PEANUT MILK PRODUCTION BY THE MICROFLUIDIZATION, PHYSICOCHEMICAL, TEXTURAL AND RHEOLOGICAL PROPERTIES OF PEANUT MILK PRODUCTS; YOGHURT AND KEFIR

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PEANUT MILK PRODUCTION BY THE MICROFLUIDIZATION, PHYSICOCHEMICAL, TEXTURAL AND RHEOLOGICAL PROPERTIES OF PEANUT MILK PRODUCTS; YOGHURT AND KEFIR

submitted by **SİMAY ARSLAN** in partial fulfillment of the requirements for the degree of **Master of Science in Food Engineering Department, Middle East Technical University** by,

Prof. Dr. Halil Kalıpçılar
Dean, Graduate School of **Natural and Applied Sciences** _______________

Prof. Dr. Serpil Şahin
Head of Department, **Food Engineering Dept., METU** _______________

Prof. Dr. Behiç Mert
Supervisor, **Food Engineering Dept., METU** _______________

Examining Committee Members:

Prof. Dr. Aziz Tekin
Food Engineering Dept., Ankara University _______________

Prof. Dr. Behiç Mert
Food Engineering Dept., METU _______________

Assoc. Prof. Dr. Deniz Çekmecelioğlu
Food Engineering Dept., METU _______________

Assoc. Prof. Dr. İlkay Şensoy
Food Engineering Dept., METU _______________

Assoc. Prof. Dr. Mecit Öztop
Food Engineering Dept., METU _______________

Date: 27.11.2018

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Simay Arslan

Signature:

ABSTRACT

PEANUT MILK PRODUCTION BY THE MICROFLUIDIZATION, PHYSICOCHEMICAL, TEXTURAL AND RHEOLOGICAL PROPERTIES OF PEANUT MILK PRODUCTS; YOGHURT AND KEFIR

Arslan, Simay

M.Sc., Department of Food Engineering

Supervisor: Prof. Dr. Behiç Mert

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The aim of this study is to investigate the physicochemical, textural and rheological properties of the peanut yogurt and kefir. In this study microfluidization was applied to obtain peanut milk instead of filter and homogenisation steps in traditional peanut milk production process.

In the first part of the study, peanut yogurt was produced as three different formulations from, non-microfluidized peanut milk, microfluidized peanut milk and adding skimmed milk powder (4%, w/w) in microfluidized peanut milk, in three different concentrations 1:3, 1:3.5, 1:4; peanut (g): water (g), for each formulation with 2% (w/w) sucrose and 1% (w/w) of yoghurt culture, to understand the effect of microfluidization, chemical agent (milk powder) and concentration.

In the second part of the study, peanut kefir was produced from microfluidized peanut milk in four different concentrations 1:4; 1:5; 1:6; 1:7; peanut (g): water (g) with 2% (w/w) sucrose and 1% of kefir culture to determine the effect of concentration.

Dry matter content, water holding capacity, synersis, pH, titratable acidity, color was measured in peanut yogurt and kefir as physicochemical parameters. Scanning

Electron Microscope (SEM) analysis was conducted to analyze microstructural property.

Firmness, cohesiveness and consistency were measured as textural properties of peanut yogurt and kefir. The significant effect of treatments and concentrations were determined by ANOVA statistical program.

In rheological measurements, peanut yogurt and kefir results was fitted to power law model The shear stress, elastic (G') modulus and viscous (G") modulus was obtained for all samples.

As a result, when mechanical treatment is combined with the chemical agent as milk powder it was found that the final effect was more stronger, however its possible to produce peanut peanut yogurt and kefir with only sucrose and culture using microfluidization technique with the optimization of concentrations.

Keywords: Peanut milk, Microfluidization, Peanut yogurt, Peanut kefir, Physicochemical parameters, Texture, Rheology

ÖZ

MİKROAKIŞKANLAŞTIRMA İLE YER FISTIĞI SÜTÜ ÜRETİMİ; YER FISTIĞI YOĞURT VE KEFİRİNİN FİZİKOKİMYASAL, TEXTÜREL VE REOLOJİK ÖZELLİKLERİ

Arslan, Simay
Yüksek Lisans, Gıda Mühendisliği Bölümü
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Bu çalışmanın amacı, yer fıstığı yoğurt ve kefirinin fizikokimyasal, textürel ve reolojik özelliklerini araştırmaktır. Bu çalışmada, geleneksel yer fıstığı sütünün elde edilmesi işleminde uygulanan filtrasyon ve homojenizasyon basamakları yerine mikroakışkanlaştırma uygulanmıştır.

Çalışmanın ilk bölümünde, yer fıstığı yoğurdu; mikrosıvılaştırılmamış yer fıstığı sütü, mikrosıvılaştırılmış yer fıstığı sütü ve mikro sıvılaştırılmış yer fıstığı sütüne yağsız süt tozu (%4, g/g) ilavesi ile üç farklı formülasyon olarak ve her bir formülasyon için üç farklı konsantrasyonda 1:3, 1:3.5, 1:4; yer fıstık (g): su (g) olarak %2 (g/g) sükroz ve %1 (g/g) yoğurt kültürü ile mikroakışkanlaştırma, kimyasal madde (süt tozu) ilavesi ve konsantrasyonun etkisini anlamak için üretilmiştir.

Çalışmanın ikinci bölümünde, yer fıstığı kefiri; mikrosıvılaştırılmış yer fıstığı sütünden dört farklı konsantrasyonda 1:4; 1:5; 1:6; 1:7; yer fıstığı (g): su (g) olarak üzere %2 (g/g) sükroz ve %1 (g/g) kefir kültürü ile konsantrasyonun etkisini belirlemek için üretilmiştir.

Yer fıstığı yoğurt ve kefirinde fizikokimyasal parametreler olarak, kuru madde içeriği, su tutma kapasitesi, sinersis, pH, titrasyon asitliği ve renk ölçülmüştür. Mikroyapısal özelliği analiz etmek için Taramalı Elektron Mikroskobu (SEM) analizi yapılmıştır.

Sıkılık, yapışkanlık ve kıvam, yer fıstığı yoğurt ve kefiri textürel özellikleri olarak ölçülmüştür. Yöntemlerin ve konsantrasyonların anlamlı etkisi ANOVA istatistik testi ile belirlenmiştir.

Reolojik ölçümlerde, yerfıstığı yoğurt ve kefirinin akış davranışları the power law modeliyle açıklanmıştır. Tüm örneklerde kayma gerilmesi, elastik (G') modül ve viskoz (G") modülü elde edilmiştir.

Sonuç olarak, mekanik işlemin kimyasal madde ile birlikte (süt tozu) birleştirildiği zaman etkinin güçlendiği, ancak sadece mikrosıvılaştırılma tekniği kullanılarak uygun konsantrasyonlarla sukroz ve kültür ile yer fıstığı yoğurt ve kefirinin üretilebildiği bulunmuştur.

Anahtar Kelimeler: Yer fıstığı sütü, Mikroakışkanlaştırma, Yer fıstığı yoğurdu, Yer fıstığı kefiri, Fizikokimyasal parametreler, Tekstür, Reoloji

To Beloved My Family

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LIST OF ABBREVIATIONS

ABBREVIATIONS

G' Elastic modulus

G" Viscous modulus

PY Peanut Yogurt

MF Microfluidized

MP Milk Powder

MPK Microfluidized Peanut Kefir

CHAPTER 1

INTRODUCTION

1.1 Peanut

Peanut is a significant crop grown and consumed in a wide diversity of forms around the world. Peanut*(Arachis hypogaea)* is the member of fabaceae family of bean/legume. According to USDA's Foreign Agricultural Service, China is the largest producer of peanuts about 45% whereas India is the second largest peanut manufacturer about 16% and followed by The United States about 5% in terms of world production (Boriss and Kreith 2006).

Peanuts major constituents are protein, fats, and fiber (Table 1). The ingredients are available in their most useful forms for human nutrition; the plant-based protein, unsaturated fat and the complex carbohydrate fiber (Arya, Salve, and Chauhan 2016).

Peanut is good source for oleic and linoleic acids, a typical peanut make up 50% fat, of which about 80% is unsaturated and majority of these unsaturated fatty acids are oleic and linoleic acids. The linoleic acid essential for people metabolism and people don't have enzyme to synthesize it so omega-6 fatty acid must take with foods (Baker et al. 2002). The oleic acid ensure health benefits and offer an advantage for long shelf life attribute beside oxidizable polyunsaturated fatty acids. Also peanut contains polyphenols, antioxidants, phytosterols (which inhibit the absorption of cholesterol from diet) vitamins, minerals and some important compounds like flavonoids, resveratrol, phenolic acids. It is revealed that peanuts contains all the 20 amino acids (highest amount of arginine) with Co-enzyme Q10 and these bioactive compounds have precaution effect on disease are thought to encourage longevity (Duncan, Gorbet, and Talcott 2006).

Principle	Nutrient value (per 100 g)
Energy	567 Kcal
Carbohydrates	16.13 g
Protein	25.80 g
Total Fat	49.24 g
Cholesterol	0 mg
Dietary Fiber	8.5 g
Vitamins	
Folates	240 µg
Niacin	12.066 mg
Pantothenic acid	1.767 mg
Pyridoxine	0.348 mg
Riboflavin	0.135 mg
Thiamin	0.640 mg
Vitamin E	8.33 mg
Electrolytes	
Sodium	18 mg
Potassium	705 mg
Minerals	
Calcium	92 mg
Copper	1.144 mg
Iron	4.58 mg
Magnesium	168 mg
Manganese	1.934 mg
Phosphorus	76 mg
Selenium	7.2 µg
Zinc	3.27 mg

Table 1.1 Groundnuts Peanut (Arachis hypogaea), All types, Nutritional value per 100 g. Source: USDA National Nutrient Database for Standard Reference Release Legacy April, 2018; Basic Report 16087, Peanuts, all types, raw.

Developing countries have considerable problem which is the deficiency in protein intake by poor people. This problem request a need for developing processes by which plant proteins can be economically included into diets with low cost and good quality (de Albuquerque et al. 2015).

The people has become aware of the nutritional benefits of vegetable proteins which have protective effect against chronic degenerative diseases and preferable in low cholesterol diets by health conscious people (Diarra, Nong, and Jie 2005).

1.2 Peanut Milk

Vegetable milk's lactose-free, animal protein-free and cholesterol-free contents led to an increasing demand for nut and cereal vegetable milks and their derivatives although minor knowledge is available about their manufacturing process except from soya (Chiralt 2014).

Since the early 1950s, several ways were developed by researchers produce peanut milk and derivatives of peanut milk products (Diarra, Nong, and Jie 2005).

In 1950, a way improved to produce stable nut emulsions as mixture of finely obtained peanut flour and water. However, stability of emulsions didn't maintain for long period, milk was settled down and they try to improve it with edible emulsifying agents (Jasper 1973).

An other way was defined as per Barley (1951), peanut milk could be obtained from mixing of raw peanut and water for 30 min as yellow sludge. The researchers followed the same way for peanut milk production in time but they always led to enhance the peanut milk production process for manufacturing peanut milk. Dora Armstrong (Jasper 1973) made peanut milk in similar way, but subsequently deodorizing was followed by bubbling stream through it.

Reseracher were tried deodorizing or blanching or oil removal or chemical additives in production as different methods but mainly process was described in Chan Lee and

Beuchat study (Lee and Beuchat 1992). According to this study, these steps are followed; dry blanch peanut kernels and soak 0.5% sodium bicarbonate for 18 hour. Drain and rinse with tap water. Adding water 2:1 (water: peanut). Cooking 100 ◦C, 10 min. Adding water 5:1 (water: peanut). Grind in colloid mill. Filter with three-layered muslin cloth. Homogenization and heat treatment. The flow chart was presented in Figure 1.1.

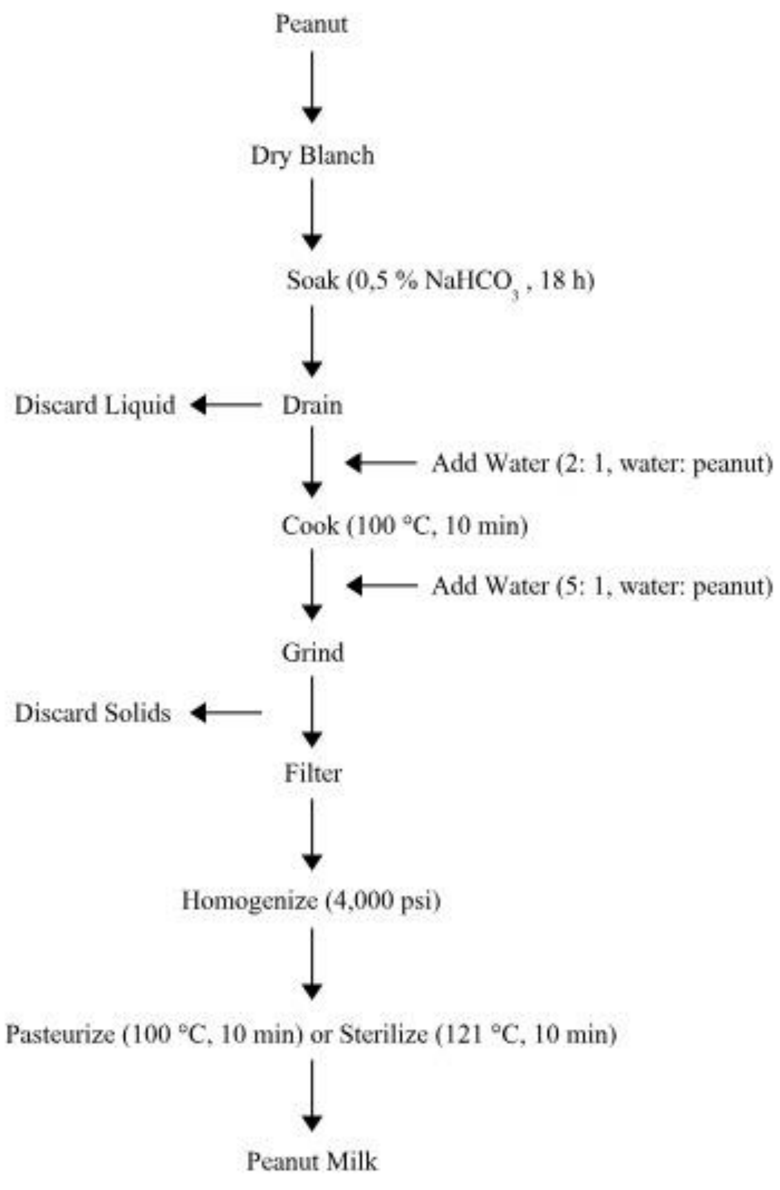

Figure 1.1 Flow chart preparation of peanut milk (Source: Lee and Beuchat 1992).

