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Developing Vacuum Fried Pumpkin (Cucurbita Moschata Dutch) Snack

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Abstract: In this study, the possibility of producing pumpkin chips by vacuum frying, which is a relatively new method to produce fruit snacks was considered. A laboratory scale vacuum frying apparatus was used to study interactions and optimization of process parameters on vacuum frying of pumpkin slices. The results of this study suggest that vacuum frying at 84.53°C, pressure of 40 mbar for 18 minutes might produce pumpkin chips with acceptable quality. The composition of raw and processed pumpkin in the optimum conditions were determined and compared with each other. It was found that 60% of water content was exited from pumpkin slices during vacuum frying and around 20% oil absorbed to fried slices. In order to determine, sensory evaluation of the final product was considered. The results of sensory evaluation for customer acceptance implied that in terms of the evaluated factors, most of the panelists considered pumpkin chips desirable. Also, the results of sensory evaluation showed that panelists choose color of pumpkin chips as the finest factor of this product. Statistical analysis showed that there was no significant difference between view points of panelists ($p \leq 0.05$) in crispiness, odor, aftertaste, adherence and month feel.

Key words: Vacuum frying · Pumpkin chips · Snack · Customer acceptance

INTRODUCTION

Vacuum frying is a promising technology that may be an option for the production of novel snacks such as fruit and vegetable crisps that present the desired quality attributes and respond to new health trends [1]. Fruits and vegetables are important sources of vitamins and antioxidants. However, average consumption of fruits and vegetables in modern societies is low because of their early decay and rather high price [2]. Fruits and vegetables are high in sugar content and they are heat sensitive, thus they usually burn in temperature of usual frying process and lose their natural color and flavor, unless frying process takes place at low temperatures [3]. One of the modern methods for processing fruits and vegetables in the world is vacuum frying that can be performed at low temperatures. In addition, it enables us to make products with desirable crisp texture and high nutritional value [4]. Recent consumer trends towards healthier and low fat products have had a significant impact on the snack industry [1]. Many fruits and vegetables with high nutritional value, such as cauliflower, carrots, mangoes, and pineapples, cannot be processed by ordinary frying methods. However, they can be processed by vacuum frying because of its low temperature [5]. Many countries in Asia, (e.g. Japan, Thailand, Taiwan) use this technology to produce high nutritious snacks. This technology is expected to improve the nutrition and health of nations by producing products that taste good, keep most of their nutrition values, have lower fat contents than the conventionally fried snacks, also they are safer with little or no acrylamide formation, and they can be kept longer [6]. Compared with other dehydration technologies for fruit and vegetables, vacuum frying is a viable option to obtain high quality dried products in a much shorter processing time [7]. It has been demonstrated that vacuum fried snacks (blue potato, green bean, mango and sweet potato chips) retain more of their natural colors and flavors due to the less oxidation and lower frying temperature [2]. Yamsaengsung and Rungsee observed that vacuum fried potato chips and guava slices have lower oil content and more natural colorations than those fried conventionally [8].

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Pumpkin (Cucurbita moschata, Dutch) is a vegetable coming from tropical and subtropical zones, such as Mexico and South America, with high consumption in the local market [2]. Pumpkin, as a good source of nutrients, such as carotenoidsþ, vitamins B2, C, K and E, has a low energetic content and a large amount of fiber [4]. The fruit of pumpkin has been widely accepted as a dietary constituent among peasants in the world. It is green when unripe and turns yellow on ripening. Pumpkin has received considerable attention in recent years because of the nutritional and health protective value of the proteins and oil [9].

In this study, development of a new snack from pumpkin by means of vacuum frying method is presented and the effects of this specific processing on the organoleptic properties of pumpkin have been studied.

MATERIAL AND METHODS

Fresh pumpkins (*Cucurbita moschata dutch)* used in this study were obtained directly from Rasht which is located in the north part of Iran. They were stored at +4°C until required for the experiments. After one hour stabilization at ambient temperature, samples were washed with water and drained. RBD sunflower oil was used as a medium in the vacuum frying process of pumpkin slices [10].

Preparation of Pumpkin Slices: Washed and drained pumpkin were cut into 1.5mm thick slices with a slicer (Siemens, model CNAS 11ST2), followed by cutting in to rectangular pieces with 50mm length and 20mm width.

