determination (R_2) and adjusted R_2 value of 0.91 and 0.88, respectively. According to the results of analysis of variance the only meaningful model is screwing rate ($p<0.05$). In Figure 2 the independent effect of two variables, screw rate and humidity on water solubility index is shown. Accordingly, accelerating screw rate significant increase the water solubility index. Water solubility index as an indicator to analyze the molecular composition is the amount of destruction and starch dextrin during extrusion to show that the solution of the polysaccharide molecules released from the starch granule is proportional to [Ding et al., 2005, Lazou & krokida., 2010, De mesa et al., 2009]. Therefore shear stress at the screw rate of the surge and the destruction of macro molecules of starch increased water solubility increases [Haile et al., 2012]. Despite all the changes in the macro-molecules during the extrusion cooking extruder shear force developed the most affected. Cutting rate for mechanical energy (SME) and extrusion process variables (feed rate, temperature and screw rate) and features the formula (humidity, raw materials, viscosity) are dependent [Liang et al., 2002].

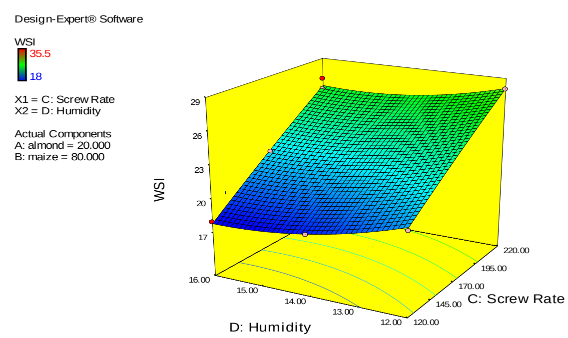

Figure 2: Effect of humidity and the rotation screw rate of the helix on the properties of water solubility

The effect of screw rate and humidity on oil absorption index

The optimal model was proposed by design expert software. As for oil absorption index binomial model was statistically significant ($p<0.05$). According to analysis of variance results the significant model is screw rate ($p<0.05$). ANOVA results for model of OAI are given in Table 3. Acceptable coefficient of determination (R_2) and adjusted R_2 values (0.94 and 0.85, respectively) were obtained for significant model of OIA. In Figure 3, the effect of screw rate of helix and humidity on oil absorption index is shown. Oil absorption index can be used as an indicator to represent the hydrophobic characteristics of the extruded product. And also increases of these factors will improve the aroma and mouth feel of the product [Omohimi et al., 2014].By increasing molecules destruction and starch results are smaller molecules with more hydrophobic properties [Lazou & krokida., 2010]. By increasing the rotation rate of the helix, destruction of molecules increased and too much oil absorbed because of the speed and energy increasing, but with the increase of screw rate more than 170 rpm the amount of oil absorption is reduced based on the same results reported of Omohimi (2014) and co-workers the level of destruction due to excessive starch molecules and their hydrophobic properties drastic changes in the molecular structure is reduced. The maximum amount of oil absorption in the screw rate range 170 rpm and the humidity of 14% is achieved.

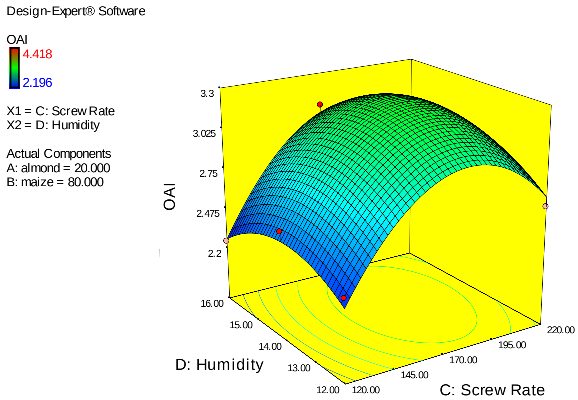

Figure.3: Effect of humidity level and the screw rate on the oil absorbing index

Optimization of extrusion process conditions to improve functional properties

In this section, the purpose of optimization was to maximize the functional properties (water absorption, fat absorption and water solubility). To modeling based on process variables such as humidity and screw rate, these variables were tested. Snacks optimal conditions to achieve a product with maximum performance characteristics were obtained as follows.

If the Properties of water absorption index 6.54085, water solubility 25.6472 and fat absorption 3.09778 the production condition of spiral rotation 209.17 rpm and humidity of 14% should be considered.