Also vegan consumers, whether it's for ethical, dietary or environmental reasons or people who have allergic to animal milk proteins can consume peanut milk and derivatives safely (Isanga and Zhang 2009).

So far, inexpensive and nutritional supplement peanut milk has modified into fermented products such as buttermilk, yoghurt and cheese (Lee and Beuchat 1992).

1.3 Peanut Yoghurt

Yogurt is a fermented dairy product produced around the world. Yogurt manufacturing processes base on a lactic fermentation in milk to gelification due to destabilization of the protein system by acid coagulation of milk (Sodini et al. 2010). Characteristic flavour of yogurt are generated by the starter cultures as lactic acid bacteria convert lactose into lactic acid during fermentation generates flavour compounds (Liu et al. 2008). Mostly lactic acid, acetaldehyde, and diacetyl resposible flavour in yogurt (Gallardo-Escamilla, Kelly, and Delahunty 2005; Pinto, Clemente, and De Abreu 2009).

Even though yogurt is made from cow’s milk, there have been approaches to make this type of product from variation food sources, including soy milk, corn milk or a combination of mango pulp–soy milk and buffalo milk (Isanga and Zhang 2009).

Fermentation of peanut milk has several advantages; fermented products have better chemical and sensory properties than unfermented products. In addition, hexanal vanish with fermentation which is compound accountable for the unwanted beany flavor in peanut milk and the production of a considerable amount of acetaldehyde. Also fermentation significantly reducing sulfur. In result of fermentation beany, bitter flavors decrease and sour, creamy flavor increase (Lee and Beuchat 1992). In this regard, fermentation could increase the peanut consumption and hence improve protein availability (Sunny-Roberts, Otunola, and Iwakun 2004).

A yoghurt-like product (Dahi) was produced in India, in 1967 (Salunkhe and Kadam 1989). Reserachers were used lactic acid cultures and fermented peanut milk in regards to this area, they produced beverages, flavored buttermilk, an acceptable custard-like texture with peanut milk. A yoghurt-like product production process was improved in terms of culture strains, sort of sugar and heat treatment studied have done to define the optimum processes.

Peanut milk yogurt was prepared by Isanga and Zhang (2009) and the flow for preparation of peanut milk yogurt is representn in Figure 1.2. Briefly, these steps were followed; peanuts were de-skinned as soaked in 0.5 g/100 mL $NaHCO_3$ for 12 h. After washing with water, the kernels were taken into a blender with water at a ratio of 1:5 [peanut (g):water (mL)] and blended for 5 min. The slurry was filtred with three-layered cheese cloth to obtain peanut milk. 4 g/100 g skimmed milk powder added to penut milk and stirred warmed the milk at 43 ◦C. 7 g/100 mL sucrose was added to the milk as sweetener. Then homogenization and pasteurization was done. Cooling to 43 ◦C and inoculated with 3 mL/100 mL starter culture (*L. bulgaricus* and *S. thermophilus*; 1:1) and incubated at 43 ◦C for 4–5 h. The flow chart was presented in Figure 1.2.

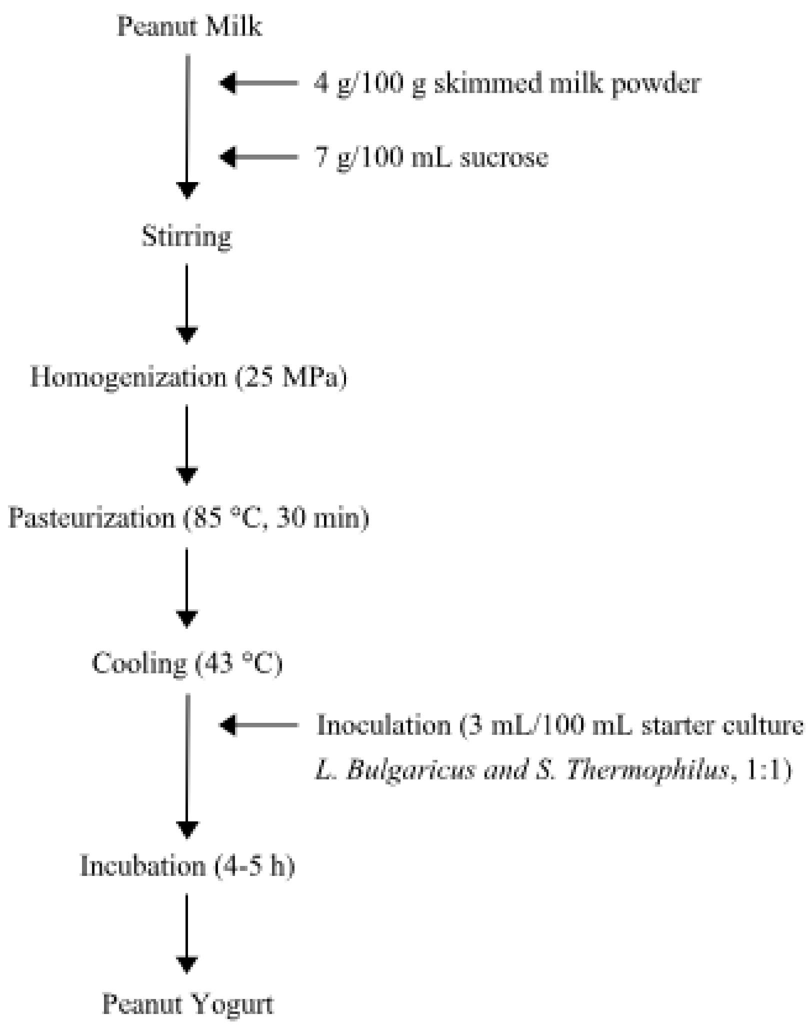

Figure 1.2 Flow chart preparation of peanut yogurt. (Source: Isanga and Zhang 2009)

The main conclusion reserachers drawn was that, the addition of glucose (2%) to pasteurized peanut milk before fermentation with *Lactobacillus bulgaricus NRRL B-1909 and L.acidophilus NRRL B-1910* incubate 38 ◦C and 12 h results in a yogurt-like product and for peanut yogurt production peanut milk fortify with milk powder due to improve the physical properties (Diarra, Nong, and Jie 2005).

1.4 Peanut Kefir

Kefir is a fermented dairy beverage, root comes from Eastern Europe and its popularity is increasing worldwide (Wang and Wang 2017). Kefir, is produced by lactic acid bacteria and yeasts and has unique mildly acidic flavour due to mixture of lactic acid, carbon dioxide, ethanol, and flavouring products as acetoin and acetaldehyde (Altay et al. 2013). The microorganisms in kefir are predominantly Lactobacillus species, synthesis vitamins, degrade protein and hydrolyse lactose, resulting in a highly nutritious and digestible foodstuff (Arslan 2015).

Kefir, can be made from any kind of animal milk as cow, sheep, goat, buffalo, camel milk or also can be prepared from vegetable milk such as walnut milk, cocoapulp beverage, rice milk, coconut milk, soy milk and peanut milk (Nielsen, Gurakan, and Unlu 2014). The sort of milk is important for chemical, textural and sensorial properties of kefir (Altay et al. 2013). Meriem Bensmira and Bo Jiang have done some studies on kefir production from peanut milk and resulted that a novel kefir formulation (Bensmira and Jiang 2011, 2012, 2015).

The flow chart of peanut milk kefir production is representn in Figure 1.3 (Bensmira and Jiang 2011). According to this study, these steps is followed; peanut milk was produced as method of Isanga and Zhang (2009) representn in the Figure 1. 60% peanut-milk with 40% reconstituted skimmed-milk powder at 12% was mixed and 3% (w/v) of sucrose was added. Homogenisation, pasteurization and inoculation with the culture at approximately 25 ºC, then fermentation at 24 °C for 18 h.

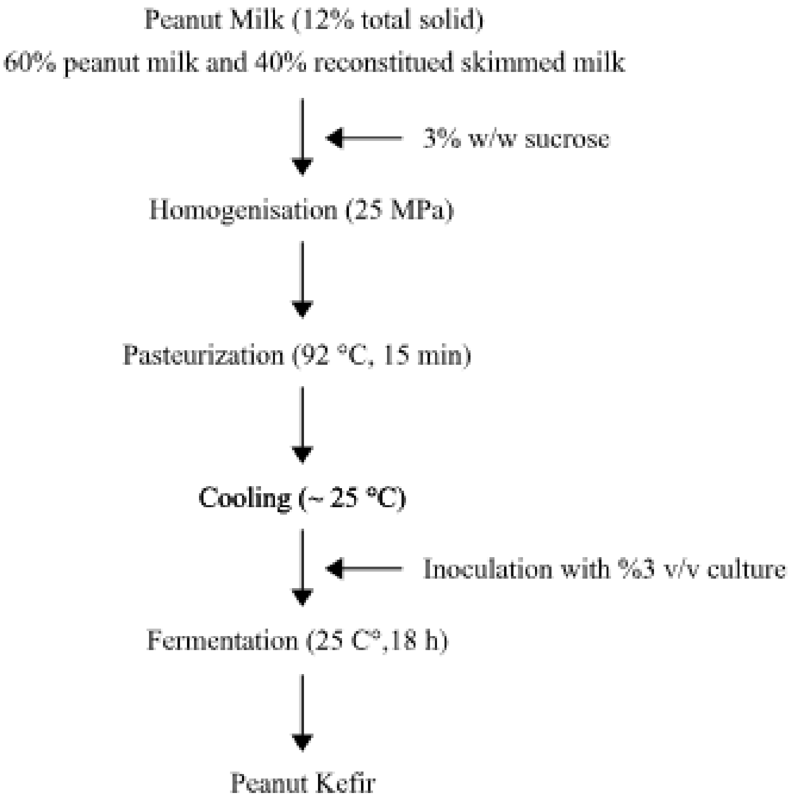

Figure 1.3 Flow chart of peanut kefir production (Source: Bensmira and Jiang 2011).

1.5 Microfluidization

Microfluidization process reduce particle size produce more uniform samples which enhance the stability, taste, color and textural properties of emulsions in food industry. Microfluidization combine ultrahigh pressure, instantaneous pressure drop, high-velocity, intense shear, high-frequency vibration and cavitation (Hu et al. 2011). These components works together decrease droplet diameter dispersion of particles produce more uniform distribution (Pinnamaneni et al. 2003).

In this process, raw metarial passes through from microchannels acquire high velocity by high pressure collide each other which cause fracture of inner structure of flow stream hereby bigger particles become smaller and uniform and more homogenous product can be produce with high stability (Ozturk and Mert 2018).

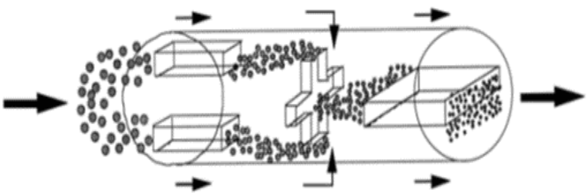

Figure 1.4 The reaction chamber of the microfluidizer (Source: Lagoueyte and Paquin 1998).

Microfluidization method has several advantages over to traditional homogenization methods. Producing standardize smaller particles/droplet sizes, little or no contamination occurs and the equipment cleaning is easy. Also, its processing time is faster, same conditions valid for both large and small scale production, appropriate for continuous process (Garad et al. 2010). Morover, no need any extra chemicals and maintain nutritional composition with low treatment temperature (Hu et al. 2011).

The homogenization method is applied to get smoother, glossier and more consistent structure of products by reducing particle size in food industry. In microfluidization method, raw metarials enter microscopic opening in the homogenizing valve which create high shear and turbulence as a result, dispersion and disintegration of the solids occur (Mert 2012).

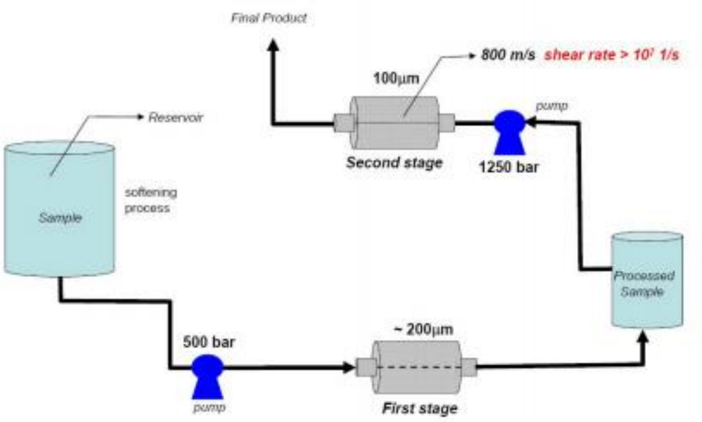

Figure 1.5 Production of fiber (Source: Kocak 2010).

