Optimization of Process Parameters for Foaming of potato puree with Response surface methodology

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Abstract

Foaming conditions of potato puree were optimized using response surface methodology (RSM) with respect to Arabic gum concentration (0.1 – 0.9% w/w), potato puree to water ratio (1:1 – 2:1 w/w) and whipping time (3 – 9 min) for minimum foam density and foam drainage volume as response variables.. Twenty experiments were carried out using a central composite design with three independent variables. The optimized conditions were Arabic gum concentration =0.77, potato puree to water ratio =2:1 w/w and whipping time =6.8 min in order to obtain foam density and foam drainage volume were 0.3 gcm−3 and 5 mL, respectively.

Keywords: **pottao, foam mat drying, Response surface methodology, Foaming Parameters, Arabic gum.**

I. INTRODUCTION

Foam mat drying is an alternative and relatively simple method which the liquid or semi food is converted to form stable foam by cooperation with foaming agents or stabilizing agents and then spread into a thin sheet and dried by using hot air at lower temperature compared to other drying techniques such as spray drying and steam drying. Foam mat drying enables remove free water from heat-sensitive, high-sugar content and viscous foods that are difficult to dry. The main advantages of foam-mat drying are lower temperatures and shorter drying times, when compared to non-foamed material. These advantages can be attributed to the larger surface area exposed to the drying air which accelerates the moisture removal process. Over the past decade, this relatively old technology, known as foam mat drying, received renewed attention because of its added ability to process hard-to-dry materials, obtain products of desired properties (e.g., favorable rehydration, controlled density), and retain volatiles that otherwise would be lost during the drying of non-foamed materials. This drying process is comparatively simple and inexpensive [4,5]. Potatoes is one of the most consumed and highly nutritious vegetables which containing high energy, dietary fiber, biologically active photochemicals, vitamins, and minerals which offer great benefit for use as functional food ingredient [3]. The dried Potato powder is important product and can be used in formulation of many foods like soups, snacks, sauces, noodles, etc.

II. MATERIALS AND METHODS

The Fresh potatoes used in this study were obtained from local markets in Mashhad, Iran. Arabic gum was supplied by sigma Chemical Company.

To perpetrate the potato puree, fresh potatoes were washed and peeled by steel knife and they were washed again and additional water was taken absolutely and then crushed by Phillips home crusher with maximum speed for 3 minutes to get a homogeneous puree. In order to prepare foam, we mixed prepared puree with the gum as percentage (w / w) with ratio of 2:1 and it was stirred by Sunny home mixer with maximum speed stirrer in optimal time until foam is created.

Arabic gum`s solution (w/w) was prepared by dispersing the proper amount of the gums powder in the specific amount of distillated water and stirred with a magnetic stirrer, until a uniform solution was obtained and finally were kept in the refrigerator for 18 –24 hours to complete hydration [4].

A. Foam density

Foam density was determined by measuring the mass of a fixed volume of the foam at ambient temperature. The foam transferring was performed carefully to avoid destroying the foam structure [5].

B. Foam stability

Foam stability was determined by drainage test which employed by Sauter and Montoure [7] with slight modifications. In this method, the foam was transferred into the Buchner filter with 80 mm diameter which was covered with mesh cloth and placed directly on the 50 ml the measuring cylinder to collect the drainage from the foam by natural gravity. The liquid juice was collected from the foam after 1 hour as a result of drainage and recorded.

C. Analysis of data and optimization technique

The statistic design, centered central composite design (FCCD) with three independent variables and six replicates at the center point of design was used to find the effect of independent variables (Arabic gum, puree to water ratio and whipping time) on the foam density and separated liquid from the foam. Design variables were Arabic gum (0.1-0.9), puree to water ratio (1-2) and whipping time (3-9). Deign Expert software Version 6.0.4 (Minneapolis America) was used to design the experiment and analyze the results. Design variables as true levels and the response variables were shown in Table 1 Response functions model was fitted with related models. And the best model was selected according to ANOVA results. Then they optimized by using the Response Level method.

