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Chaitali Chakraborty
Assistant Professor
Department of Food Technology, Gurunanak Institute of Technology, 157/F, Nilgunj Road, Panihati, Sodepur, Kolkata 700114, West Bengal, India

Kakali Bandyopadhyay
Assistant Professor
Department of Food Technology, Gurunanak Institute of Technology, 157/F, Nilgunj Road, Panihati, Sodepur, Kolkata 700114, West Bengal, India

Shairee Ganguly
Assistant Professor
Department of Food Technology, Gurunanak Institute of Technology, 157/F, Nilgunj Road, Panihati, Sodepur, Kolkata 700114, West Bengal, India

Urmi Sarkar
Second Year B. Tech Student,
Department of Food Technology, Gurunanak Institute of Technology, 157/F, Nilgunj Road, Panihati, Sodepur, Kolkata 700114, West Bengal, India.

Shreosi Das
Second Year B. Tech Student,
Department of Food Technology, Gurunanak Institute of Technology, 157/F, Nilgunj Road, Panihati, Sodepur, Kolkata 700114, West Bengal, India.

Correspondence
Chaitali Chakraborty
Assistant Professor
Department of Food Technology, Gurunanak Institute of Technology, 157/F, Nilgunj Road, Panihati, Sodepur, Kolkata 700114, West Bengal, India

Evaluation of rheological, physicochemical and sensory properties of low calorie coffee yogurt

Chaitali Chakraborty, Kakali Bandyopadhyay, Shairee Ganguly, Urmi Sarkar and Shreosi Das

Abstract
Fermented foods and beverages possess various nutritional and therapeutic properties. Lactic acid bacteria (LAB) play a major role in determining the positive health effects of fermented dairy products. Amongst them, yoghurt is redefined as a probiotic carrier food. In order to expand the consumer market of this product, many flavours are added with it. However using synthetic flavour could be harmful for health. In today's progressive world a shift from synthetic to natural flavour is observed. In the present study two types of flavoured yogurt were prepared and the characteristics were compared with the control sample (C). In both the samples coffee was used as natural flavouring agent and as sweetening agent sucrose was used for Y1 and low calorie sweetener, aspartame was used for Y2. The rheological properties of all the samples were analyzed by using Brookfield rheometer and it was found that all the samples follow pseudo plastic nature by following power law model of viscosity. Flow index for C, Y1 and Y2 were found as 0.57, 0.401 and 0.395 respectively. Sensory analysis were done by 9 point hedonic scale and it revealed that overall acceptability of Y2 (7.95) was higher than Y1 (7.55). Syneresis, acidity (%LA) and pH of all the samples were measured. The syneresis percentage was revealed that it was highest in case of control yogurt and lowest in case of Y2. The pH values of all the samples were lie between ranges of 4.2 to 4.4. The highest acidity was observed in case of control yogurt. Therefore it can be concluded from the values of overall acceptability and flow index that sugar-free yogurt (Y2) can get easily accepted by the consumers in the worldwide market.

Keywords: Coffee Yogurt, sensory analysis, rheological analysis, syneresis, aspartame

1. Introduction

1.1 Yogurt

The search for a healthier diet is becoming increasingly prevalent throughout the world. People are now concerned about their health and well-being which have ensured a growing demand for healthy products. In this context, the demand for functional foods, which besides their basic nutritional functions; provide many benefits to human health is growing day by day. There are a wide variety of products with this appeal, and the dairy industry plays an important role in this market (Goncalvez *et al.*, 2005) [12].

Yogurt can be noted as functional food. It is a product obtained from the fermentation of milk by the symbiotic action of traditional lactic microorganisms, *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. Yogurt is rich in protein, folic acid, vitamins A, B and minerals and its regular consumption brings many health benefits, such as gastrointestinal regulation, stimulation of the immune system, etc. (Chandan, *et al*., 2006) [7]

The consumption of yogurt has experienced significant increase and there are various types to achieve the broad consumer market. These products may vary according to the ingredients, composition, flavor, consistency, texture, calorific value and development process. The final product quality has great importance in its acceptance, and is influenced mainly by its consistency and viscosity (Rasic, *et al*., 1978) [24].

The texture of the product and propensity to syneresis (serum separation) are the main characteristics that define the quality of yogurt (Lee, *et al*., 2010) [17]. Generally, to increase the viscosity, the practice used in industries is to increase the solids content by adding milk or whey powder.