Microfluidization method has been applied to diverse production process in food industry; including milk (Dalgleish et al. 1996; Hardham et al. 2000), cream liqueurs (Paguin and Giasson 1989), xanthan gum (Lagoueyte and Paquin 1998), ice cream (Olson et al. 2003), mozzerella cheese (Tunick et al. 2000), yoghurt (Ciron et al. 2010), peanut (Hu et al. 2011), orange juice (Yuce, 2011), wheat bran (Wang et al. 2012), high methoxyl pectin (Chen et al. 2012), lentinan (Huang et al. 2012), ketchup type products (Mert 2012), cacao fiber (Duman 2013), wheat bran fibers (Mert et al. 2014), palm-based tocotrienol (Goh et al. 2015), hazelnut skin fibres (Cikrikci 2013 ; Yildiz 2014), inulin (Farahmand 2014), wheat straw (Turhan et al. 2015), gluten-free corn breads (Ozturk and Mert 2018).

1.6 Chemical Analysis of Yogurt and Kefir

Dry matter content influences yogurt production substantially even under a certain value (it depends the type of milk) yogurt production can not been achievable. Dry matter content has effect on consistency and viscosity of yoghurt. Besides its physical properties, its also important for ingredient of yogurt which are lactose, proteins, other carbohydrates, fat and minerals in cow milk therefore, legal standards is applied to dry matter content of yogurt production for protect the consumers rights however peanut yogurt composition depends on peanut water ratio so directly related to the demand of the producer (Dincel 2012).

Water holding capacity and syneresis are important quality parameters for sensory properties of yogurts from consumers point of view (Emirdagi 2014). Intrinsic factors affecting water holding capacity of food proteins include amino acid composition, protein conformation and surface polarity/ hydrophobicity (Barbut 1999). Syneresis is defined as the shrinkage of gel and this occurs expulsion of a liquid. Syneresis is related with homogenisation, total solids content, milk composition (proteins, salts), acidity resulting from the growth of bacterial cultures, heat pre-treatment of milk and type of culture (Vareltzis et al. 2016).

Total titratable acidity (TTA) and pH are other important quality control parameters which are related to the growth of lactic acid bacteria. pH refers total acidity whereas total titratable acidity indicated lactic acid amount in samples. Acidity is the important characteristic of yoghurt since determines the shelf-life of product also have a crucial importance on taste.

1.7 Structural Analysis of Yogurt and Kefir

Color of a product has been always an important parameter for consumer's acceptance by visual impression. Physiochemical and microbiological poperties of yoghurt changes over time which effect shelf life and reason for colour deterioration (Cruz et al. 2010).

Image processing systems are useful way for food industry to understand some properties of products like shape, color and texture of the products. Image acquisition, pre-processing, image segmentation, object measurement and classification which are

five steps of image processing system (Du and Sun 2004). TEM (industry transmission electron microscopy), LM (light microscopy) and SEM (scanning electron microscopy) are used as imaging techniques in foods. SEM is an significant method due to suitable for wide range of food products and presents three dimensional images which provide comparing morphological changes of starch granules and protein matrix in products (Yildiz 2013).

1.8 Texture Profile Analysis (TPA) of Yogurt and Kefir

Texture analyzers are used to acquire the texture profile of a food which compress the food with a proper probe, uniaxial pressing to food sample twice like chewing. When force access its peak value in the measurents also the areas under the curves are calculated and these results in relation with the some sensory and textural properties like as chewiness, gumminess and cohesiveness of food are analysed (Sahin and Sumnu 2006).

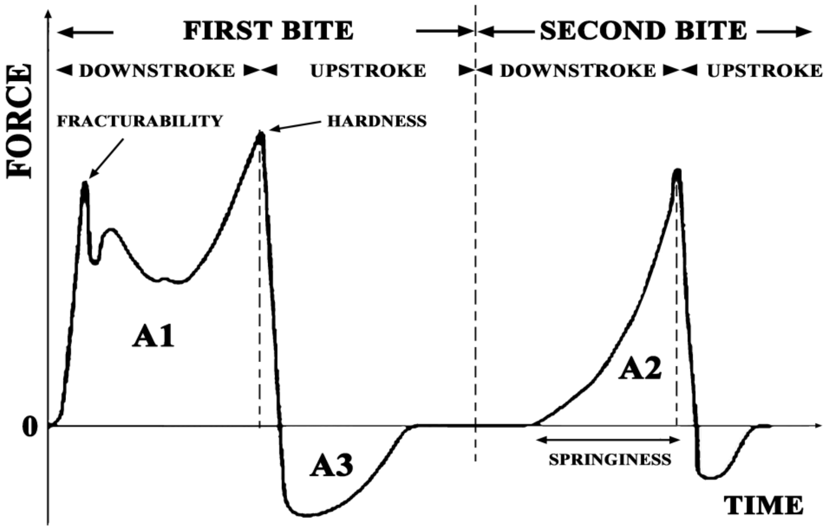

Figure 1.6 Generalize Texture Profile.

Several parameters can be defined for variety of foods. The textural characteristics of peanut yogurts are presented as three different texture parameters; firmness, consistency and cohesiveness.

Hardness has primary importance for characterization of yoghurt texture. Hardness described as the force required to achieve a certain deformation and is regarded as a measure of firmness of the yoghurt.(Mudgil, Barak, and Khatkar 2017). Cohesiveness describes withstands of the product to second compression which is related to its resistance below the first deformation which is estimated the area of work of second compression divided by the area of work of the first compression (Ozcan 2013). Consistency refers the the viscosity of the fluid, and the proportions of solids to fluid a kind of a integration of the size and texture of the solid units (Szczesniak 1963).

1.9 Rheology of Yogurt and Kefir

Rheology investigate the relation between flow and deformation. Deformation charateristic of products defined and classified as elastic and viscous; elastic modulus, (G') the measure of energy stored per deformation cycle, gives information about the elastic behaviour of the material and viscous modulus, (G") the magnitude of energy lost as viscous dissipation per cycle of deformation, gives information about the elastic behaviour of the material (Brummer 2005).

Yoghurt rheological properties have been achieved by dynamic oscillatory test due to its visco-elastic property, viscoelastic means the material has some of the elastic properties like solid and some of the viscous properties like liquid. Yogurt also exhibits time-dependent shear thinning behavior, it means it flows with low shear, but represents elastic behaviour with high shear. There are several characteristic rheological parameters can be determined in yogurts as applying an oscillatory stress or strain and measuring the strain or stress responses. (Glibowski and Rybak 2016).

1.10 Objectives of the Study

There is an increasing demand for nut and cereal vegetable milks worldwide due to their lactose-free, animal protein-free and cholesterol-free contents. Peanut is good source for human nutrition which contein high amount of protein, healty fats as oleic and linoleic acids. Regarding health care tasks, developing processes is a necessity for vegetable milks and their derivatives with low cost and good quality. There is minor knowledge available about their manufacturing process except from soya. Microfluidization process was applied in this study to obtain peanut milk. Microfluidization provide formation of inner structure as particle size reduction with high pressure. In this study physicochemical, textural and rheological properties of the final product; yogurt and kefir was investigated. In the literature, there is no study on studying the effect of microfluidization on the peanut milk or its derivatives.

Dry matter content, water holding capacity, synersis, pH, titratable acidity, color was measured to observe effect of microfluidization in peanut yogurt and kefir as physicochemical parameters. Scanning Electron Microscope (SEM) Analysis was conducted to analyze microstructural property. Firmness, cohesiveness and consistency were measured as textural properties and rheological properties were also measured in order to determine effect of microfluidization on yogurt and kefir. In rheological measurements, peanut yogurt and kefir results was fitted to power law model and the shear stress, elastic (G') modulus and viscous (G") modulus was obtained for all samples.

CHAPTER 2

MATERIALS AND METHODS

2.1 Materials

Peanut of Tadım was purchased from markets. Sucrose was obteined from Smart Chemistry Trade Co. (Çiğli, İzmir, Turkey) as sugar. Yaylamaya probiotic yogurt yeast and Yaylamaya kefir yeast was used as commercial culture from Maysa Dairy and Food Industry Co. Inc (Tuza, İstanbul, Turkey) throughout the experiments. Pınar milk powder was taken from Pınar Milk Industry Co. Inc (Pınarbaşı, İzmir Turkey). Also sodium bicarbonate were provided from Sigma-Aldrich Chemical Co. (Steinheim, Germany).

2.2 Methods

2.2.1 Preparation of peanut milk for yoghurt production

Preparation of peanut milk for yoghurt production; method of Isanga and Zhang (2009) was followed until the filtration step. Peanuts were soaked in 0.5% $NaHCO_3$ (1:3/w:w kernels to 0.5% $NaHCO_3$) for 16-18 h. The soaked peanuts were washed with clean water then dehusked peanut kernels were mixed with water in ratio of 1:3, 1:3.5, 1:4 [peanut (g):water (g)] in the blender (Blender 8011ES, USA) for 8 min. Then instead of the filter (with cheesecloth) and homogenization step; colloidal mill (Magic Lab, IKA, Staufen, Germany) step and microfluidization step (Microfluidizer equipment

(M-110Y, Microfluidics, USA) was conducted. At the collidal mill kernels was broken into more small pieces to obtain slurry like product for microfluidization process.

Microfluidization process, slurry like product was placed in the inlet reservoir and it was pumped with 1500 bar pressure through the microchannels and collected them in the output reservoir as peanut milk.

Then peanut milk was pasteurized (100 ºC,10 min) in waterbath.

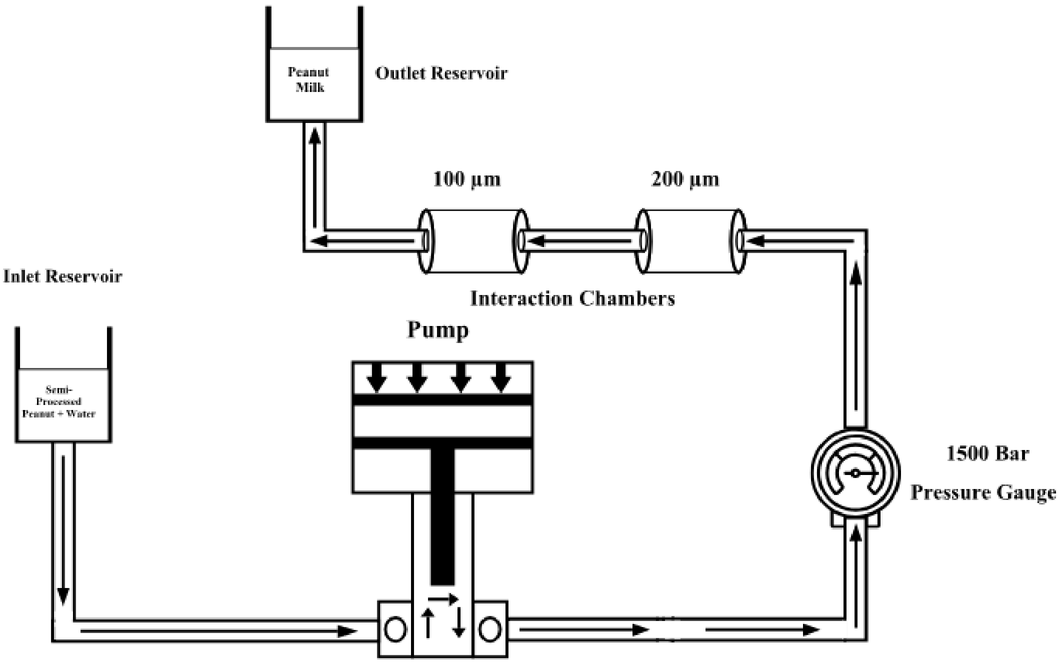

Figure 2.1 Microfluidization process for peanut milk.

2.2.2 Production of peanut yoghurt

For yoghurt production; after pasteurization step peanut milks were cooled to 45 ºC added 2% (w/w) sucrose (Lee and Beuchat 1992) and inoculated with 1% (w/w) of

yoghurt culture (Bansal et al. 2016) which contein *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus,* prebiotic bacteria *Lactobacillus acidophilus* ve *Bifidobacterium animalis* ssp. *Lactis* (Maysa Dairy and Food Ing.) stirred with mixer (Ika T18 Basic Ultra-Turrax, Germany) than fermented at 38 ºC for 12 h.

Three different group peanut yoghurt samples was prepared for comparison.

First group of yoghurt samples; non-microfluidized peanut milk (in three different ratio which are 1:3, 1:3.5, 1:4 [peanut(g):water(g)] was taken after collidal mill step before microfluidization and fermented with 2% (w/w) sucrose and 1% (w/w) of yoghurt culture.

Second group of yoghurt samples; microfluidized peanut milk (in three different ratio which are 1:3, 1:3.5, 1:4 [peanut(g):water(g)] was taken and fermented with 2% (w/w) sucrose and 1% (w/w) of yoghurt culture.

Third group of yoghurt samples; microfluidized peanut milk (in three different ratio which are 1:3, 1:3.5, 1:4 [peanut(g):water(g)] was taken and fermented with 2% (w/w) sucrose, 4% milk powder (Beuchat and Nail 1978) and 1% (w/w) of yoghurt culture.

At the end of the fermentation period, the yoghurt samples were transferred to a refrigerator at 5 ºC where they were stored overnight prior to analysis.

