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The Effect of Xanthan Gum and Temperature on Foam Stability of Milk-Based Espresso Coffees

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ABSTRACT: Milk-based espresso coffee is one of the most popular beverages. Foam is an essential quality characteristic for this beverage. Foam formation and stability is mainly related to the milk composition. In this study the influence of three different concentrations of Xanthan gum (0.05, 0.1 and 0.2 g dm^{-3}) and three different temperatures (50, 60 and 70 °C) on foam stability were examined and experimental data was determined 5, 10 and 15 minutes after aeration. Sensory properties were also evaluated and the results were analyzed using Duncan’s mean comparison test at the probability level of 95%. The viscosity of coffee milk was increased due to the addition of Xanthan. The highest foam stability and sensory acceptance were observed in the product containing 0.2 g dm^{-3} Xanthan at 70°C.

Keywords: *Coffee, Foam, Temperature, Xanthan Gum.*

Introduction

Espresso coffee and its products are popular among many people. Espresso is a kind of coffee which has been discovered in Italy in the beginning of the twentieth century. Brewed espresso is generally more concentrated than other kinds of coffee due to the higher concentration of suspended and dissolved solids as well as caffeine. Crema, the reddish-brown foam that forms on the top of the brewed espresso, is the most important aspect of consumers’ acceptance of the espresso coffee (Illy & Navarini, 2011).

One of the essential quality characteristics in espresso beverages is the stability of the foam. Stable foams are appealing because of the light and soft texture and pleasant feeling in the mouth. In addition a foam layer helps to trap coffee aroma, providing a more gradual release. Over the past several years, many coffee house owners and baristas have revealed that they have been unable to properly froth the milk (Schramm, 2005).

Over 70% of espresso beverages incorporate milk. Foaming and stability of the foam depends on the milk composition. Milk proteins due to their physio-chemical features play an important role in the production of dairy foams. Researchers have found that dairy foaming properties are influenced and affected by whey proteins.

There are basically two different approaches for enhancing the stability of foam; First to strengthen the physical properties of the foam film that it is less susceptible to the external disturbance and

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second to modify the unfavorable foaming environment. Some additives might help to stabilise the foam by increasing the elasticity of the foam film and the surface and bulk viscosity of the foam film. Studies on finding new additives which has an effect on foam properties of dairy products are ongoing (Lai & Dixit, 1996).

Some studies have been concerned on different effective techniques on milk foaming properties. These studies have specifically examined the influence of temperature (Kamath *et al.,* 2008; Oetjen *et al.,* 2008).

Polymeric compounds such as gums and gelatins at low concentrations are good foam stabilisers. According to some published articles, gums have a good effect on the stability of food foams like egg white (Ptazeshk *et al.,* 2014). To reach a proper solution, it is better to examine the influence of both gums and temperature on the stability of dairy-based foams.

Gums are widely used in food productions. Gums are hydrocolloids which can absorb water, enhance the viscosity and stabilise food foams. Xanthan gum is a microbial extracellular polysaccharide which is produced from Xanthamonas campestris. Xanthan gum is mainly consists of glucose, mannose and galacturonic acid. Despite its high molecular weight, it is easily dissolved in hot and cold water. It makes a viscose solution at low concentrations and pH changes do not have significant effect on its viscosity. (Damodaran *et al.,* 2007)

In the present study, production of milk-based espresso containing Xanthan gum was examined as a new approach in order to stabilise foam. The influence of parameters like Xanthan gum concentration in three temperatures on the viscosity, foam stability and sensory properties were also evaluated.

Materials and Methods

-Materials

Pasteurized low fat milk samples (0.5 g dm^{-3}) were supplied from Tehran Pegah Dairy Company (Iran). Skim milk powder was provided by Nestle Company (Iran) and Xanthan gum powder was purchased from GM Company (China). Brown sugar was bought from Mississippi Company (England) and grinded espresso coffee was provided from Arabika Company (Brazil).