Experimental Apparatus: The frying behavior of pumpkin slices under vacuum has been studied experimentally by a laboratory vacuum frying apparatus. The fryer contains a number of units and accessories to control and carry out an effective frying operation under vacuum. A one liter borosilicate glass flat bottom flask equipped with three joints necks (to connect vacuum pump, thermometer probe and lift rod) was used as a frying vessel to observe product changes during the process. A dual seal vacuum pump (Platinum JB industries model DV-85N-250) which could generate an absolute pressure up to 3.115 kPa was used to provide and retain pressure in the vessel. The condenser was used to condense and collect the water vapor to prevent it from entering the pump. In order to hang the basket, a thin glass rod with a small fishing hook was used. Heating was performed by a 400 watts electric heater (Isopad model RM4002) and there was a control pressure valve near the pressure gauge [11].

Experimental Design: As full factorial design of experiments was time and cost consuming, the Response Surface Methodology (RSM) approach, and specifically, the central composite rotatable design (CCRD) was considered to optimizing the process parameters.

Experimental Conditions: Selecting the significant ranges of variables is the most important stage in response surface methodology, thus pretests were setup and it was found that the pressure range from 40-140 mbar, temperature range from 70 to 140°C and processing time from 3 to 18 minutes could be used for the design [12]. The vacuum vessel was set to the determined temperature and allowed to operate for 20 minutes before starting the frying process. 600ml sunflower oil was used as the medium in the vessel. According to the experimental design layout, a batch of 15 gram pumpkin slices was fried each time. When the oil temperature reached the target value, the pumpkins were placed in to stainless steel basket and the lid closed. Since the tempreture and pressure reached to the regulated range, the basket including pumpkin slices was immerse to the oil and frying process began for the desired time. Once the frying time was compeleted the basket was lifted from the oil and the vessel pressurized. The lid of the vessel was opened and the pumpkin chips were removed from the basket. In the next step, fried pumpkin chipes were centrifuged at 400rpm for 10 minutes in room temperature to remove the surface frying oil and then packed in the polyethylene bags for furthur analysis [11].

Laboratory Materials: All laboratory materials that were used in this study, including ethanol, toluene, petroleum ether, sulfuric acid, copper sulfate, potassium sulfate, indicators, boric acid and hydrochloric acid, were of analytical grade and prepared form Merck and Sigma companies.

Analytical Methods: Moisture content of raw and processed pumpkin was determined in a vacuum oven at 70°C until constant weight was achieved [13]. The oil content of raw and processed pumpkin was determined gravimetrically by Soxhlet extraction with petroleum ether [14]. The Kjeldahl method according to method 920.152 was used to determine protein of pumpkin slices.

The nitrogen factor used for pumpkin samples was 6.25 [15]. Ash content was determined by ignition at 550°C up to constant weight, according to the method 923.03 [15]. Total dietary fiber was analyzed according to the enzymatic-gravimetric method 985.29 [15]. Content of carbohydrate was evaluated according to the following formula [9]:

Carbohydrate content =100- (moisture + ash + protein + lipid)

The color of pumpkin chips was measured with a colorimeter (Hunter lab Color Flex made in USA) and expressed as Hunter L (lightness), a (redness) and b (yellowness) values. The colorimeter was standardized using a white tile and color difference (Hunter ΔE) was calculated according to equation (1) [16].

$$\Delta E^* = [(L^*_0 - L^*)^2 + (a^*_2 - a^*)^2 + (b^*_2 - b^*)^2]^{1/2} \qquad (1)$$

The sensory evaluation was performed according to the acceptance method. This method is part of consumer-oriented methods, in which a number of evaluators are selected, as representatives of potential consumers, to provide some information about behaviors and tendencies of consumers of food products. Members of this group are not trained and are just consumers of this product [10]. To determine the level of acceptance among consumers, samples were given to 25 evaluators simultaneously or separately and they were asked to evaluate the product and fill out the form according to properties of the product [17].

Panelists, using a hedonic scale of 1-5 judged the following parameters: Crispiness, Color, Flavor , Odor, Adhesion to oral, After taste, Mouth feel , Overall acceptance, and whether they will buy this product or not (1=too bad, 2=bad, 3=moderate, 4=good, 5=very good). The analyses were performed in isolated booths in a standard taste panel kitchen [6, 17].

Statistical Analysis: All data were obtained by triplicate analyses and were analyzed using the Design-Expert 7.1.3 State ease software. Analysis of variance was performed by the ANOVA procedure. Also, the results of sensory evaluation were statistically analyzed by SPSS 14.0 software via analysis of variance and Duncan test. A level of significance of $P<0.05$ was used throughout the analysis.