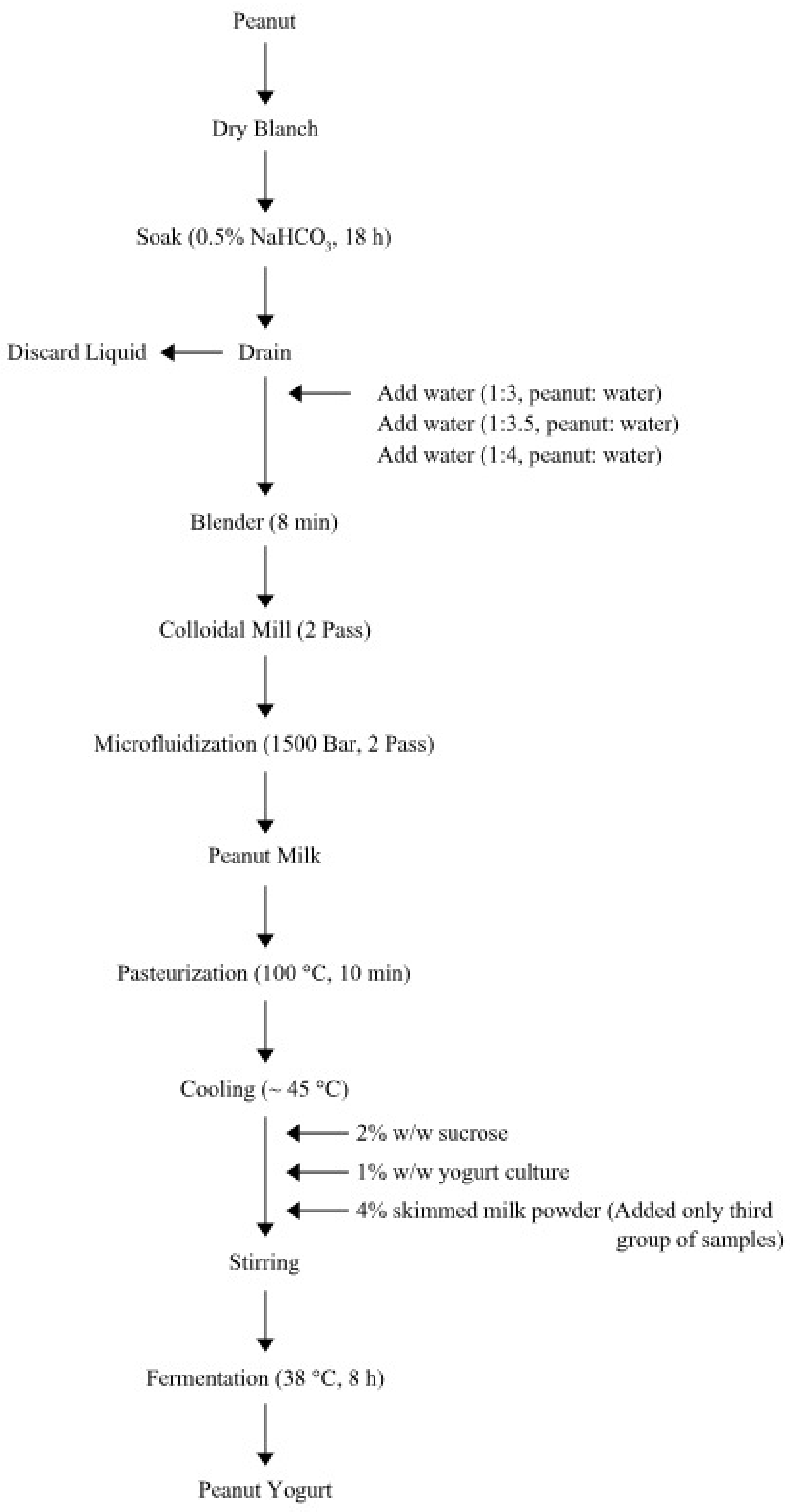

Figure 2.2 Flow chart of peanut yogurt preparation.

2.2.3 Preparation of peanut milk for kefir production

Preparation of peanut milk for kefir production, by microfudization process same method was followed as preparation of peanut milk for yoghurt production (2.2.1) but in different ratios.

Peanuts were soaked in 0.5% $NaHCO_3$ (1:3/W:W kernels to 0.5% $NaHCO_3$) for 16-18 h. The soaked peanuts were washed with clean water then dehusked peanut kernels were mixed with water in a ratio of 1:4, 1:5, 1:6, 1:7 [peanut(g): water(g)] in the blender (Blender 8011ES, USA) for 8 min (Isanga and Zhang 2009). Then in place of the filter (with cheesecloth) and homogenization step; a colloidal mill (Magic Lab, IKA, Staufen, Germany) step and microfluidization step (Microfluidizer equipment (M-110Y, Microfluidics, USA) was run. At the collidal mill kernels was broken into more small pieces to obtain slurry like product for microfluidization process.

Microfluidization process, slurry like product was placed in the inlet reservoir and it was pumped with 1500 bar pressure through the chamber in order to smaller size and collecting them in the output reservoir as peanut milk.

Then peanut milk was pasteurized (100 ºC,10 min) in waterbath.

2.2.4 Production of Peanut Kefir

For kefir production, pasteurized peanut milks in diffrent ratios 1:4; 1:5; 1:6; 1:7 peanut(g): water(g) was cooled to 30 ºC added 2% (w/w) sucrose and 1% of culture which contein Lactococcus *lactis* subsp. *lactis, Lactococcus lactis* ssp. *lactis* biovar *diacetylactis, Leuconostoc mesenteroides, Lactobacillus acidophilus, Streptococcus thermophilus* bacteria and *Saccharomyces cerevisiae* (Y. Maysa Dairy and Food Ing.) yeast stirred with mixer (Ika T18 Basic Ultra-Turrax, Germany) than fermented at 28 ºC for 18 hours (Bensmira and Jiang 2012). At the end of the fermentation period, the kefir samples were transferred to a refrigerator at 5ºC where they were stored overnight prior to analysis.

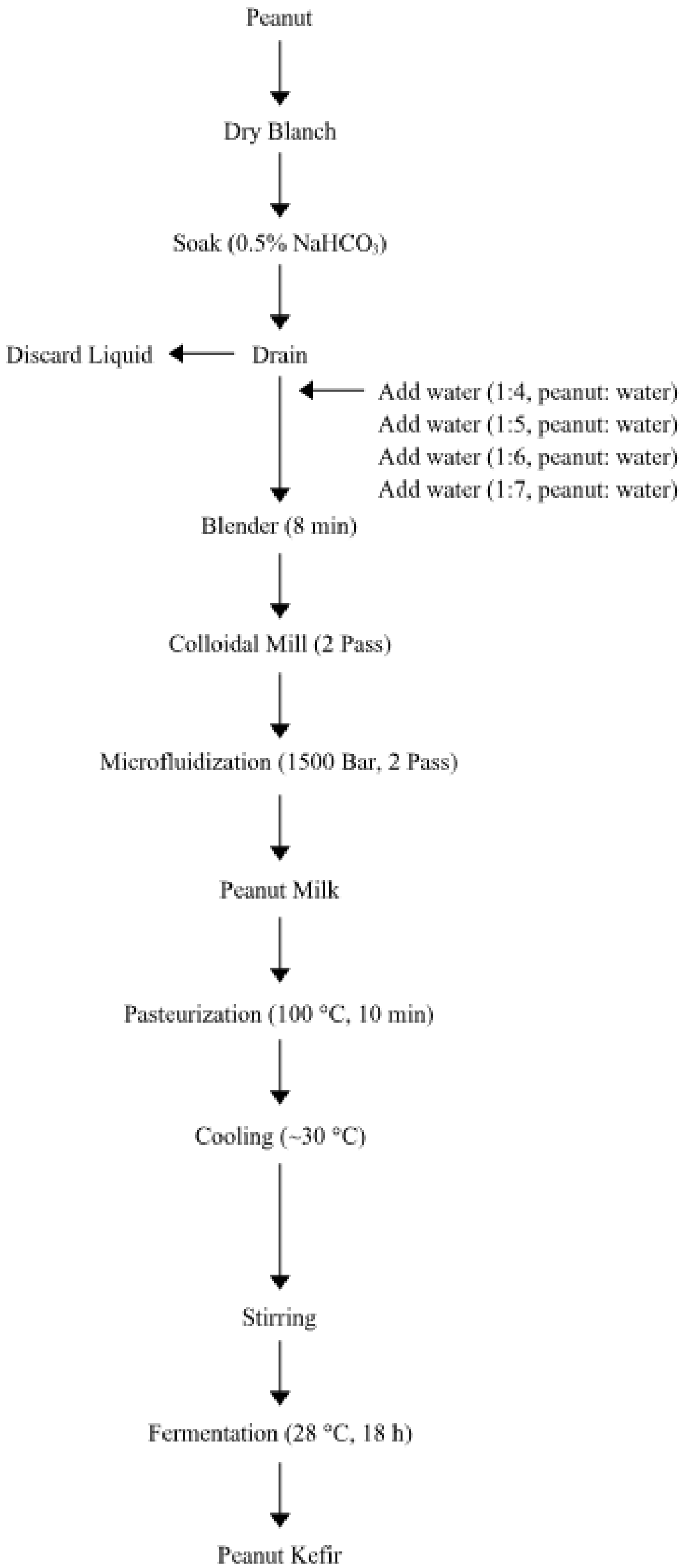

Figure 2.3 Flow chart for preparation for peanut kefir.

2.2.5 Dry Matter Content Determination

Dry matter (DM %) contents of the samples, the peanut yogurt and kefir samples were weighed then put in oven for 12 h at 105 ºC. Moisture contents (as percent) of peanut yoghurt and kefir samples were calculated using Equation 2.1 below (Ahn et al. 2014) (AOAC, 2005; method 2001. 12).

$$DM\ (\%) = \left(\frac{w_1}{w_2}\right) * 100 \tag{2.1}$$

where; w_1= The sample's weight after oven and w_2 = The sample's initial weight.

2.2.6 Water Holding Capacity

The water holding capacity (WHC %) of peanut yoghurt and kefir samples was determined by a method of (Yuksel and Erdem 2010). The samples was subjected to 15-min centrifugation at 8000 rpm at a temperature of 4 ºC using a (Sigma 2-16PK,Germany). Then separated whey from the gel was weighed. The subsequent formula was used to calculate WHC is given as Equation 2.2 :

$$WHC(\%) = \left(\frac{w_1}{w_2}\right) * 100 \tag{2.2}$$

where; w_1= Weight of the whey separated from the sample and w_2 = The initial weight of the sample.

2.2.7 Syneresis

To determine the synersis, centrifugation method was followed in Bansal’s study (Bansal et al. 2015). In this method, peanut yoghurt and kefir samples was stirred 20 times clockwise and anticlockwise with a glass rod, then approximately 30 mL of the stirred samples were kept on a filter paper and stored at 4 ◦C for 16 hours to collect water. Synersis (%) of peanut yoghurt and kefir samples were calculated based on formula below which is Equation 2.3.

$$Syneresis(\%) \ = \left(\frac{v_1}{v_2}\right) * 100 \qquad (2.3)$$

where; v_1= Volume of water collected after drainage and v_2 = Volume of yoghurt sample before drainage.

2.2.8 Titratable Acidity Determination

Titratable acidity of penut yoghurt and kefir samples was found according to (Sert, Mercan, and Dertli 2017) and this procedure was followed.

Weighted 10 grams of samples into a erlenmeyer, added 10 mL distilled water for smooth texture and mixed well before titration, added 0.5 mL phenolphthalein as the indicator. Then samples were titrated with 0.1 N NaOH, until 30 second-stable pink color keep up. Calculated titratable acidity based on Equation (2.4).

$$TTA\ (\%) = \left(\frac{v * N * 0.09}{m}\right) * 100$$

(2.4)

Where; TTA(%): titratable acidity, g/mL of lactic acid %, v: 0.1 N NaOH solution (mL), m: weight of sample (g), and N: Normality of NaOH solution.

2.2.9 pH Analysis

pH of peanut yogurt and kefir samples was measured a digital pH meter (InoLab pH 720, Germany) and distilled water (pH 7.00) was used for calibration. pH data of all samples were taken at 1^{st}, 7^{th}, 14^{th} and 21^{th} days of storage.

2.2.10 Color Determination

For the color of the samples, colourimeter (Colour Reader CR-10,Japan) was used. CIE L*, a*, and b* color measurements was used which are L*(luminosity), a*(redness) and b* (yellowness) and L* corresponds light/dark chromaticity (changing between 0% dark and 100% light), a* represents green/red chromaticity (changing from -60% green to 60% red) and b*demonstrates blue/yellow chromaticity (changing from -60% blue to 60% yellow).

Total color change (ΔE) was obtained from the following Equation (2.5);

$$\Delta E^* = [(L^* - L_0)^2 + (a^* - a_0)2 + (b^* - b_0)^2]^{1/2}$$

(2.5)

White commercial yoghurt and kefir was chosen as the reference point and L_0, a_0 and b_0 which were 81, -0.5 and 8.1, respectively stood for its L*, a* and b* values (Francis 1991).

2.2.11 Scanning Electron Microscope (SEM) Analysis

Scanning Electron Microscope (SEM) Analysis was carried out at Central Laboratory of METU (Ankara, Turkey) to see the microstructure of chosen samples. First three samples were chosen from different steps of production to compare the differences step by step. First sample was taken after blender. Second sample was taken after colloidal mill step. Third sample was taken after microfluidization. Other four chosen from the products; Fourth sample was non-microfluidized peanut yoghurt, fifth sample microfluidized peanut yoghurt, sixth sample was microfluidized and milk powder added peanut yoghurt, seventh sample was peanut kefir.