-Methods

-Coffee milk preparation

For providing the standard milk for this research, 25 ml skim milk powder was dissolved in pasteurized low fat milk. 5 g grinded espresso was brewed in 10 ml water using a traditional espresso maker (Igory, Italy) in 10 minutes and 100°C. The aqueous solutions with three different concentrations of Xanthan (0.05, 0.1, and 0.2 g dm^{-3}) were prepared for each intended mixture. Aqueous solutions of Xanthan, standard milk, coffee and sugar with specific concentrations were mixed and then it was completely stirred using shaker. Prepared samples were bubbled in a foaming apparatus.

-Determination of total solid, protein and fat contents

Total solid, protein and fat contents were determined according to Pearsons`s Chemical Analysis of Foods (1988).

-Design of the foaming apparatus

An apparatus which was designed for bubbling the sample is depicted in Figure 1. The foaming apparatus consisted of a sintered silicon disc (3 cm diameters and 0.5 cm thickness) attached to the bottom of a measuring glass column (3 cm diameter and 30 cm height). The air, which was provided by the air compressor with 10 bar pressure (Hava Sanat Mofidi, Iran), passed the flowmeter with the rate of 4 Lit/min and reached the sintered glass and finally the sample. The end of the column was connected to the flowmeter via a tube. 50 ml

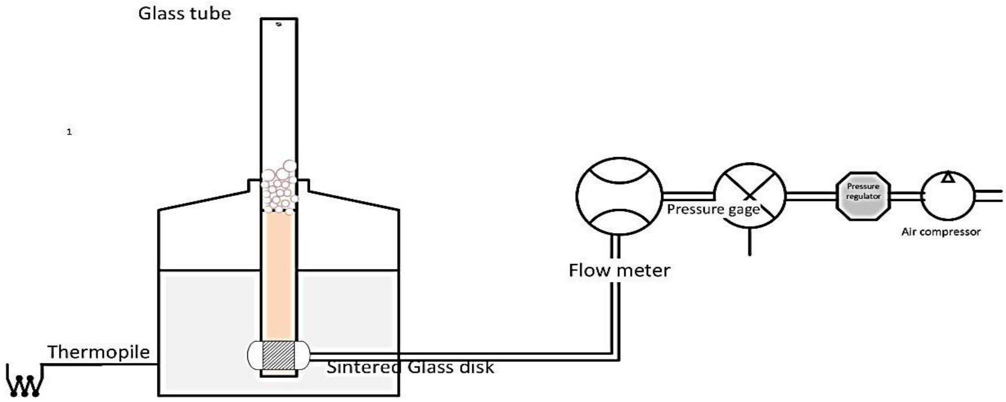

Fig. 1. Diagrammatic representation of foaming apparatus

of coffee milk sample to be foamed was placed in the measuring column and heated to the desired temperature using a water bath equipped with the thermometer (Atbin, Iran). The time of aeration was estimated as 10 seconds and controlled by a chronometer (Ross & Nishioka, 1976).

- Foam stability measurements

All foams were produced in the foaming apparatus which is described in Figure 1. Foam ability was expressed as the height of the foam obtained immediately after aeration was stopped and was measured in centimeters. Foam stability was considered as the changes of the height of the produced foam during specific times in minutes.

-Viscosity measurement

The viscosity of coffee milk samples was determined using Ostwald viscometer. The viscosities of the samples were measured at three different temperatures (50, 60, 70 °C) and three concentrations of Xanthan (0.05, 0.1 and 0.2 g dm^{-3}) (Valentas *et al.*, 1997).

-Sensory evaluation

Sensory evaluation was aimed to determine the consumers` general acceptance of the produced coffee milk containing Xanthan. Sensory properties were evaluated using 5-points hedonic test (Harry *et al.*, 2010). The method was consisted of 10 panelists who were requested to score the points from 1 to 5 for each sample.

-Statistical analysis

In this study, the experiments have been reported in triplicate order in the form of a completely randomised basis design. The data analysis was performed using Duncan's mean comparison test at the probability level of 95gdm^{-3}. All the statistical analyses were performed by SPSS20 statistical software . The curves were plotted using the MS excel.

Results and Discussion

-Total solid, protein and fat contents

Total solid of standard milk was reported to be 12.21 ± 0.041%. The fat content was 0.53 ± 0.057 % and the protein content was 3.68± 0.035%.