RESULTS AND DISCUSSION

To optimize the process conditions, frying temperature, time and pressure were selected as the main process conditions which could have effect on the quality attributes of vacuum fried pumpkin chips. Layout of the central composite rotatable design and corresponding quality values for vacuum fried pumpkin chips are shown in Table 1.

Table 1: Layout of the central composite design and corresponding quality values for vacuum fried pumpkin chips

Variables				Reponses			
Run	Frying Temperature (°C)	Frying Time (Min)	Frying Pressure (mbar)	Moisture (%)	Shrinkage (%)	Color (ΔE)	Breaking Force (N)
1	105	10.50	90	14.24	88.23	13.96	9.73
2	105	10.50	90	15.81	84.81	7.16	9.82
3	84.19	14.96	60.27	11.13	85.48	15.04	10.94
4	84.19	6.04	60.27	79.55	77.76	7.46	5.13
5	125.81	14.96	60.27	5.58	80/43	9.36	15.11
6	105	3	90	82.5	64.53	12.83	3.45
7	105	18	90	13.89	82.82	10.95	9.18
8	70	10.50	90	76.27	60.63	3.63	3.75
9	140	10.50	90	15.15	80.26	41.8	6.20
10	105	10.50	140	30.37	84.12	14.43	11.57
11	125.81	6.04	119.73	34.74	81.47	13.03	9.40
12	84.19	14.96	119.73	20.87	87.22	7.31	5.87
13	105	10.50	90	15.98	84.17	7.45	12.52
14	105	10.50	90	15.95	86.12	8.65	10.05
15	84.19	6.04	119.73	76.79	70.40	11.84	2.57
16	125.81	6.04	60.27	25.11	85.23	12.32	8.90
17	105	10.50	90	14.33	86.34	8/19	9.81
18	125.81	14.96	119.73	0.21	86.03	22/52	7.16
19	105	10.50	40	5.56	84.06	9/33	5.79
20	105	10.50	90	19.84	84.97	16/98	9.59

Table 2: Composition of raw and vacuum fried pumpkin

Test	Raw pumpkin (%)	Processed pumpkin (%)	Method
Moisture content	92.05±0.894	31.93±0.751	AOAC 44-15
Protein	1.3±0.332	4.49±0.145	AOAC, 1990
Oil content	0.32±0.003	20.60±0.840	AOCS 3-49 BC
Ash	0.921±0.005	3.655±0.139	AACC 08-01
Carbohydrate	5.3±0.157	30.52±0.225	AOCS Da 24-48
Fiber	0.62±0.004	8.6±0.603	AOAC 985.29
Acidity	-	0.20±0.016	AOCS F 9a-44