All seven samples were first frozen, later freeze dried in freeze-drier (Christ, Alpha 2-4 LD plus, Germany) for 48 hours. Freeze-dried samples were covered a layer which is gold-palladium for make them electrically conductive by Sputter Coater Device (Polaron Range, East Sussex, England). Then images of the seven freze dried samples were recorded with a scanning electron microscope (QUANTA 400F Field Emission SEM, Eindhoven, Holland) at magnification levels of 100X, 250X, 1000X and 4000X with accelerating voltage of 20 kV.

2.2.12 Texture Analysis

Texture of samples was measured by the Texture Analyzer (Stable Micro Systems, TA.XT plus Texture Analyzer, UK).The cylindrical probe was used which have a diameter 17 mm and thickness 1 mm for the compression to samples. The glass jars have 5.5 cm diameter where samples had taken place. Before measurements, weight and height calibrated with 500 g load and 10 mm high. After the calibration procedure, the measurements were done at a 1 mm/s pre-test speed, at 1 mm/s test speed and at 10 mm/s post-test speed. The probe compressed to sample 10 mm height with 1 g trigger force and it returned to its beginning position.

Firmness, consistency and cohesiveness values were obtained as average of triplicates. Firmness was taken as maximum force of first compression, consistency which is work was calculated as area under firmess, and cohesiveness was taken from negative side of graph (produced when probe return) as maximum negative force.

2.2.13 Rheological Measurements

The rheological analysis were conducted the rheometer (Kinexus dynamic rheometer, Malvern, Worcestershire, UK), using parallel plate geometry (40 mm diameter and 1 mm gap). The peanut yoghurt and kefir samples were placed between the plates and the edges were trimmed with a spatula then to measure the flow behavior of samples, shear rate properties was applied between 0.1-100 s^{-1} and the corresponding shear stress(Pa), shear rate(s-^{1}) and shear viscosity(Pa s) data was obtained. Additionally, frequency sweep test was performed to determine linear viscoelastic region as a result shear strain was taken 0.5 and elastic (G') and loss (G") modules values were measured. All measurements were doubled at 5 ˚C.

2.2.14 Particle Size Measurements

Particle size measurements conducted with the Malvern Mastersizer 3000 system (Malvern Instruments Limited, Worcestershire, U.K). Particle sizes were measured before microfluidization process and after microfluidization process to make a comparison in between them for all the ratios of peanut milk were prepared in experiments [1:3, 1:3.5, 1: 4 ; 1:5, 1:6, 1:7; peanut(g): water(g)]. Samples were loaded into pure water and the laser beam passes through particles then analysis the signal to calculate the size of the particles.

The refractive index of 1.6 was used to calculate particle size distributions and results were taken as volume based mean diameter D [4,3].

2.2.15 Statistical Analysis

Statistical analysis was performed to understand the effect of changing concentrations, microfluidization process and adding milk powder. ANOVA (analysis of variance) was used by MINITAB 18 statistical program to analyze experiment results and Tukey Single Range Test was used to compare if significant difference was obtained, means $p \leq 0.05$.

CHAPTER 3

RESULTS AND DISCUSSION

Firstly, in this study peanut yogurts were made from peanut milk as non-microfluidized, microfluidized and milk powder added microfludized peanut yogurts in three different ratios 1:3, 1:3.5 and 1:4 (peanut(g): water(g)). Dry matter content, water holding capacity, syneresis, pH, titratable acidity, color were measured to comprehend effect of microfluidization and adding skimmed milk powder in microfluidized peanut yogurts. Scanning Electron Microscope (SEM) analysis was conducted to analyze microstructural property. Also, textural and rheological measurements of penaut yogurts were determined.

Secondly, peanut kefir was done from microfluidized peanut milk in different concentrations as 1:4, 1:5, 1:6 and 1:7 ((peanut(g): water(g)) without any additive. Dry matter content, water holding capacity, synersis, pH, titratable acidity, color properties were examined to understand the characteristic properties of peanut kefirs in different concentrations. SEM analysis was used to determine microscopic structure. Textural and rheological measurements of penaut kefirs were evaluated.

3.1 Peanut Yoghurt Physicochemical, Textural and Rheological Properties

3.1.1 Dry Matter Content Determination

Dry matter contents of yogurt samples were presented in Table 3.1.

Sample	DM Content (%)
non-microfluidized peanut yoghurt 1/4	25.2±0.09[e]
microfluidized peanut yoghurt 1/4	25.17±0.15[e]
microfluidized and milk powder peanut yoghurt 1/4	28.54±0.14[b]
non-microfluidized peanut yoghurt 1/3.5	25.0±0.48[f]
microfluidized peanut yoghurt 1/3.5	24.68±0.21[ef]
microfluidized and milk powder peanut yoghurt 1/3.5	28.17±0.13[bc]
non-microfluidized peanut yoghurt 1/3	27.5±0.30[d]
microfluidized peanut yoghurt 1/3	27.9±0.32[cd]
microfluidized and milk powder peanut yoghurt 1/3	31.1±0.15[a]

Table 3.1 Dry matter contents of peanut yogurt samples. Standard deviations were also indicated. Different letters show significant difference ($p \leq 0.05$).

As can be seen in the table, dry matter contents were changed in range of min. 25.0 and max. 31.1. The results were found extremely higher than before produced peanut yogurts. According to the studies in the litetature, researchers have represented dry matter contents of peanut yogurts around 5 - 13% although milk powder added (Isanga and Zhang 2009) but in these study dry matter contents of peanut yogurts was found more than doubled the reason for that, filtration step was skipped. The solids were discarded with muslin cloth on the filter step, in traditional way of producing peanut yogurt whereas in this study whole de-skinned peanuts was used therefore nutritonal values of product was increased. In addition to this, any solid waste wasn’t put out in production. Dry matter contents of peanut yoghurt samples changed significantly when concentration changed ($p \leq 0.05$). On the other hand, there is no significantly difference between non-microfluidized peanut yoghurts dry matter content and microfluidized peanut yoghurts dry matter content ($p \geq 0.05$). When milk powder was added to microfluidized peanut yoghurts dry matter contents increased as expected. According to ANOVA results, microfluidization process has no effect on dry matter contents of peanut yogurts.

Turkish Codex had adjusted dry matter contents of yogurt as 12% untill 2010, but today there no report about dry matter content of yogurt.

3.1.2 Water Holding Capacity

Peanut yogurt samples' water holding capacity values were presented in Table 3.2 below**.**

Sample	WHC (%)
non-microfluidized peanut yoghurt 1/4	47.41 ± 0.35^{a}
microfluidized peanut yoghurt 1/4	60.21 ± 0.25^{d}
microfluidized and milk powdered peanut yoghurt 1/4	67.86 ± 0.11^{e}
non-microfluidized peanut yoghurt 1/3.5	52.74 ± 0.25^{b}
microfluidized peanut yoghurt 1/3.5	64.20 ± 0.10^{f}
microfluidized and milk powdered peanut yoghurt 1/3.5	73.78 ± 0.25^{g}
non-microfluidized peanut yoghurt 1/3	57.51 ± 0.12^{c}
microfluidized peanut yoghurt 1/3	69.69 ± 0.30^{h}
microfluidized and milk powdered peanut yoghurt 1/3	78.19 ± 0.18^{i}

Table 3.2 Water holding capacity of peanut yogurt samples. Standard deviations were also indicated. Different letters show significant difference ($p \leq 0.05$).

Water holding capacity of peanut yoghurt samples changed significantly with concentration and treatment. All samples were represented different pattern from each other ($p \leq 0.05$). When concentration was increased, water holding capacity of peanut yoghurt samples increased. When it was compared non-microfluidized peanut yoghurt results and microfluidized peanut yoghurt results, microfluidization process was increased water holding capacity of peanut yoghurt.

Water-oil emulsions are considered thermodynamically unstable formulations due to the interfacial tension, the large surface area of the dispersed phase with the differential densities of the two phases. The dispersed droplets tend to coalesce in order to reduce the excess surface free energy, causing instability with eventual phase separation. Research on stabilization of emulsions has focused on the type and concentration of emulsifying agents and processing techniques that reduce dispersed droplet diameter and hence delay the aggregation of droplets (Pinnamaneni, Das, and Das 2003). Emulsion stability can be study as function of particle size and microfluidization process perform submicron emulsions which increase the stability.

According to Isanga and Zhang (2009) water holding capacity were found 46.6% and 42.25% for peanut milk yogurt and cow milk yogurt and applying microfluidization was increased water holding capacity of peanut yoghurt. Microfluidization reduces particle size and increase the protein solubility, protein-water interaction bind the free water leads to more stabilize homogeneous products as higher water holding capacity values (Ozturk 2014). In the microfluidization process, strict structure of proteins break down and conversion of insoluble block to soluble ones by effect of high pressure, high-frequency vibration, high-velocity impact and cavitation (Hu et al. 2011). Microfluidization was resulted in overcome phase separation in non-microfludized peanut yoghurt samples. Adding milk powder to the microfluidized peanut yoghurt enhanced water holding capacity of peanut yoghurt samples. The stabilizers bind the free water and reduce water flowing in the matrix space and other effect of them enhance the textural properties of products (Thaiudom and Goff 2003) and some of them could interaction with protein in the food matrix hence, further increase hydration behavior (Duboc and Mollet 2001). Therefore, microfluidized and milk powder added peanut yoghurt samples have the highest water holding capacity values in all samples.

3.1.3 Syneresis

Syneresis of yogurt samples were presented in Table 3.3 below.

Sample	Syneresis %
non-microfluidized peanut yoghurt 1/4	77.59±0.01[a]
microfluidized peanut yoghurt 1/4	36.28±0.20[d]
microfluidized and milk powdered peanut yoghurt 1/4	31.02±0.02[e]
non-microfluidized peanut yoghurt 1/3.5	68.36±0.15[b]
microfluidized peanut yoghurt 1/3.5	29.48±0.09[f]
microfluidized and milk powdered peanut yoghurt 1/3.5	20.38±0.02[g]
non-microfluidized peanut yoghurt 1/3	44.94±0.04[c]
microfluidized peanut yoghurt 1/3	7.4±0.25[h]
microfluidized and milk powdered peanut yoghurt 1/3	0.95±0.11[i]

Table 3.3 Syneresis of peanut yogurt samples. Standard deviations were also indicated. Different letters show significant difference ($p \leq 0.05$).

The non-microfluidized peanut yoghurt samples and milk powder addded microfluidized peanut yoghurt samples demonstrated the lowest and highest degree of syneresis, respectively. Senoglu (2011) have founded the 5.6 as syneresis value from cow milk produced yogurt and low syneresis values preferable from the consumers point of view. As can be seen from table, microfluidization process have considerable effect on syneresis values which were decreased nearly more than half with respect to non-microfluidized peanut yoghurt samples. The microfluidization process has effect on emulsification of fat (smaller and more uniform fat globules) as a consequence of more fat globules connected and bound to the protein (Ciron et al. 2010) and peanut has high fat content. Also adding milk powder to the microfluidized peanut yoghurts resulted the best syneresis values for peanut yoghurt samples. The reason for that, peanut proteins and cow milk proteins bound each other and produced more strong structure (Isanga and Guo-Nong 2007). According to comparisions, all samples were significantly different from each other ($p \leq 0.05$) so microfluidization process, adding milk powder to microfluidized peanut milk and concentration are significant parameters for the peanut yoghurt production. Syneresis degree of peanut yoghurt samples was become lower with higher concentration due to syneresis relation with solid content (Ale et al. 2016).

The results for water holding capacity and syneresis were confirmative for each other. When concentration was decreased water holding capacity increased and syneresis decreased, applying microfluidization process increased water holding capacity and decreased syneresis. Adding milk powder to the microfluidized peanut milk more increased water holding capacity and decreased syneresis of penut yogurts.

3.1.4 Titratable Acidity and pH Determination

Peanut yogurt samples' TTA were presented in Figure 3.1 for 21 days storage at 4°C.

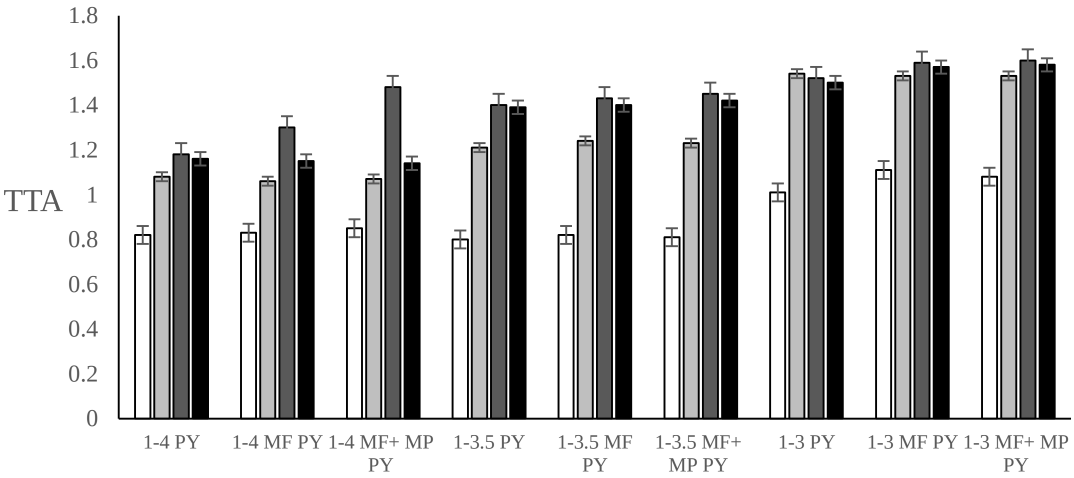

Figure 3.1 Total titratable acidity (TTA) values of peanut yoghurt samples during the storage period. (white bar): 1st day TTA, (light gray bar): 7th day TTA, (dark gray bar): 14th day TTA, (black bar): 21th day TTA. Bars present standard deviation of the replicates.