-The influence of Xanthan and temperature on coffee milk viscosity

The influence of three different temperatures (50, 60 and 70 °C) and three different concentrations of Xanthan (0.05, 0.1 and 0.2 g dm^{-3}) are displayed in Table 1. It is evident that in a particular temperature, by increasing the Xanthan concentration the viscosity of coffee milk has been increased. The reason for viscosity increase in a specific temperature is the fact that gums are hydrocolloids which are able to absorb water, keep it in their structure and enhance the sample viscosity. Although in a specific concentration by increasing the temperature the viscosity had a slight decrease.

By increasing the temperature the ability of adhesion forces against molecular movement becomes less and as the result the viscosity decreases.

-The influence of Xanthan on foam stability

The influence of the three concentrations of Xanthan on foam ability at different times (5, 10 and 15 minutes) is illustrated in Figures 2, 3, 4 and 5. According to the charts, it is clear that at a particular temperature by increasing the Xanthan concentration the initial height of the foam has decreased. The reason is the fact that increasing Xanthan and viscosity of the samples leads to decrease in the ability of foaming in a specific time of aeration.

Table 1. Viscosity measurement of coffee milk samples (μ: viscosity T: temperature).

T (°C)	**Xanthan (g dm^{-3})**	**μ** ± σ [a] **(pa.s)**
50	0	0.88 ± 0.05
60	0	0.85 ± 0.02
70	0	0.81 ± 0.058
50	0.05	2.09 ± 0.075
60	0.05	1.97 ± 0.005
70	0.05	1.82 ± 0.02
50	0.1	3.16 ± 0.05
60	0.1	3.29 ± 0.02
70	0.1	3.16 ± 0.058
50	0.2	4.21 ± 0.056
60	0.2	4.14 ± 0.025
70	0.2	4.12 ± 0.025