Conclusions

The extrusion process variables that include the screw rate and the humidity level, has a great effect on the product's functional characteristics. So that by controlling them large product with optimal performance characteristics is obtained. By increasing the screw rate of the helix and loss of humidity due to macromolecules damaging amount of oil absorption and water solubility of the product increased while reducing the screw rate and humidity increasing due to the increase of starch gelatinization the snack water absorption based on almond is increased. The production of Peanut Snack based on almond due to favorable performance characteristics is recommended as a nutritious snack.

References

Aguilar-Palazulos, E., Zazueta-Morales, J., Harumi, E. & Martinez-Bustos, F., 2012, Optimization of extrusion process for production of nutritious pellets, Ciênc. Tecnol. Aliment. Campinas, Vol.32, No. 1, PP. 34-42,

AOAC. 2000. Official Methods of Analysis, 15th Ed., Association of Official Analytical Chemists,Washington, DC

Asare, E. K., Sefa-Dedeh, S., Sakyi-Dawson, E., & Afoakwa, E. O. 2004. Application of response surface methodology for studying the product characteristics of extruded rice–cowpea–groundnut blends. International Journal of Food Sciences and Nutrition, 55(5), 431–439.

De Mesa,N J. E., Sajid, A., Narpinder, S., Shi, Y-C, Hulya, D. and Yijun, S., 2009, Soy Protein-fortified Expanded Extrudates: Baseline Study Using Normal Corn Starch, J. Food Eng, Vol. 90, PP. 262-270.

De Pilli, T., Jouppila, K., Ikonen, J., Kansikas, J., Derossi, A. and Severini, C. 2008, Study on formation of starch–lipid complexes during extrusion-cooking of almond flour. J. Food Eng. Vol. 87, 495–504 a.

De Pilli, T., Carbone, B.F., Derossi, A., Fiore, A.G. & Severini, C . 2008, Effects of operating conditions on oil loss and structure of almond snacks, Int J Food Sci Technol. Vol.43, PP. 430–439b.

Ding, Q.-B., Ainsworth, P., Plunkett, A., Tucker, G., and Marson, H., 2006, The effect of extrusion conditions on the functional and physical properties of wheat-based expanded snacks, Journal of Food Engineering, 73(2): p. 142-148.

Gupta, M., Bawa, A.S., and Semwal, A.D., 2008, Effect of barley flour on development of rice-based extruded snacks, Cereal Chemistry, Vol. 85, No. 2, PP. 115-122.

Haile, M., Zhongli, P., Baoguo, L., Griffiths, G.A., Donald A, O., Marisa M, W., and Tara H, M., 2012, Properties of extruded expandable breadfruit products, LWT-Food Science and Technology, Vol.46, No.1, PP. 326-334.

Lazou, A., & Krokida, M., 2010, Functional properties of corn and corn–lentil extrudates, Food Research International Vol.43, PP. 609–616.

Liang, M., Huff, H., and Hsieh, F.H., 2002, Evaluating Energy Consumption and Efficiency of a Twin-Screw Extruder, Journal of food science, Vol. 67, No. 5, PP. 1803-1807.

Omohimi, C.I., Sobukola, O.P., Sarafadeen, K.O. and Sanni, L.O. "Effect of Thermo-extrusion Process Parameters on Selected Quality Attributes of Meat Analogue from Mucuna Bean Seed Flour", Nigerian Food Journal, Vol. 32, No. 1, PP. 21 – 30, 2014

Patel, J R .,. Patel., A A & Singh., A K ., 2016, Production of a protein-rich extruded snack base using tapioca starch, sorghum flour and casein. J Food Sci Technol Vol. 53, No.1, PP.71–87

Ros, E., 2010, Health benefits of nut consumption, J Nutrition, Vol. 2, No. 7, PP. 652-682.

Sibel, Y. and Fahrettin, G. 2008. Response Surface Methodology for Evaluation of Physical and Functional Properties of Extruded Snack Food Developed from Food-by-products. J. Food Eng., 86: 122– 132.

Singh, S., Gamlath, S., & Wakeling, Lara., 2007, Nutritional aspects of food extrusion: a review, International Journal of Food Science and Technology,Vol. 42, PP. 916–929.

Yağci, S. and Göğüs, F., 2009, Selected physical of expanded extrudates from the blend of hazelnut flour-durum clear flour-rice, Int J Food Prop. 12: 405–413.

Yağci, S., and Fahrettin, G., 2008, Response Surface Methodology for Evaluation of Physical and Functional Properties of Extruded Snack Food Developed from Food-by-products. J. Food Eng., Vol. 86, PP. 122–132.