III. RESULT

As shown in Figure 1, With increasing concentration of Gum Arabic, foam density has increased while we observed declining trend in foam density with increasing whipping time.

Some commercial gums containing some protein as impurity or part of their structure are able to been absorbed in interface of the two phases and create the surface activity due to hydrophobic property. Improving foaming property is due to an interaction - of gum with puree compounds such proteins. Increasing whipping time lead to enter more air into foam system and further reducing of density and further increasing of foam expansion. Denatured protein and possible increased hydrophilic groups in surface after increased whipping time could be other reasons of reducing foam density [6].

The other factor that affect on the foam density is the potatoes puree to water ratio that as shown in Figure 2, by increasing this rate, the foam density slowly increased . With increasing puree to water ratio, foaming capability decreased because viscosity can be increased by increasing the concentration of solids in suspension [1,2].

As shown in Fig. 3, with increasing whipping time, foam density reduced slowly until third minute and then showed an increasing trend. According to puree to water ratio, with increasing puree amount to 1/5 ratio, foam density increased while then an increasing trend was observed (Fig. 3).

As shown in Figure 4, with increasing the concentration of Arabic gum, the amount of removed fluid has reduced while with increasing whipping time, the amount of removed fluid has increased. Possible increase in protein denaturation because of the mechanical force exerted from long whipping and also thinning foam walls and ultimately reducing foam stability are possible reasons of this event.

The effect of the concentration of Arabic gum and puree to water ratio on changes in the amount of separated fluid from foam is shown in Figure 5. As you can see with increasing the concentration of Arabic gum, the amount of separated fluid from foam decreased while with increasing the puree ratio, the increasing trend in separated fluid from foam was seen.

Whipping time until producing foam is the another factor that affect the amount of separated fluid from the foam and as is shown in Figure 6, you see by increasing whipping time, the amount of separated fluid from foam increases slowly.

The ideal processing parameters for minimum foam density and minimum drainage volume were in the range of 0.1 to 0.9 % (w/w) for arabic gum, 1:1 to 2:1 (w/w) for potato puree to water ratio and 3 to 9 (min) for whipping time, based on the analysis of Response surface methodology. Using the given criteria, process conditions were optimized at arabic gum concentration (0.77% w/w), pottao puree to water ratio (2:1) and whipping time (6.8 min). The predicted values for foam density and drainage volume were 0.3 gcm^{-3} and 5 mL, respectively.

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Table1. Independent variable and responses for the CCD

Std	gum	Time	dilution	FD	DV
1	0.1	3	1	0.42	18
2	0.9	3	1	0.60	9
3	0.1	9	1	0.37	23
4	0.9	9	1	0.69	8
5	0.1	3	2	0.48	20
6	0.9	3	2	0.39	7
7	0.1	9	2	0.44	20
8	0.9	9	2	0.38	5
9	0.1	6	1.5	0.39	21.5
10	0.9	6	1.5	0.53	10
11	0.5	3	1.5	0.49	16.15
12	0.5	9	1.5	0.40	12
13	0.5	6	1	0.44	11
14	0.5	6	2	0.27	7
15	0.5	6	1.5	0.45	14.5
16	0.5	6	1.5	0.46	13.5
17	0.5	6	1.5	0.40	11
18	0.5	6	1.5	0.45	16
19	0.5	6	1.5	0.46	14
20	0.5	6	1.5	0.44	17

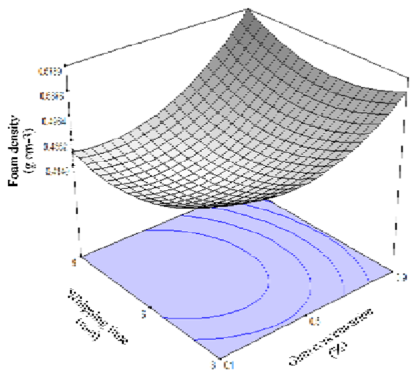

Fig. 1. Response surface and contour plots for foams density as a function of whipping time and gum concentration (at dilution: 1.5).