a: Standard deviation

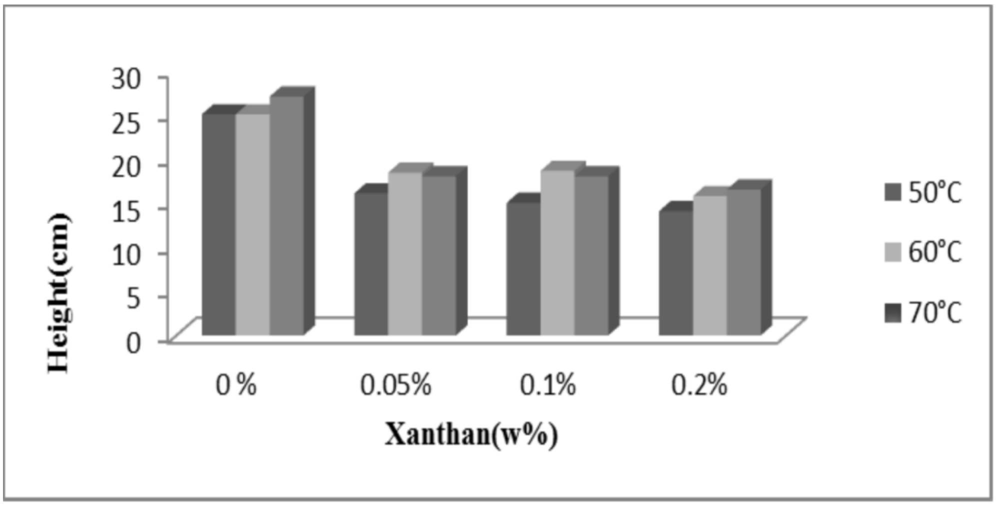

Fig. 2. The initial height of the foam

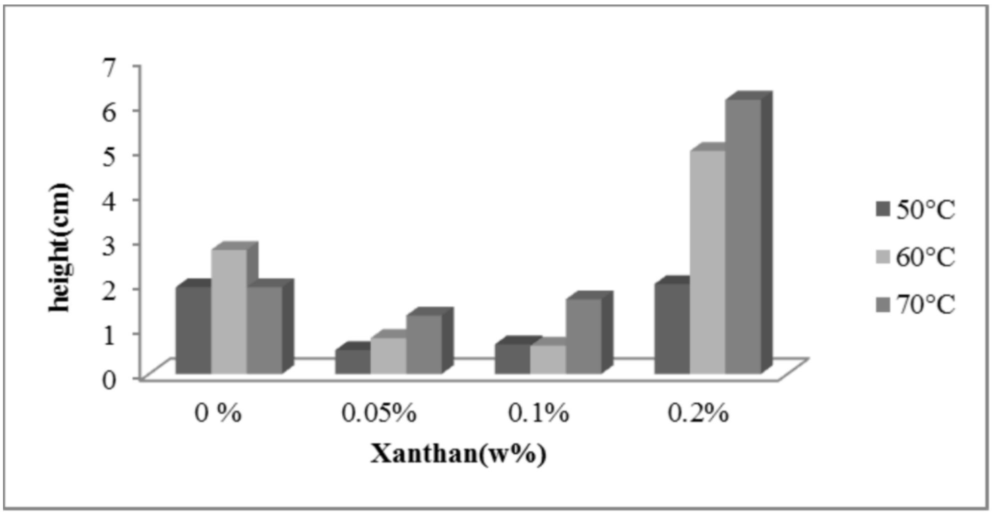

Fig. 3. The height of the foam 5 minutes after aeration

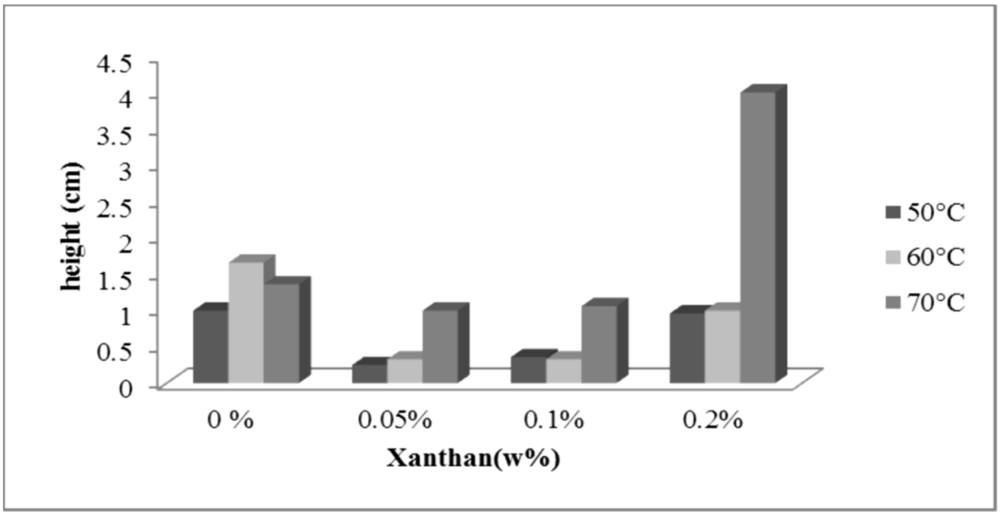

Fig. 4. The height of the foam 10 minutes after aeration

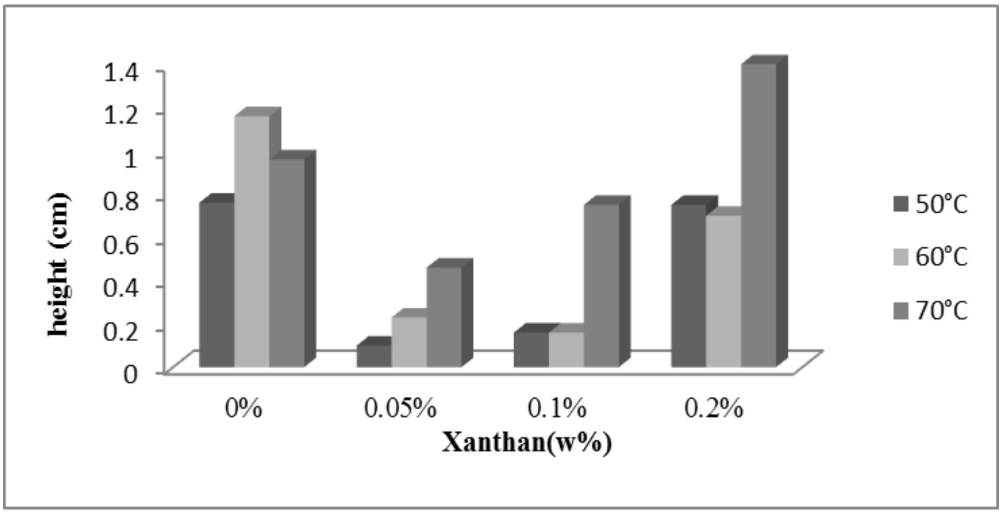

Fig. 5. The height of the foam 15 minutes after aeration

It is also observed that the foam stability of the samples containing 0.5 g dm^{-3} and 0.1 g dm^{-3} of Xanthan gum has been decreased during 5, 10 and 15 minutes. The results have shown that there was a dramatic rise in the foam ability in the sample containing 0.2 g dm^{-3} of Xanthan. It might be concluded that 0.2 g dm^{-3} of Xanthan enhanced the viscosity of coffee milk considerably which can decrease the pace of bubbles coalescence and increase the foam stability. By increasing the viscosity of continuous phase, the cohesion time of two bubbles increases. There is a thin layer of liquid between two bubbles, therefore by increasing the viscosity, the discharge time increases.

An increase in the concentration of xantan has an effect on the density of phases.

Also, the density difference between the two phases increases contact surface area, and the dispersed phase will be stable.

Statistical results have shown that different concentration of Xanthan gum had a significant influence on stability of foam. Although there was no significant difference between the results of foam stability produced in the samples containing 0.05 and 0.1 g dm^{-3} of Xanthan gum.

-The influence of temperature on foam stability

The influence of three different temperatures (50, 60 and 70 °C) for three different concentrations of Xanthan (0.05, 0.1 and 0.2 g dm^{-3}), on foam stability of coffee milk is depicted in Figures 2 to 5. It is vivid that by increasing the temperature, the height of the foam was also increased. Temperature affects viscosity, density and surface tension. Surface tension decreases due to the temperature increase. Surface tension is resulted by molecular van der Waals` forces and stronger the forces are, the stronger surface tension will get. Increase in temperature enhances