JRIFST

https://journals.rifst.ac.ir
ISSN: 2252-0937(print), 2538-2357(online)

Journal of Research and Innovation in Food Science and Technology

Research Institute of Food Science and Technology

Volume 11, Issue 1, June 2022, Pages 1-16
Document Type: Extended Abstract
https://doi.org/10.22101/JRIFST.2020.254462.1192

Extended Abstract

Optimization of Formulation for Aerated Dessert Containing whey Protein and Xanthan Gum Concentrate using Response Surface Methodology and Investigation on Rheological and Texture Properties

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Recieved: 2020.10.25; **Accepted:** 2020.12.21

Abstract

Aerated dessert is a type of dessert based on the foam system, in which the presence of air in these desserts changes the rheological, sensory, and appearance characteristics. The aim of this study was optimization of aerated dessert using response surface methodology (RSM) and evaluate its rheological properties as a function of whey protein concentrate (2, 5 and 8%), xanthan gum (0.1, 0.25 and 0.4%) and whipping time (2, 5 and 8 min). The results showed that increasing protein and whipping time decreased density and increased overrun. Elevation of the xanthan gum concentration increased the density and decreased overrun. Optimal conditions for the production of aerated dessert foam with the lowest density and the highest overrun was determined in the concentration of xanthan gum 0.1% (low level), whey protein concentrate 8% (high level) and whipping time 8 min (High level). Power low model was the best model to describe flow behavior of the aerated dessert with high R^2 (R^2>0.99) and low RMSE (0.01). It was determined that with increasing the whey protein concentrate and xanthan gum decreased the flow behavior index and increased coefficient of consistency (P<0.05). Also, increasing the whey protein concentrate, xanthan gum and whipping time increased hardness, adhesiveness and consistency coefficient. The production of aerated desserts, in addition to producing a new product; increases the power of consumer choice and the profitability of the producer and can be an effective contribution to the growth of the industrial economy.

Keywords: Aerated dessert, Rheological properties, Texture properties, Xanthan gum, Whey protein concentrate

Introduction

Aerated dessert is a type of dessert based on the foam system and is usually called cold dairy dessert, the most important feature is having a porous structure (Rao, 2010). The presence of air in desserts decreases the density product, changes the rheological characteristics and enhanced taste perception due to increased surface area and modification of digestibility. Whey protein concentrate has received much attention in the food industry due to its functional properties such as water solubility, viscosity, shear thinning, foaming, and their effect on the taste, texture and nutritional value of products (Perez *et al.*, 2017). Foams are thermodynamically unstable, because they have high surface energy at the air-liquid interface (Muthukumaran *et al.*, 2008). Xanthan gum creates flexible viscous films, helps the stability

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of foams and emulsions, and is used as a stabilizer and strengthener of foam structure in various food products. In addition to producing a new product, the production of aerated desserts increases the power of consumer choice and increases profitability for the producer and can effectively contribute to the growth of the industrial economy. Studies on the optimization by Response Surface Methodology (RSM) and investigation of the effect of whey protein on the physical and rheological properties of aerated desserts are limited, while this method has been used for a wide range of products. Therefore, the aim of this study was to optimize the formulation of vanilla aerated dessert using the RSM and to evaluate the rheological properties as a function of whey protein concentrate (2, 5 and 8%), xanthan gum (0.1, 0.25 and 0.4 %) and whipping time (2, 5 and 8 min).

Materials and methods

Density

The foam density was measured using a calibrated ambient temperature (22-25 °C). Finally, the density of vanilla aerated dessert was expressed as the ratio of mass to volume per unit (g/cm^3).

Overrun

Overrun was calculated by weighing a certain volume of dessert before and after the aeration and determining their percentage difference according to Eq. (1).

$$\text{Overrun} = \frac{(\text{aeration before sample weight} - \text{aeration after sample weight})}{\text{aeration after sample weight}} \times 100 \qquad (1)$$

Rheological properties

The rheological properties of the samples were investigated using a Bohlin rotary viscometer (Bohlin Model Visco 88, Bohlin instruments, UK). To study the flow behavior of the aerated dessert and describe its rheological data, common time-independent flow models, including Herschel bulkley (Eq. 1) and Power law (Eq. 2) were used. Using statistical analysis, the most appropriate mathematical model is based on the determination coefficient (R^2) and Root means square error (RSME). Matlab software, version R2011, was also used to fit rheological models.

$$\tau = \tau_{0H} + K_H \gamma^{nH} \qquad (2)$$

$$K(\gamma)^n \qquad (3)$$

Textural characteristics

Textural properties of the samples were evaluated immediately after leaving the freezer by a Texture analyzer (Texture analyzer LLOYD Instruments, TA plus ametek, UK) and penetration test. Hardness (maximum force during loading stage (g)), adhesiveness force (maximum force during uploading stage (g)), consistency coefficient (surface area under the curve until the target deformation (g/s)) from the force-time curve (Akalın *et al*., 2008).

Results and discussion

The results obtained from the experimental design used to optimize the production conditions of vanilla Aerated dessert foam are presented in (Table 1).