Total titratable acidity values of peanut yoghurt samples were changed as the highest and the lowest between 1.11 and 0.80 at 1st day; 1.54 and 1.06 at 7th day; 1.60 and 1.30 at 14th day lastly 1.58 and 1.14 at 21th day. For each peanut yoghurt sample total titratable acidity values was increased continuously until 14th day then a slight decrease of total titratable acidity values were obtained in 21th day. According to the limits in Turkish Codex lactic acid % between 0.80-1.60 for cow milk yogurt (TS 1330/February 1999) and all TTA values were measured between 0.80-1.60 for 21 days. According to results; concentration, microfluidization or adding milk powder to microfluidized peanut yogurts has no effect on TTA of peanut yogurts during storage period.

The pH of milk was between 6.6 and 6.8 (Walstra et al. 2006). In our study before fermantation pH values of peanut milk 1/3, peanut milk 1/3.5, peanut milk 1/4 samples were obtained as 6.60, 6.64 and 6.68, respectively. The numbers were declared that peanut milk pH values in these concentrations same with the cow milk this is provide the proper acidity for growth and activity of lactic acid bacteria (Angeles et al. 1971).

Peanut yogurt samples' pH were presented in Figure 3.2 for 21 days storage at 4 °C.

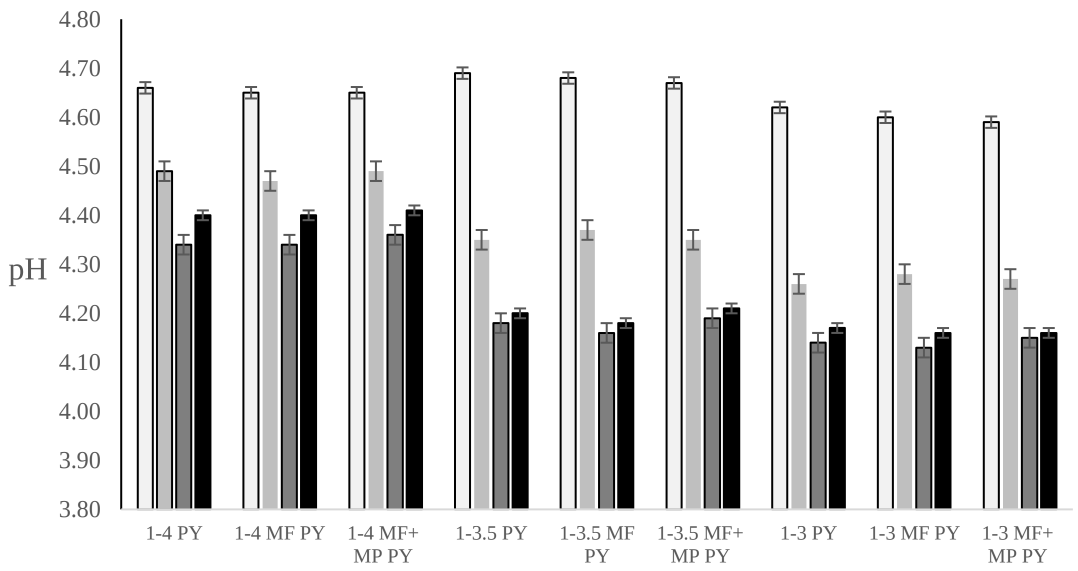

Figure 3.2 pH values of peanut yoghurt samples during the storage period. (white bar): 1st day pH, (light gray bar): 7th day pH, (dark gray bar): 14th day pH, (black bar): 21th day pH. Bars present standard deviation of the replicates.

pH values for all of peanut yoghurt samples were changed as the highest and the lowest between 4.69 and 4.59 at 1st day; 4.49 and 4.26 at 7th day; 4.36 and 4.13 at 14th day lastly 4.40 and 4.16 at 21th day. pH was decreased continuously until 14th day then a slight increased pH values was obtained in 21th day for all samples. According to Walstra et al. (2006), preferred yoghurt acidity for consumption was between 4.6 - 4.1

and all pH values were measured between 4.13 - 4.59 for 21 days. According to the results, concentration, microfluidization or adding milk powder to microfluidized peanut yogurts has no effect on pH of peanut yogurt samples during storage period. Also, the pH results was found same range with cow milk in terms of microfluidization process (Bucci et al. 2018).

As a consequence, pH decrease and TTA increase in a certain range during storage represented that *S. thermophilus* and *L. bulgaricus* are active even at refrigerated temperatures and can ferment sugar to lactic acid (Basiri et al. 2018). It was indicated that in this study, microfluidization process or adding 4% milk powder to microfluidized peanut milk or changing the concentration of peanut milk between 1/3 – 1/4 has no effect on acidity of peanut yogurts.

3.1.5 Color Determination

Total Color Change (ΔE) values of yogurt samples were presented in Table 3.4.

Sample	ΔE
non-microfluidized peanut yoghurt 1/4	18.36±0.005[a]
microfluidized peanut yoghurt 1/4	13.45±0.010[b]
microfluidized and milk powdered peanut yoghurt 1/4	12.51±0.015[c]
non-microfluidized peanut yoghurt 1/3.5	18.35±0.060[a]
microfluidized peanut yoghurt 1/3.5	13.44±0.010[b]
microfluidized and milk powdered peanut yoghurt 1/3.5	12.55±0.026[c]
non-microfluidized peanut yoghurt 1/3	18.36±0.035[a]
microfluidized peanut yoghurt 1/3	13.40±0.025[b]
microfluidized and milk powdered peanut yoghurt 1/3	12.50±0.061[c]

Table 3.4 Total color change (ΔE) values of peanut yogurt samples. Standard deviations were also indicated. Different letters show significant difference ($p \leq 0.05$).

As could be seen from Table 3.4 ΔE values were obtanined as 18.4, 13.4 and 12.5 for non-microfluidized peanut yoghurt samples, microfluidized peanut yoghurt and milk powder added microfluidized peanut yoghurt, respectively in all concentrations.

According to ANOVA results, concentration didn't affect the color results, significantly ($p \geq 0.05$), however implementation of microfluidization and adding milk powder to the microfluidized peanut milk had significant effect on ΔE values of samples ($p \leq 0.05$). Microfluidization process decreased the ΔE values substantially from 18.4 to 13.4 while adding milk powder to the microfluidized peanut milk changed the results slightly from 13.4 to 12.5.

The most important pigments in the coloration of oilseed protein products are the plant phenols and these compounds also contribute to the coloration of fermented legume milks.(Diarra, Nong, and Jie 2005). The study of Mert et al. (2014) reported that, microfluidization process proves higher free phenolic content due to the change in structure. This result is in agreement with the study of Lemay et al. (1994) which

indicated that microfluidized milk produced cheese that was significantly whiter. Also Pinnamaneni et al. (2003) indicated that, submicron oil-water emulsions appear white in color. A slight ΔE value increase in milk powder added microfluidized peanut yoghurt samples maybe due to white color of reconstituted milk powder.

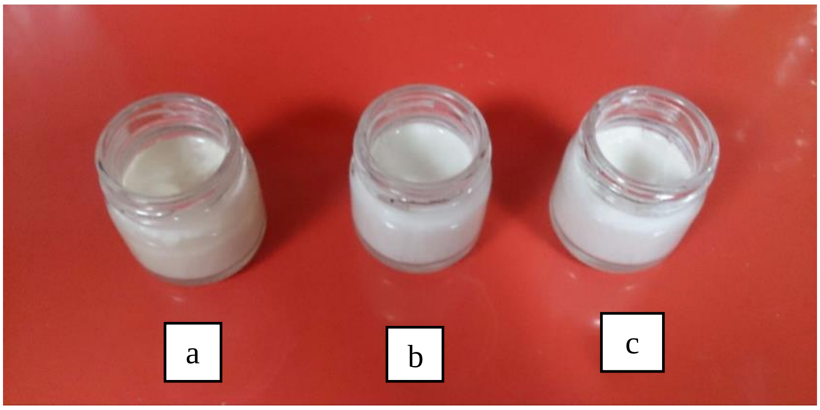

Figure 3.3 Picture of of peanut yogurt samples. a, non-microfluidized peanut yoghurt; b, microfluidized peanut yoghurt; c, milk powder added microfluidized peanut yoghurt.

3.1.6 Scanning Electron Microscope (SEM) Analysis

Scanning Electron Microscope (SEM) analysis provides the knowledge about the microstructure, and depict the effect of these treatments on distribution, size and structure of peanut products. Scanning electron microscopy photographs of the some steps of production were taken after freeze drying process of samples. Figures 3.4 – 3.10 present the SEM images of at 250x and 1000x magnification levels.

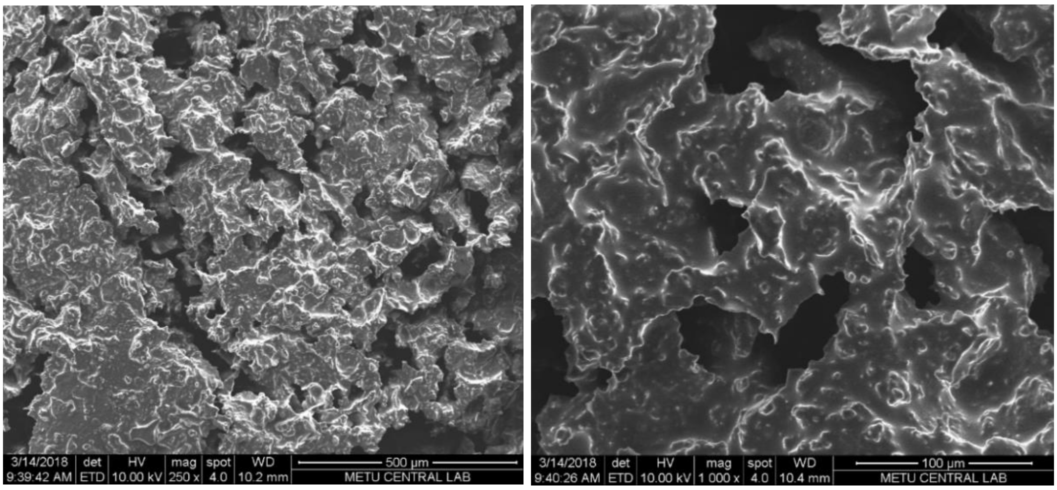

Figure 3.4 Peanut milk SEM image after blender step. (250x,1000x magnification)

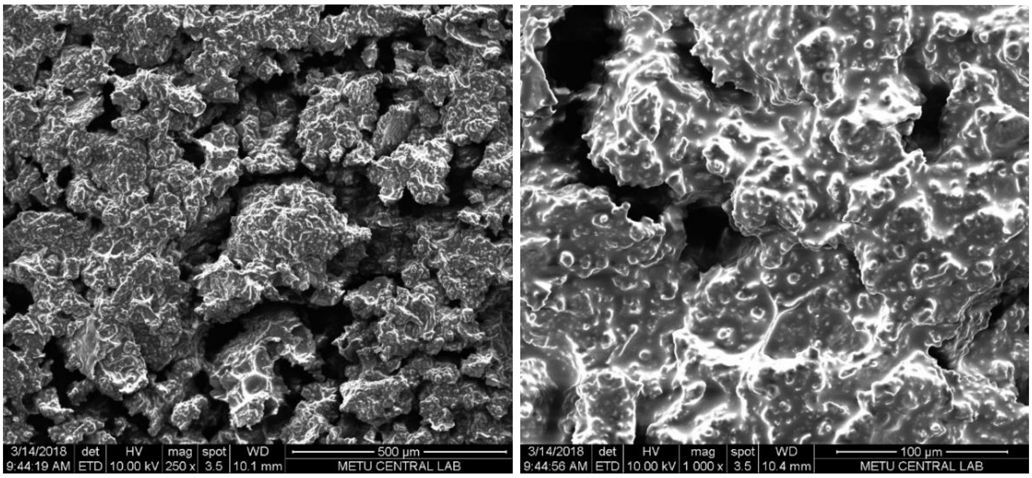

Figure 3.5 Peanut milk SEM image after colloidal mill step. (250x,1000x magnification)

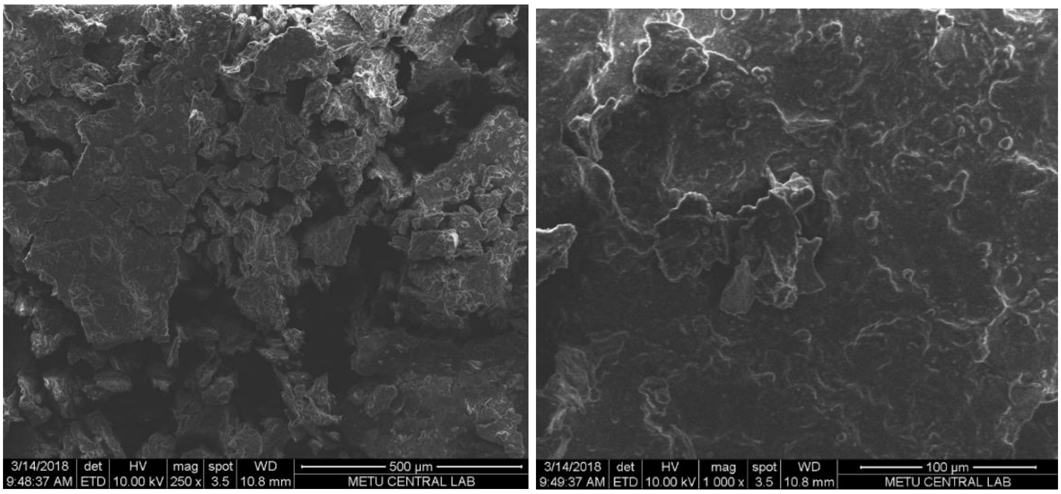

Figure 3.6 Peanut milk SEM image after microfluidization step. (250x,1000x magnification)

