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Effect of Iranian Endemic Gums on Rheological and Tribological Properties of Non-dairy reduced-fat Coffee Creamer Powder

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Abstract

Coffee creamers are commonly used to reduce the acidity and enhance the texture of coffee, but they often have high fat content. This study investigated low-fat alternatives using two types of Iranian gum: cress seed gum and Serish root gum. The creamers were tested using rheological and tribological tests, and the results indicated that as fat content decreased, dynamic viscosity also reduced. Notably, cress seed gum samples had superior viscosity than the other group. At a speed of 100 mm/s, friction coefficients were lowest for the sample without fat reduction containing cress seed gum, while the sample with 30% fat reduction and cress seed gum had the highest coefficient of friction. Overall, the cress seed gum samples performed better, while those containing Serish root gum closely resembled the commercial sample. These findings highlight the potential of Iranian endemic gums as effective thickeners in reduced-fat liquid food systems.

Keywords: tribology- rheology- fat reduction- cress seed gum- Serish root gum

1. Introduction

Coffee is a widely consumed beverage globally, commonly accompanied by coffee creamers to add a creamy texture and appearance to their drinks, but they're high in saturated fat [1]. High-fat diets increase health risks like cardiovascular diseases, high blood pressure, and obesity. This has led consumers to prefer low-fat products. Therefore, creating low-fat foods that mimic standard products is challenging for manufacturers [2, 3].

Hydrocolloids are commonly used as fat substitutes in food and as thickeners, gel-forming agents, emulsifiers, and stabilizers [4]. Iran's endemic gums have excellent stabilizing and consistency properties in various food systems [5]. Cress seed gum (CSG) is a stable and effective food thickener with a molecular weight of 540 kilodaltons and is a suitable alternative to xanthan gum [6]. Also, based on the recent research by Salahi et al. Serish root gum (SRG) has great potential for different functions in food systems [7].

Combining rheological and tribological properties can be a promising method to predict food oral perceptions [8]. Given the lack of prior research, our study investigates CSG and SRG's effects on coffee creamers' oral behavior with varying fat content (0%, 10%, 20%, and 30%). We will analyze the product's rheological and tribological properties as an emulsion in hot water to accomplish this.

2. Experimental

2.1. Materials

Raw materials necessary for the basic formulation were purchased from food ingredient centers. Cress seeds and serish roots were purchased from a local medicinal market in Mashhad, Iran. CSG and SRG powder were extracted based on the method used by Karazhiyan et al. and Salahi et al. [6, 7]. Then, all the samples were mixed in water at 95°C with a constant amount for each.

2.2. Methods

The samples' dynamic viscosity was measured using a capillary viscometer (Canon Ablod, Semi Micro Viscometer, No. 100, k = 0.019907 mm^2/s^2, Canon, USA) at 37°C. The test was repeated three times for each sample, and the average passing time was recorded. The dynamic viscosity (η) using the following equation (Eq (1)):

$$\eta = k.\rho.t \quad (1)$$

Which "t" was the sample passage time and "ρ" was the density of the samples.

Samples were evaluated using a designed tribometer. AISI 52100 steel disc was used with 1 N normal force at 37°C. Results were recorded at 100-450 mm/s rotational speeds.

3. Results and Discussion

3.1. Dynamic viscosity

The findings demonstrate the influential role of CSG and SRG as stabilizers and thickeners. Analysis of Fig.1(c) and Table 1 reveals that samples with CSG have higher viscosity than the commercial sample. Reducing fat in samples with SRG has a greater impact on dynamic viscosity than the CSG samples. The fat content reduction did not significantly impact the viscosity of these treatments (P>0.05). Also, Samples with SRG had a similar viscosity to the

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commercial sample (P>0.05), which indicates that samples containing CSG have acted better as a thickener.

3.2. Stribeck curve

According to the results of the tribology test (Figure 1(a)), which covered two Stribeck regimes (mix, elastohydrodynamic, until the middle of hydrodynamic) with increasing speed from 100 to 450 mm/s, the friction coefficient increased. However, the sample containing CSG with a 30% fat reduction had the highest friction coefficient values at higher speeds and in the elastohydrodynamic region, which was the opposite in the mix region (Figure 1(b)). Conversely, the sample containing CSG without fat had the lowest friction coefficient values in all areas. Additionally, the friction coefficients of the samples at a speed of 100 mm/s, which was the optimal speed for oral simulation to assess creaminess, almost showed that the reduction of fat led to a decrease in friction coefficients, although this was not significant. In conclusion, the CSG samples exhibited lower friction coefficients than those containing SRG.

4. Conclusion

Based on the data derived from both tests, it is evident that the samples containing CSG exhibited superior performance, displaying higher dynamic viscosity and lower friction across various regions of the Stribeck curve. This suggests that creaminess can be better perceived through these examples. Conversely, the SRG samples demonstrated favorable results that resembled the commercial sample. Consequently, it can be inferred that using Iranian endemic gums as substitutes for commercial thickeners and fat reduction has yielded commendable outcomes, thereby, the possibility of producing a healthier product.

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Figures and Graphs

Table 1. Dynamic viscosity of all treatments with two reputation

C-0%(b)	C-10%(b)	C-20%(b)	C-30%(b)
0.799± 0.003	0.79± 0.008	0.796± 0.004	0.787± 0.007
S-0%(a)	S-10%(a)	S-20%(a)	S-30%(a)
0.721± 0.004	0.717± 0.008	0.712± 0.003	0.712± 0.01
CC(a)		0.723±0.003	

a-b: Means followed by the same letters are not significantly different (P> 0.05). (CC = commercial creamer)

Fig 1. (a) tribology trend of all treatments speeding from 0 to 450 mm/s (b) area under the curve of all tribology trends (c) dynamic viscosity of all treatments