Rheological studies usually involve relationships between shear rate and shear stress. When the relationship is linear, the fluid is referred Newtonian and its viscosity is constant, independent of the rate and shear stress applied. However, in many cases, this relationship is nonlinear and the fluid is classified as non-Newtonian.

According to Schramm, 2006, these fluids can be pseudo plastic fluids, which have lower viscosity with increasing shear rate applied.

1.2 Coffee

Coffee is a product consumed daily in the world by all social classes. Brazil is the largest producer and second consumer market in the world. The coffee contains about 1 to 2.5% caffeine and feature a large variety of minerals, amino acids, lipids and sugars. Coffee is a good source of vitamin B_3, niacin and chlorogenic acids, which**,** after roasting**,** form several compounds with pharmacological effects. (Mathias *et al*., 2011) [19]

Some of the beneficial effects of coffee on health are: reduction of cholesterol, aid against heart disease, antidepressant effects, reduced risk of Parkinson's disease, protection against type 2 diabetes, acts as antioxidant, aiding in weight loss procedures and prevention of some types of cancer (colon and rectum). (Chou *et al*., 1994) [8]

1.3 Aspartame

Aspartame is a methyl ester of the aspartic acid/phenylalanine dipeptide. (Ager *et al,* 1998) [1]. It is an artificial non-nutritive sweetener used in various food industries as sugar (sucrose) substitute. In 2013 the European Food Safety Authority concluded that, re-evaluation of aspartame and its breakdown products are safe for human consumption at current levels of exposure. It is approximately 200 times sweeter than sucrose. As it is a low calorie sweetener it is beneficial for the diabetic patients and the health conscious consumers. The taste of aspartame and other artificial sweeteners differs from that of table sugar in the times of onset and how long the sweetness lasts, though aspartame comes closest to sugar's taste profile among approved artificial sweeteners. (O'Donnell *et al.,* 2006) [20]

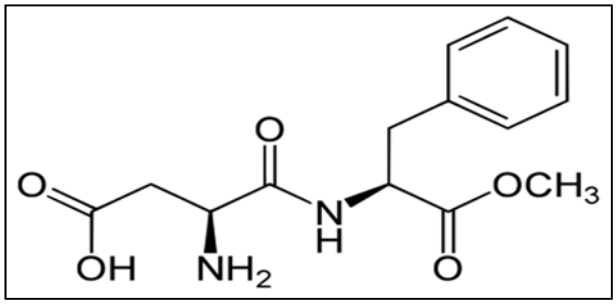

Fig 1: Structure of Aspartame

In this present study two types of flavoured yogurt were prepared Y1 (yogurt with coffee flavor and sucrose as sweetener) and Y2 (yogurt with coffee flavor and aspartame as sweetener).In both the samples coffee was used as natural flavouring agent and as sweetening agent sucrose was used for Y1 and low calorie sweetener aspartame was used for Y2. To compare the quality characteristics control sample was also prepared.

2. Materials and Methods

2.1 Coffee flavoured yogurt preparation

Homogenized and Pasteurized cow's milk (milk fat 3.6%, protein 3.3%, SNF 8.6%, pH 6.6-6.7) was brought from local market (Sodepur, Kolkata). Pasteurized toned milk was heated to 90-95 ºC till its volume reduces to 1/3rd of its original volume and then it was cooled to about 37 ºC. The milk was separated in three parts by volume. One part was separated for control yogurt (C) preparation and another two parts were for coffee yogurt preparation. In coffee yogurt preparation firstly 5 % (w/v) Instant Coffee powder (Nescafe) was added to the milk for coffee preparation. The prepared coffee was divided into two samples: Y1 and Y2. As sweetening agents 12% (w/v) table sugar (sucrose) and 0.2% (w/v) aspartame (Sugar Free Gold) were added to Y1 and Y2 respectively. Then, 2% of yoghurt (purchased from local market of Sodepur, manufactured by a reputed dairy industry located in Kolkata) is being mixed thoroughly to both the samples individually. In case of control yogurt table sugar (sucrose) and starter culture were added. The samples were then incubated at 37 ºC for 7 hours and refrigerated at 4 ºC till use.

2.2 Rheological analysis of yogurt samples:

The rheological flow properties of shear-thinning materials are most commonly described by a two parameter power law model of the form (Jumah *et al*., 2001) [15].

$\tau = m\gamma^n$

Where, τ is the shear stress, γ is the shear rate; *m* is the flow consistency index and *n* is the flow behavior index. The value of *n* is less than one for pseudo plastic material. This power-law model was used in this study to describe the behavior of the different Yogurt samples.