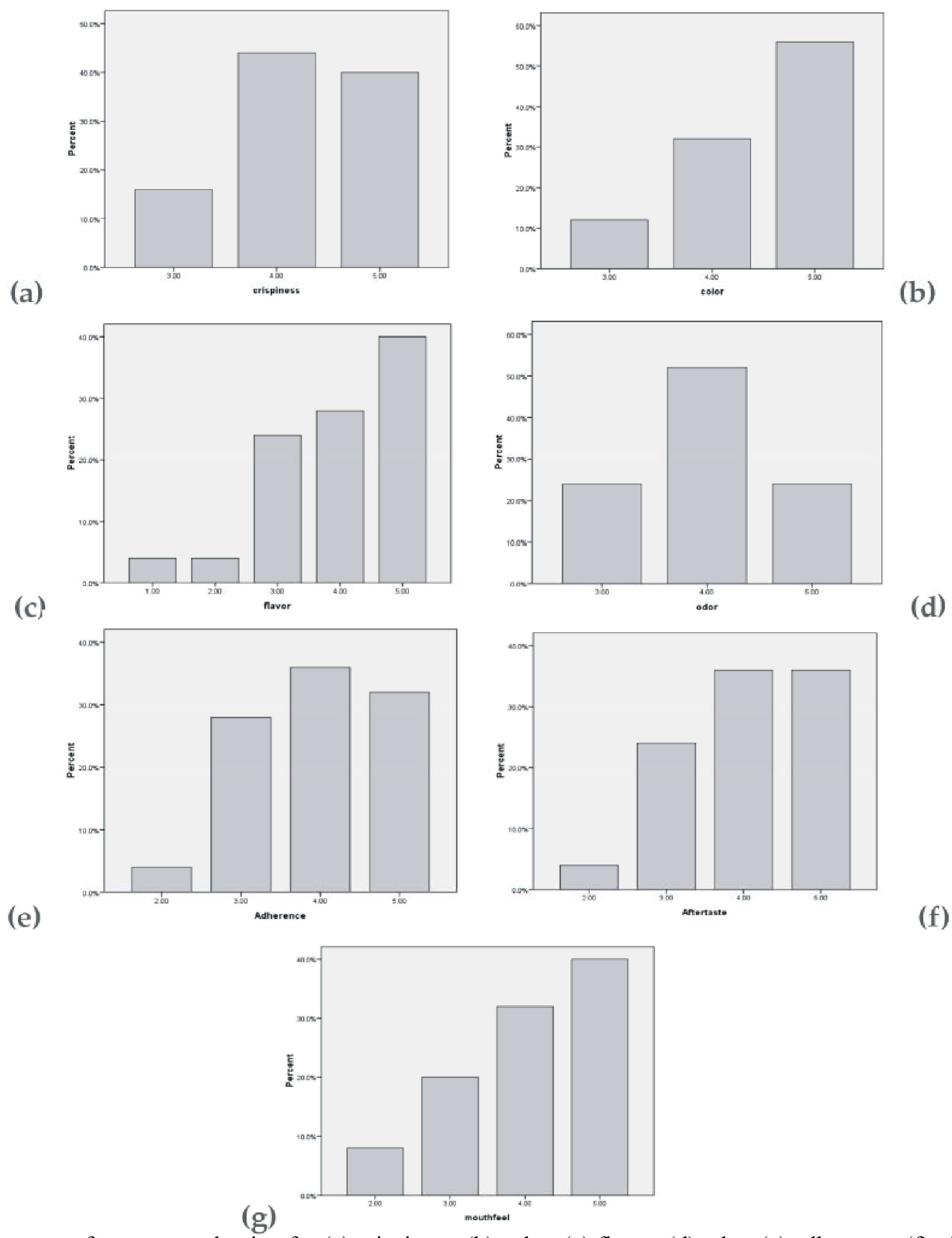

Fig 1: The Diagrams of sensory evaluation for (a) crispiness, (b) color, (c) flavor, (d) odor, (e) adherence, (f) after taste and (h) mouth feel of pumpkin chips

The results of this study based on surface responses and contour plots, suggests that vacuum frying at 84.53°C and vacuum pressure of 40 mbar for 18 minutes can produce pumpkin chips with lower shrinkage, moisture as well as good color and crispy texture.

Optimization conditions of vacuum frying of apple slices by Shyi-Liang Shyu et al, were determined as 100-110°C for temperature, 20-25min for processing time and immersing fructose concentration of 30-40% [3]. The results of optimization of process parameters on vacuum frying of fresh mushroom slices by Ghiassi et al, in 2011 assumed variables ranges as 70-140°C for temperature, 4.11 to 9.88 kPa for vacuum pressure and 1-15 minutes for processing time [11].

Qualitative Analysis of the Raw Material (Raw Pumpkin): The results of analyzing the raw pumpkin are shown in Table 2.

According to the results, it is clear that the main part of the pumpkin consists of water that it is observed that 60% of moisture content had been exit from pumpkin which might help to increase the shelf life of this product. Also it is observed that a negligible part of pumpkin is composed of fat. Moreover, it contains a remarkable amount of fiber which can be beneficial in terms of nutrition. Moreover, it can be found that around 20% oil had been absorbed to pumpkin during vacuum frying. Results indicate that compounds of raw and processed pumpkin have significant difference ($p \leq 0.05$). The amount of minerals and protein in process pumpkin is significant rather than raw one and increased around 3% that indicates that it has acceptable nutritional value. Furthermore, it can be found that carbohydrate content had been increased 6 times more, in processed pumpkin rather than raw pumpkin because of losing water during the vacuum frying process.

The Results of Sensory Evaluation: The test results of sensory evaluation about the final product for crispiness, odor, adhesion to oral preparations, taste and month feel indicated that the difference between view points of panelists was not significant ($P<0.05$). The analysis of variance for the color of the product showed that the difference between responses was significant ($P<0.05$). About 57% of panelists gave the score of five for the product color. The analysis of variance for flavor showed that the difference between panelists' score pertaining to flavor of the product was significant as well ($P<0.05$). About 40% of panelists considered score five.