the kinetic energy considerably and also affects van der Waals` forces. Therefore, by increasing the temperature of liquid, the molecules located on the liquid surface are pulled down into the liquid using less intermolecular forces. Meanwhile, the surface tension of liquid decreases, therefore the stability of foam increases. In fact, a decrease in the surface tension causes the time of bubbles cohesion to decrease.

Statistical results have shown that different temperatures (50, 60 and 70 °C) had a significant influence on the stability of foam.

-The influence of time

Figure 6 shows the effect of two independent variables, time and Xanthan, on stabilizing the foam in coffee milk at the temperature of 70 °C. As it has been shown in Figure 6, the 3D diagram and counter plot illustrate that by passing time, the height of the formed foam has been decreased gradually. The thermodynamics foams are disappeared rapidly in a short time that means the bubbles attach together over the time and create a single big bubble. This causes the foam to become stable (Cox *et al.*, 2009).

-Sensory evaluation

The results of hedonic test have shown that the addition of Xanthan has no significant changes in coffee milk`s taste since Xanthan is a kind of gum that has no aftertaste. It was also observed that the appearance, mouth-feel and general acceptance has been improved and the foams were more dense and compact.

Conclusion

Stability of formed foam in dairy based espresso beverages is an essential quality characteristic and appealing to consumers. In this study Xanthan gum was used in order to stabilize the coffee milk foam. The influence of three different concentrations of Xanthan gum (0.05, 0.1 and 0.2 g dm^{-3}) and three different temperatures (50, 60 and 70 °C) on foam stability were examined during 5, 10 and 15 minutes after aeration. Sensory properties were also evaluated. Xanthan gum was able to absorb water and enhance the viscosity of coffee milk. Surface tension was decreased due to the temperature increase which led the foam be stabilised. The highest foam stability and sensory acceptance were observed in coffee milk containing 0.2 g dm^{-3} Xanthan and was prepared at 70 °C.