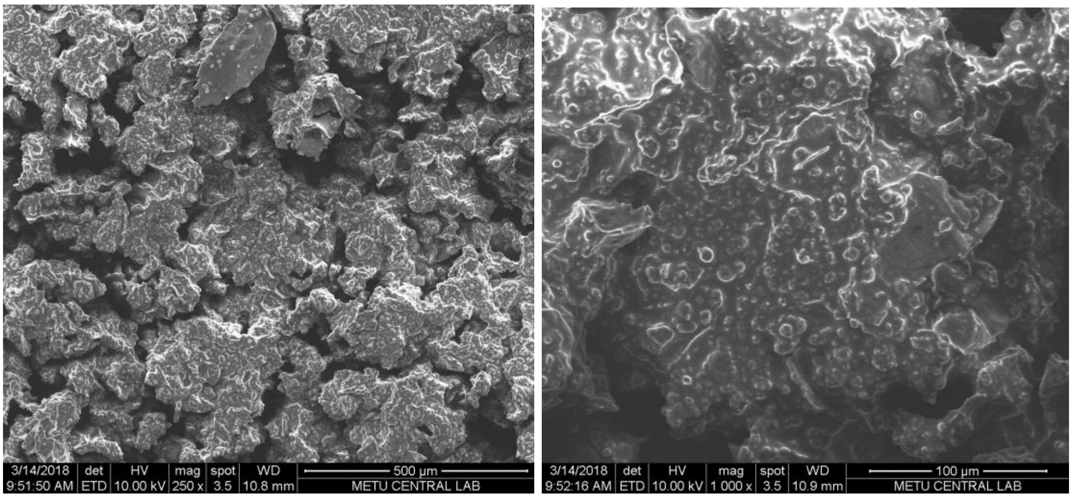

Figure 3.7 The non-microfluidized peanut yoghurt SEM image. (250x, 1000x magnification)

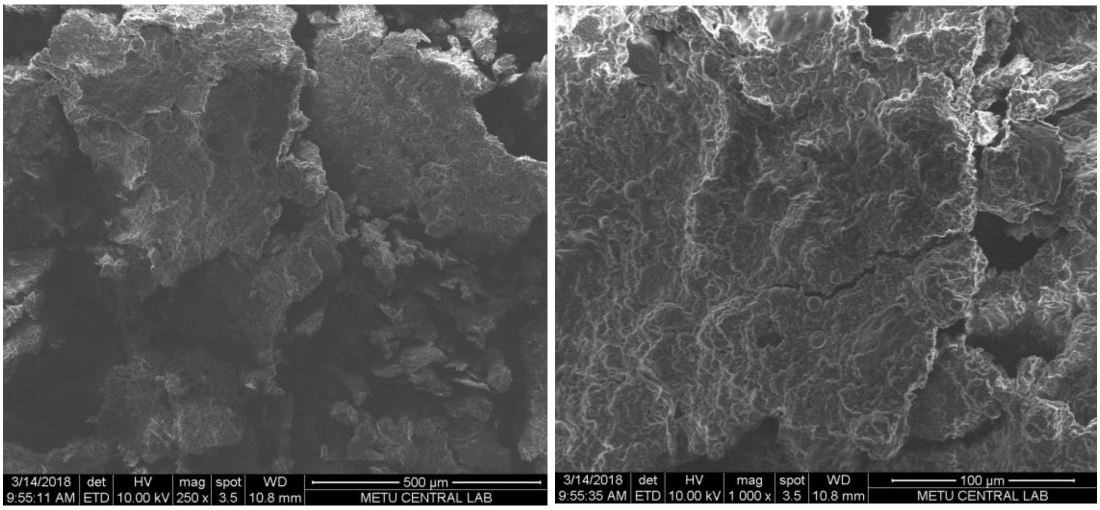

Figure 3.8 Microfluidized peanut yoghurt SEM image. (250x,1000x magnification)

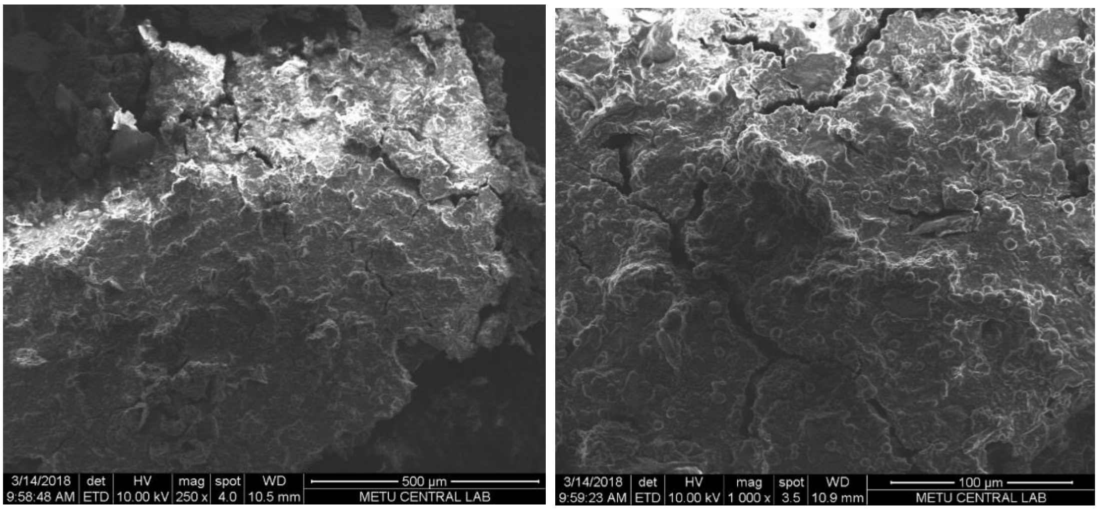

Figure 3.9 Microfluidized and milk powder added peanut yoghurt SEM image. (250x, 1000x magnification)

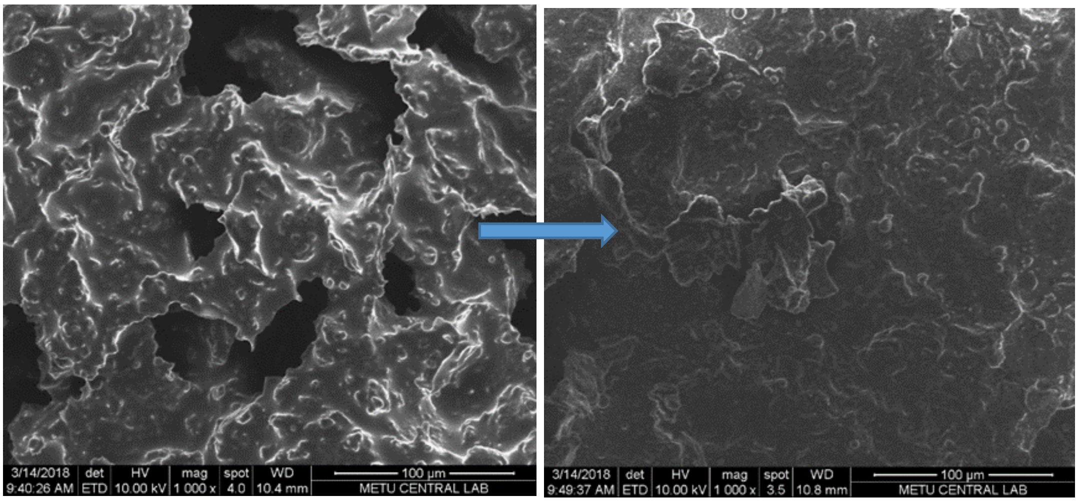

Figure 3.10 Peanut milk SEM image after blender step(left side) and microfluidized peanut milk SEM image. Magnification: 1000x.

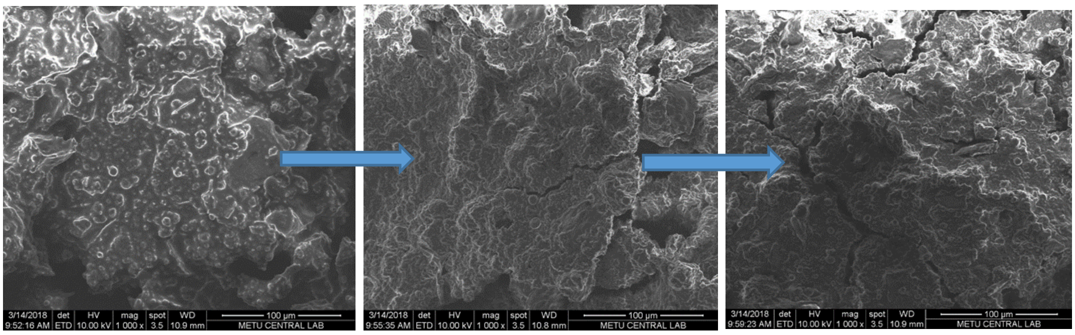

Figure 3.11 SEM image of non-microfluidized peanut yoghurt sample, SEM image of microfludized peanut yoghurt sample and SEM image of microfludized and milk powder peanut yoghurt sample from left side to right side respectively. Magnification: 1000x.

The SEM images of peanut milk after blender step were illustrated in Figure 3.4 at two different magnification levels. Figure 3.5 presented the SEM image of peanut milk after colloidal mill step at two different magnification levels and Figure 3.6 was SEM image of peanut milk after microfluidization step at two different magnification levels and presented the effect of microfluidization on peanut milk. Figure 3.11 showed SEM image of non-microfluidized peanut yoghurt sample, SEM image of microfluidized peanut yoghurt sample and SEM image of microfluidized and milk powder peanut yoghurt sample from left side to right side, respectively to compare effect of treatment step by step.

As could be seen from figures, without treatment non-homogeneous dispersion was seen through some part of the peanut milk sample and after blender and colloidal mill step perfect uniformity was not occurred, these steps were roughly affected the structure , although the picture entirely changed with microfluidization process. Microfluidization process led to formation of micro particles with high pressure resulted in more homogenous structure. The shapes of the particles were changed by mechanical forces in microfluidization (Dissanayake and Vasiljevic 2009). Also, Liu et al. (2011) reported that, bigger globular proteins became smaller and became integrated and formed network with microfluidization which enhanced emulsion properties of samples as well as textural rheological propeties of samples. Microfluidization increased gelling properties due to reduction of particle size, size of protein particles to less than 3-μm which forms creamy texture, smooth emulsion-like feel and enhance gelling properties (Farahmand 2014). Ronkart et al.(2010) reported that, microfluidization process provided an increase gel-like attitude in inulin-water systems as incrase in viscosity and from the visual aspect of view, its similar from milk to turn into yogurt or margarine. Additionally, the surface area of the sample increased by dispersion through the surface in microfluidization process and Chau et al. (2006) presented that, having larger area means more water binding sites which improve the hydration attitude of products as increases water holding capacity. Adding milk powder to microfluidized peanut yoghurt sample increased the emulsion properties due to complex casein matrix. Since the softest texture was obtained by microfluidization and adding milk powder to microfluidized peanut-milk made peanut yoghurt structure more stiff and optimization for yogurt structure can be provided with proper water concentration.

3.1.7 Texture Measurements

The firmness values of peanut yogurt samples was given in Figure 3.12.

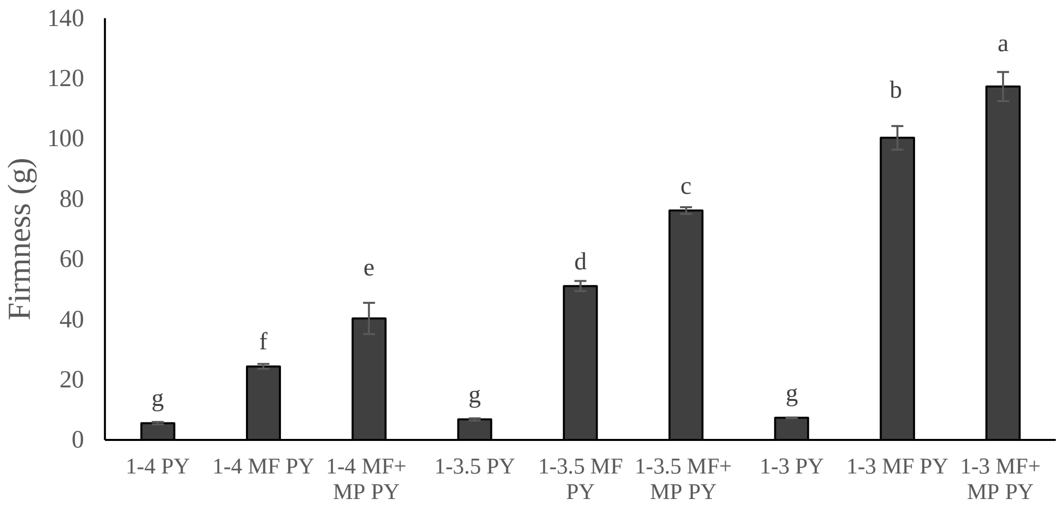

Figure 3.12 Firmness (g) values for peanut yogurts. Bars present standard deviation of the replicates.

Firmness values, changed between 5.573 (g) and 7.337 (g) for different concentrations of non-microfluidized peanut yoghurt samples; changed between 24.413 g and 100.266 g for different concentrations of microfluidized peanut yoghurt samples and changed between 40.315 g and 117.302 g for different concentrations of microfluidized and milk powder peanut yoghurt samples. According to ANNOVA results, treatment type have significant effect on firmness values of peanut yoghurt samples ($p \leq 0.05$) and when concentrations of samples were increased, firmness values of peanut yogurts increased except for non-microfluidized peanut yoghurt samples.