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Table 1. The results of experimental design for optimization of aerated dessert production

Row	Independent variable			Dependent variable	
	Whey protein concentrate (%)	Xanthan gum (%)	Whipping time (min)	Density (g/c^3)	Overrun (%)
1	5(0)	0.25(0)	5(0)	0.586±0.01	84±2.0
2	5(0)	0.25(0)	5(0)	0.594±0.02	82±2.5
3	2(-1)	0.4(+1)	2(-1)	0.741±0.02	41±3.5
4	5(0)	0.25(0)	5(0)	0.572±0.01	85±2.5
5	2(-1)	0.25(0)	5(0)	0.673±0.04	62±3.0
6	5(0)	0.25(0)	5(0)	0.584±0.02	84±2.6
7	5(0)	0.4(+1)	5(0)	0.597±0.02	82±3.5
8	2(-1)	0.1(-1)	2(-1)	0.762±0.02	32±1.5
9	5(0)	0.25(0)	8(+1)	0.554±0.02	89±1.0
10	5(0)	0.1(-1)	5(0)	0.543±0.03	87±2.5
11	8(+1)	0.1(-1)	8(+1)	0.469±0.03	116±3.0
12	5(0)	0.25(0)	5(0)	0.594±0.04	82±4.5
13	8(+1)	0.25(0)	5(0)	0.481±0.03	114±3.0
14	5(0)	0.25(0)	5(0)	0.574±0.04	82±2.5
15	8(+1)	0.4(+1)	2(-1)	0.525±0.03	98±4.5
16	8(+1)	0.1(-1)	2(-1)	0.622±0.04	75±2.0
17	2(-1)	0.1(-1)	2(-1)	0.553±0.04	85±4.7
18	5(0)	0.25(0)	2(-1)	0.682±0.01	60±5.0
19	8(+1)	0.4(+1)	8(+1)	0.457±0.02	121±2.0
20	2(-1)	0.4(+1)	8(+1)	0.697±0.02	48±1.5

Density and overrun

According to the results obtained from the analysis of variance, the quadratic polynomial model was proposed as the best model to investigate the effect of independent variables on density and overran. Increasing the whey protein concentrate and whipping time decreased density and increased overrun, respectively. Also, increasing the concentration of xanthan gum increased the density and decreased overrun (Falade & Omojola, 2010).

Optimization foam

The purpose of optimization was to produce aerated vanilla dessert foam with the lowest density and the highest overrun content. Based on this, the optimal conditions for the production of aerated dessert in whey protein concentrate of 8%, xanthan gum concentration of 0.9% and Whipping time of 8 min were determined. Under these conditions, the density and foam overrun values were measured, which were 0.44±0.020% (cm^3) and 920.84 20.2%, respectively.

Rheological properties

Investigating the aerated dessert behavior showed that all samples had non-Newtonian shear-thinning flow behavior. Power low model was the best model to describe the flow behavior of the aerated dessert with high R^2 (R^2>0.99) and low RMSE (0.04). It was determined that increasing the whey protein concentrate and xanthan gum decreased the flow behavior index and increased consistency coefficient (P<0.05), (Javidi & Razavi, 2018).

Textural characteristics

In evaluating the texture of the samples by penetration test and examination of hardness parameters, adhesiveness force and consistency coefficient, it was observed that according to (Fig. 1), increasing the whey protein concentrate, xanthan gum and whipping time increased hardness, adhesiveness and consistency coefficient (Dabestani & Yeganehzad, 2019).

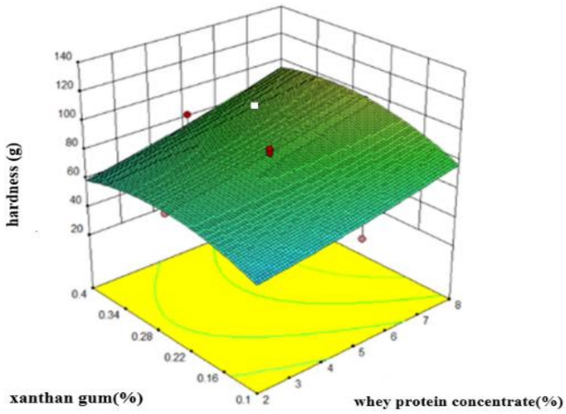

Fig. 1. The effect of whey protein concentrate and xanthan gum on the hardness of aerated dessert by RSM

Conclusions

In this study, the Response Surface Methodology was used to optimize the formulation of aerated dessert. The optimum process condition was 8% whey protein, 0.1% xanthan gum and 8 min whipping time. All samples showed non-Newtonian shear-thinning flow behavior, and the Power low model was the suitable model to describe the samples' behavior. Increasing the whey protein concentrate and xanthan gum decreased the flow behavior index and increased the consistency coefficient of the aerated dessert. Also, increasing the whey protein concentrate, xanthan gum and whipping time increased hardness, adhesiveness and consistency coefficient. This study showed that the use of whey protein and xanthan gum improves the physicochemical properties of the aerated dessert.

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