2.3 Physico-chemical analysis of yogurt samples:

Degree of syneresis, expressed as proportion of free whey, was measured by a small modification of method used by Al-Kadamany *et al*., 2003 [2].

50 grams of samples were placed on a filter paper (Whatman filter paper1) resting on the top of a Buckner funnel. The filtration was done in vacuum condition for 10 minutes. Then the final weight of the sample was taken.

% of synersis = Free whey (g/100g) = 100 x (weight of initial sample - weight of sample after filtration) /weight of initial sample

Chemical analysis was done according the method described by AOAC, 1999 [3].

2.4 Sensory analysis

Sensory analysis was done for all samples by eight trained panel members of food technology department by using 9 point hedonic scale (Hooda and Jood, 2005) [14].

2.5 Statistical analysis

All the data were statistically analyzed using the method described by Snedecor and Cochran (1967) [26].

3. Results and Discussion

3.1 Rheological analysis

Food rheology is the study of deformation and flow of food materials. Milk gels are visco-elastic, thus yogurt's rheological properties can be characterized by using both the viscous and elastic components. The flow index of all the samples were determined by using the Brookfield rheometer (Model-DV III Ultra programmable rheometer).

Rheological characteristics of coffee yogurt samples along with control were analyzed. The results are shown in fig. 2 and fig. 3 by plotting shear stress vs. shear rate. According to the rheological analysis, the values of *m* and *n* resulting from the fit of the power law model for different samples can be found in Table 1. The values of n in all samples were less than 1. Therefore it was evident that all samples along with control

show pseudo-plastic behavior. Study also revealed that the flow behavior of the samples C, Y1 and Y2 were 94.6%, 97.2% and 97.1% similar with the standard curve.

Mathias *et al*., 2011 [19] observed the flow index (n) of coffee-flavored yogurt with different types of thickener and the result revealed that all the values were less than 1, confirming the pseudoplastic characteristic, this could occur due to physical destruction of weak bonds between the molecules of the product and due to decreased energy of interaction between them. Aprodu *et al*., 2012 [4] reported that the apparent viscosity reaches a plateau of constant values, meaning that the destruction and the reformation rate of the protein aggregates were comparable. Hojjat Karazhiyan *et al*., 2009 [13] reported that for all samples, an increase in concentration or temperature led to an increase in pseudoplasticity. The rheological tests showed that the products studied demonstrated non-Newtonian behavior (shear thinning), which could be described with Herschell-Bulkley rheological model (Karsheva *et al*., 2013) [16]. The decrease of the apparent viscosity of all studied samples with the increase of the shear rate indicates the pseudo-plastic behavior, with time dependent structural viscosity (Aprodu *et al*., 2012) [4]. Dutta *et al*., 2016 [9] observed similar rheological characteristics (n less than 1) for different types of pineapple curd.

Table 1: Fluid flow behaviors of samples

Sample	Flow Index (n)	Consistency Index (m)
C	0.57	73.97
Y1	0.401	50.7
Y2	0.395	28.97

n = flow index, m= consistency index

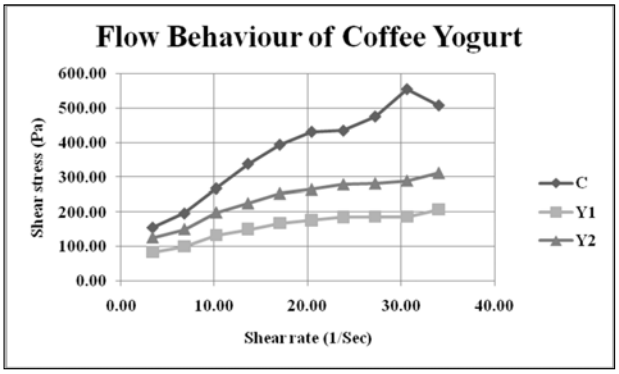

Fig 2: Flow behavior of coffee yogurt C= control yogurt, Y1= coffee flavoured yogurt with sugar, Y2= coffee flavoured yogurt with aspartame