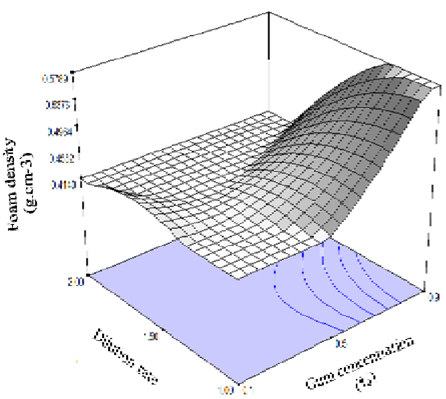

Fig. 2. Response surface and contour plots for foams density as a function of dilution rate and gum concentration (at time: 6).

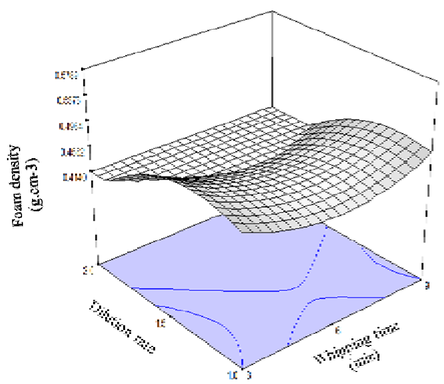

Fig. 3. Response surface and contour plots for foams density as a function of whipping time and dilution rate (at gum concentration: 0.5%).

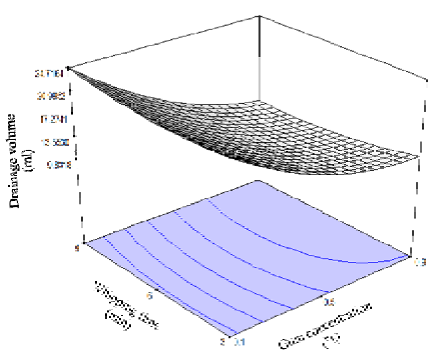

Fig. 4. Response surface and contour plots for drainage volume as a function of whip ping time and gum concentration (at dilution: 1.5).

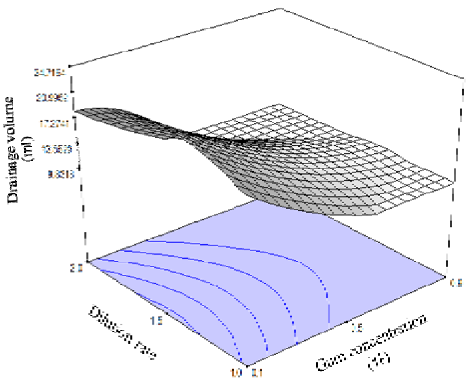

Fig. 5. Response surface and contour plots for drainage volume as a function of dilution rate and gum concentration (at time: 6).

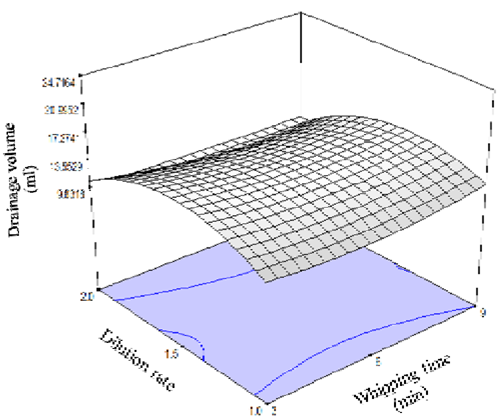

Fig. 6. Response surface and contour plots for drainage volume as a function of dilution rate and whipping time (at gum concentration: 0.5%).