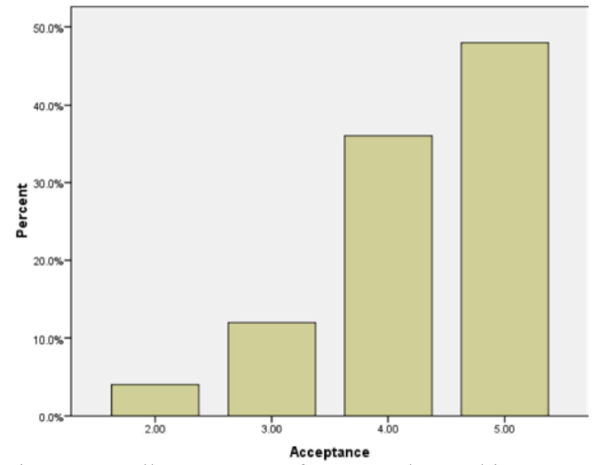

Fig. 2: Overall acceptance of processed pumpkin

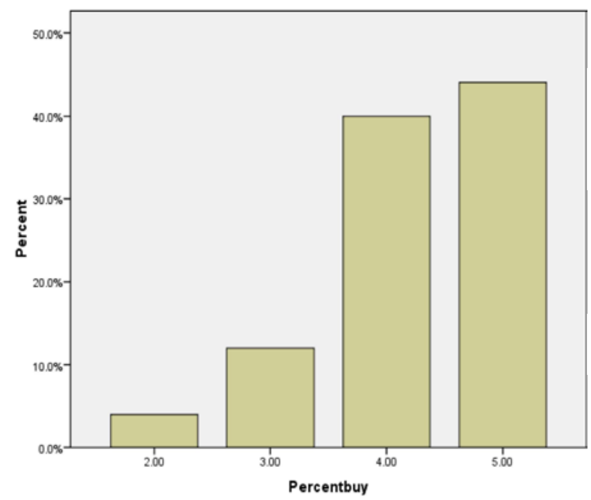

Fig. 3: Percentage of willing to buy pumpkin snack

The results of analysis of variance about the overall acceptance of the product showed a significant difference between panelists' evaluations. Figure 2 shows the histogram of the overall acceptance of the product. Overall acceptance provide an indication of the magnitude of acceptability of products based on considering all aspects. In fact, acceptance testing gives an indication of the magnitude of the level of liking of the product [6].

Finally, the panelists were asked about the fact that they will purchase the product or not, if it is offered in the market. The analysis of variance, pertaining to their decision about purchase of the product, showed a significant difference between their responses. Figure 3 shows the approximate probability distribution of the panelists' tendency to purchase the product.

The comparison of scores of sensory evaluation pertaining to each factor showed that, the highest score is related to the color of the final product. In other words,

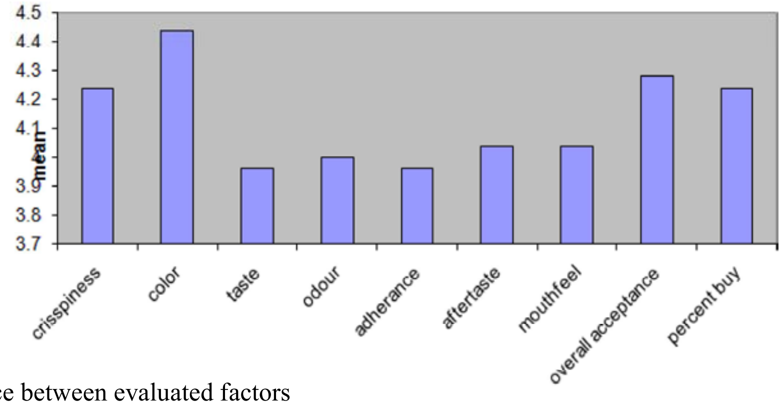

Fig. 4: Mean difference between evaluated factors

the color of the pumpkin chips is the most desirable factor in the panelists' opinion. Statistical analysis between means of all factors shows that the difference between the importances of factors, from the panelists' point of view, is not significant. Figure 4 shows the importance of different factors from the panelists' point of view.

CONCLUSION

Vacuum frying is the one of the newest and most important methods for food processing is vacuum frying. This method has recently been known as a suitable alternative for processing fruit- and vegetable- based snack foods with lower oil content and higher quality. Despite desirable and unique characteristics of this method, which is superior in terms of saving the time and retaining more nutrition in the products, it hasn't been widely implemented in the food production industry worldwide and specially in Iran. The hunter ΔE, was significantly ($p\leq 0.05$) affected by temperature of frying. To promote the efficiency of vacuum frying, such as osmotic pretreatment, freezing and etc, can be applied that affect th texture, fat content, shrinkage and color of vacuum fried foods. During vaccum frying 60% of initial moisture content decreased and about 20% oil obsorption will happen. Pumpkin chips is a desirable snack and if it being provided to the market a large percentage of consumers will purchase this product.

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