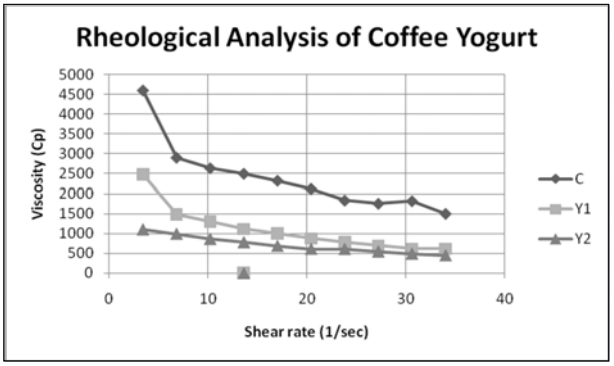

Fig 3: Rheological analysis of coffee yogurt C= control yogurt, Y1= coffee flavoured yogurt with sugar, Y2= coffee flavoured yogurt with aspartame

3.2 Physico-chemical analysis of yogurt samples

The syneresis is a measure of the quantity of whey separated from the yogurt and is one of the most important factors influencing consumers' acceptance. Higher level of syneresis shows that yogurt is of low quality (Aprodu *et al*., 2012) [4].

Degree of syneresis is expressed as proportion of free whey. This study revealed that the syneresis of control yogurt was 58.06% which was greater than the syneresis of coffee flavoured yogurt. For Y1 and Y2 syneresis were 21.6% and 11.6% respectively. According to Azam *et al*., 2015 [5], the syneresis of the prepared yoghurt samples were affected significantly ($P<0.05$) by both G*undelia tournefortii* concentration and storage time. Water-holding capacity of yoghurt-gel was not only an important property of yoghurt product but also reflected the stability of coagulation condition. Yang *et al*, (2014) [27] revealed that rebaudioside A did not participate in the lactic fermentation, which resulted in the increase of yoghurt water holding capacity. The addition of erythritol induced a decrease of water-holding capacity at lower concentration, whereas at higher levels, the water-holding capacity increased.

The pH of all the samples were found almost similar to each other and lie between ranges of 4.2 to 4.4. The highest acidity (1.04 %LA) was found in control sample, whereas Y1 and Y2 posses same acidity (0.86% LA) (Table 2). Okoye *et al*. 2009 [21], also reported that the pH and the titrable acidity of the yoghurt samples was significantly different from each other ($p<0.05$). This might be due to variation in the growth of lactic acid bacteria during fermentation.

Table 2: Physicochemical composition of different types of yogurt

Sample	pH	Acidity (% LA)	Syneresis (%)
C	4.28	1.04	58.06%
Y1	4.42	0.86	21.6%
Y2	4.39	0.86	11.6%

3.3 Sensory analysis

It was observed that colour and overall acceptance of Y2 score highest points which were 7.75 and 7.95 respectively whereas flavour of Y1 score highest that is 7.48.

Sensory analysis of the samples are presented in fig: 4. It was found that the appearance, colour, mouth-feelness and overall acceptability of Y2 (made with aspartame) were 8.7%, 1.2%, 5.23% and 5.3% more than Y1 (made with table sugar) respectively. This result was also supported by Manjula *et al*., 2010 [18].

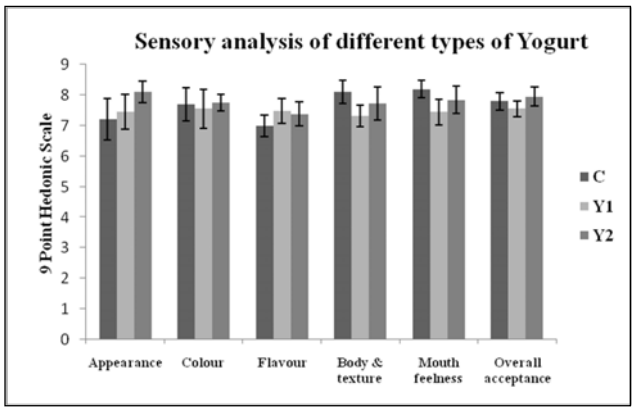

Fig 4: Sensory analysis of different types of Yogurt samples C= control yogurt, Y1= coffee flavoured yogurt with sugar, Y2= coffee flavoured yogurt with aspartame

4. Conclusion

Fermented dairy products such as yogurt have long been known for its functional value, particularly in managing intestinal disorders such as lactose intolerance or acute gastroenteritis. The application of each treatment (addition of probiotics, prebiotics, different food ingredients and process) potentially influences rheology and textural properties of yogurt. In terms of health, although technology has been applied with almost complete success to produce low - fat, low calorie and functional yoghurt with sufficient rheological properties, still there is need for product optimization.

From the values of overall acceptability and flow index it can be concluded that sugar-free yogurt (Y2) can get easily accepted by the consumers in the worldwide market.

5. Acknowledgement

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