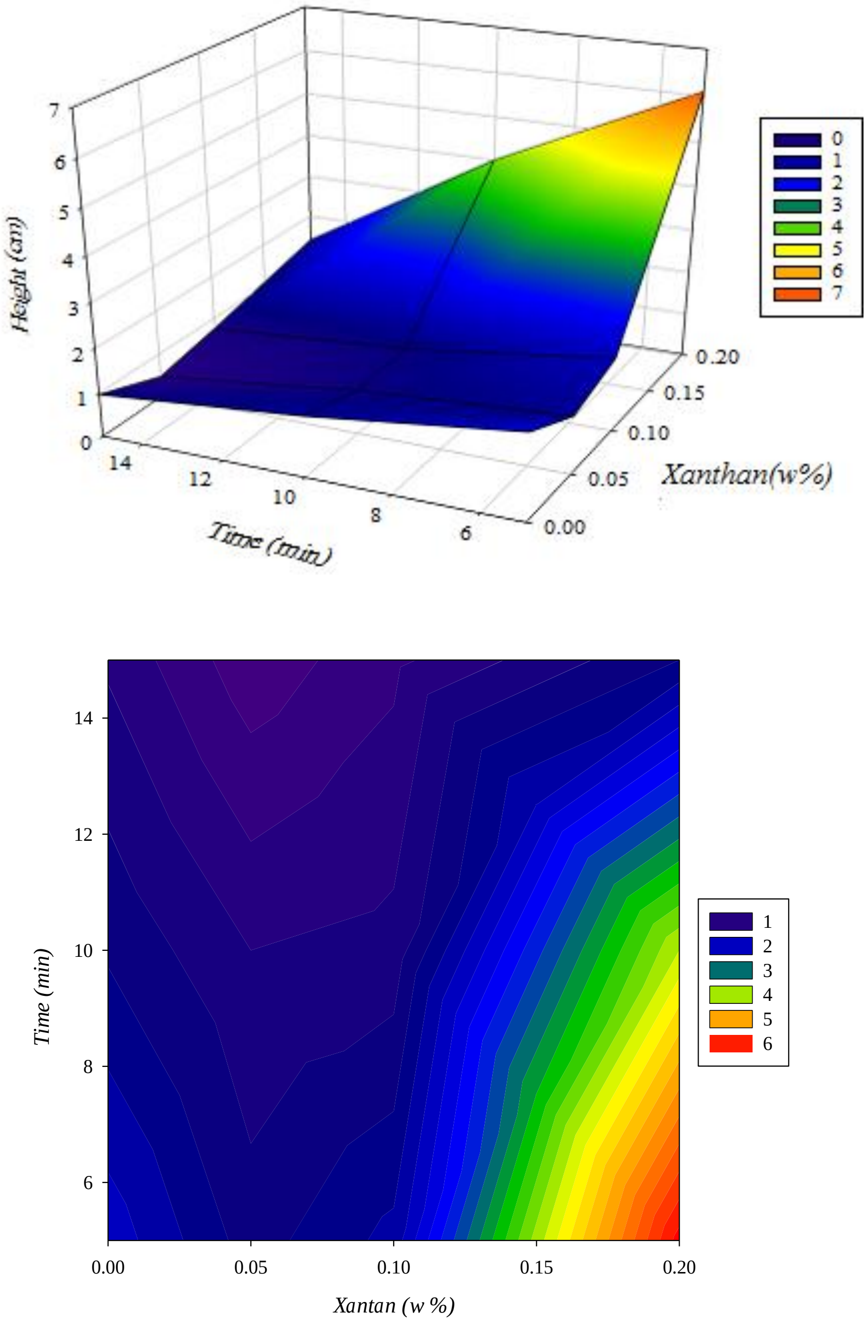

Fig. 6. Three dimensional plot (top) and counter plot (bottom) on the height of the foam with the combined effects of weight percent of Xanthan and time

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