Microfluidization process altered milk microstructure significantly produced homogenized milk and better yogurt texture. The gel firmness affect from globule size and lipid content (Nguyen et al. 2015) and microfluidization created smaller fat globules which provided continuous and homogeneous network structure in yoghurt without breaking up the oil droplets (Ciron et al. 2010) hence, considerably increased firmness values was measured for peanut yoghurt samples. When dry matter content increased in yogurts, firmness values of peanut yoghurt samples increased (Yu, Wang, and McCarthy 2016), microfluidization process instead of filter step in production increased the dry matter content of peanut yogurts. Also adding milk powder with microfluidization provided cow milk proteins which bound the peanut protein and improved the hardness of the products (Hassan 2008), this study represented that microfluidization process improved interaction between milk components as increase the hardness of the samples.

The cohesiveness values of peanut yogurt samples was presented in Figure 3. 13.

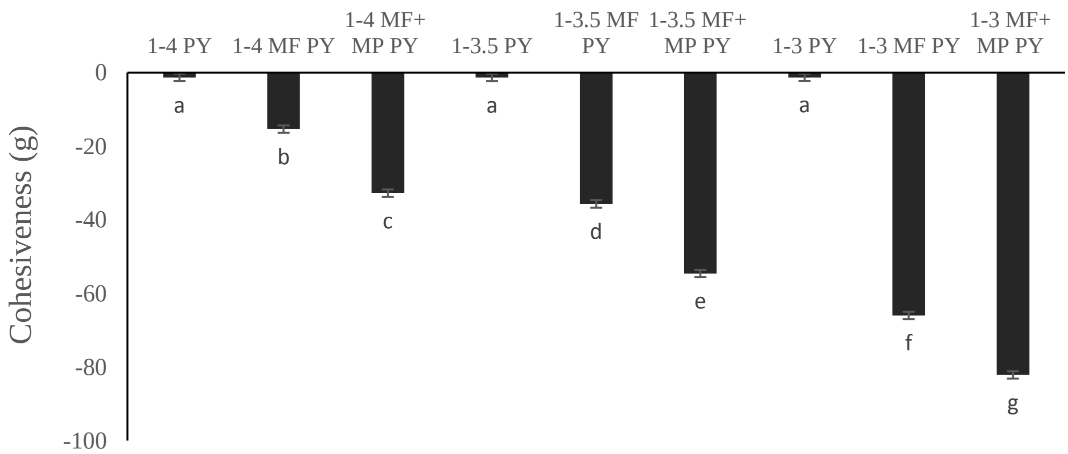

Figure 3.13 Cohesiveness (g) values for peanut yogurts. Bars present standard deviation of the replicates.

As can be seen at the Figure 3.13 the cohesiveness values of peanut yogurt samples changed between -1.313 g and -1.305 g for different concentrations of non-microfluidized peanut yoghurt samples; changed between -15.341 g and -57.982 g for different concentrations of microfluidized peanut yoghurt samples and changed between -35.68 g and -82.168 g for different concentrations of microfluidized and milk powder peanut yoghurt samples. According to ANNOVA results, treatment type have significant effect on cohesiveness values of peanut yoghurt samples ($p \leq 0.05$) and when concentrations of samples were increased, cohesiveness values of peanut yogurts decreased except for non-microfluidized peanut yoghurt samples. Microfluidized samples gave more lower cohesiveness values than non-microfluidized samples and when microfluidization process was combined with the adding milk powder peanut yoghurt samples gave the lowest cohesiveness values. Cohesiveness referred the difficulty of destroy in the gel's internal structure. The most important parameter for the gelling behaviour is the particle size and Dissanayake et al. (2013) reported that reducing the particle sizes leads to produce gel forms. Microfluidization process changed the internal structure, and consequently yogurt with modified microstructure, gave more interconnectivity (Sfakianakis and Tzia 2014) and increased the gelling property. Also, adding milk powder with microfluidization increased the rigidity of gel (Diarra, Nong, and Jie 2005) like adding the protein networks. These formations resulted in lower cohesiveness values in peanut yoghurt samples.

Cohesiveness is reverse relation with hardness, samples with higher hardness value has lower cohesiveness value which is desired characteristics for yogurts.

The consistency values of peanut yogurt samples were demonstrated in Figure 3. 14.

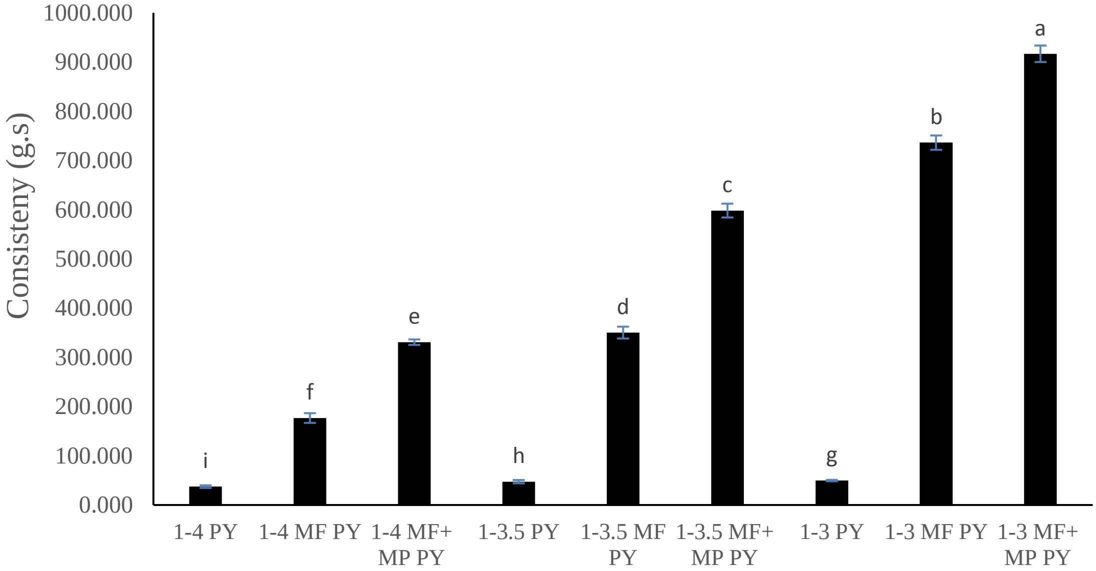

Figure 3.14 Consistency values for peanut yogurts. Bars present standard deviation of the replicates.

Consistency values changed between 37.402 g.s and 49.726 g.s for different concentrations of non-microfluidized peanut yoghurt samples; changed between 176.716 g.s and 736.226 g.s for different concentrations of microfluidized peanut yoghurt samples and changed between 330.888 g.s and 916.665 g.s for different concentrations of microfluidized and milk powder added peanut yoghurt samples. According to ANNOVA results, both treatment type and concentration had significant effect on consistency values of peanut yoghurt samples ($p \leq 0.05$). Consistency values of samples increased while concentrations of samples were increased which expected results due to increase of viscosity. Microfluidization process increased consitency of value of peanut yogurts. Microfluidization treatment to peanut milks provide smaller droplet size, homogenous dispersion, stability which are resulted in smoother products with higher consistency. In general, when lipid content increse, consistency value of yogurts became decrease as softer consistency obtained (Joon et al. 2017). In this study consistency value of yogurts was found higher althuogh high fat content of peanut so it can be related that incerase in solid matter with microfluidization or smaller droplet size with microfluidization. Basiri et al. (2018) repoted that increasing total solids had impact on yogurt consistency and microfluidization process increase the consistency such as milk (Ciron et al. 2010) or ketchup (Mert 2012).

The addition of milk powder to microfluidized peanut yogurt had significant effect on yogurt consistency ($p \leq 0.05$). The most applied methods to improve consistency of yoghurt increase the total solids in the milk as addition of stabilizers (Wang et al. 2012). Milk powder was used as stabilizers for its protein content. Fat globules are copolymer of the protein network structure (Paquin 1999) so protein content of milk powder improved the textural properties of peanut yogurts as consistency.

Joon et al. (2017) have reported firmness (g) 308.37, cohesiveness (g) -155.01 and consistency (g.sec) 7887.73 for cow milk yogurt and firmness (g) 149.51, cohesiveness (g) -62.40 and consistency (g.sec) 3038.63 for goat milk yogurt. When the results compared with animal milk yogurts, cow milk yogurt presented higher texture properties however goat milk yogurt attitudes closed to peanut milk yogurt except from consistency. Microfluidization process increase the consistency but still cannot reach the animal milk yogurt consistency due to lack of milk protein such as caseine.

3.1.8 Rheological Analysis

The flow behavior of stirred yogurt has been modeled to the power law model (Parnell-Clunies et al. 1986, Keogh and O'Kennedy 1998, Geraghty and Butler 1999). The shear stress (τ) versus shear rate (γ) data for peanut yogurts was fitted to the to power law model at 5 ºC.

The power law model is given as equation 3.1 :

$$\sigma = K(\dot{\gamma})^n \tag{3.1}$$

Where σ is shear stress (Pa), γ is the shear rate (s^{-1}), n represents flow behavior index and K is the consistency index (Pas^n). The Power Law parameters were shown for peanut yogurt in the Table 3.5 below.

Sample	K ($Pa.s^n$)	n
non-microfluidized peanut yoghurt 1/4	1.733	0.57
microfluidized peanut yoghurt 1/4	7.438	0.43
microfluidized and milk powdered peanut yoghurt 1/4	11.127	0.31
non-microfluidized peanut yoghurt 1/3.5	2.044	0.55
microfluidized peanut yoghurt 1/3.5	12.061	0.31
microfluidized and milk powdered peanut yoghurt 1/3.5	32.589	0.23
non-microfluidized peanut yoghurt 1/3	3.567	0.53
microfluidized peanut yoghurt 1/3	34.165	0.22
microfluidized and milk powdered peanut yoghurt 1/3	36.179	0.21

Table 3.5 The Power Law parameters for peanut yogurt at 5 ºC.

The consistency index value K, gives information about structural rigidity and microfluidized peanut yogurts of K values was found between 1.733 and 36.179 at non-microfluidized peanut yoghurt 1/4 and milk powder added microfluidized peanut yoghurt 1/3, respectively. K was changed between 1.733 and 3.567 for non-microfluidized peanut yogurt samples. Microfluidization application inceased the consistency index values (Mert 2012). Also increasing in total solid by microfluidization instead of filter step increased the consistency index value K (Seth, Mishra, and Deka 2018). n is a dimensionless number indicate flow behaviour index which means, $n < 1$ for pseudoplastic fluids, $n = 1$ for Newtonian fluids and $n > 1$ for dilatant fluids. In the present study, n value was found n<1 which means peanut yogurts was demonstrated shear thinning (pseudoplastic) behaviour. Earlier it was found that, yoghurts represents shear-thinning behaviour characteristic independent from the composition (Glibowski and Rybak 2016). Since interactions between components are broken down under the action of shear, viscosity decreases with the increase in shear stress (Demirkesen et al. 2010). The flow behavior index values changed between 0.21- 0.57 and microfluidized and milk powdered peanut yoghurt 1/3 represented the lowest n value as 0.21 which indicated the most complex structure (Gómez et al. 2010).

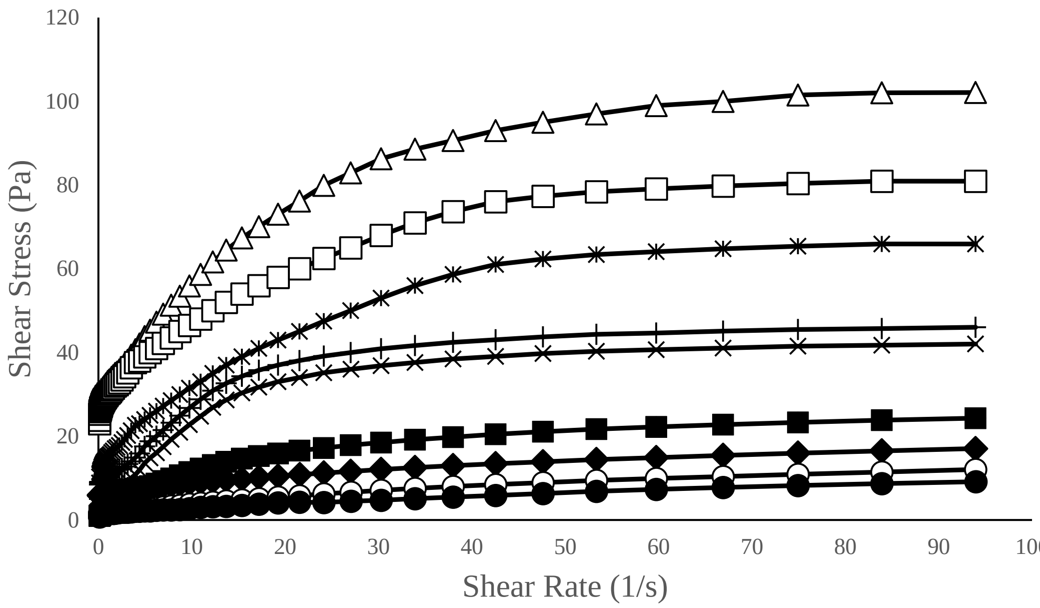

Figure 3.15 Flow curves obtained for peanut yogurt samples. (●): non-microfluidized peanut yoghurt 1/4, (❍): non-microfluidized peanut yoghurt 1/3.5, (◆): non-microfluidized peanut yoghurt 1/3, (■): microfluidized peanut yoghurt 1/4, (x): microfluidized and milk powder peanut yoghurt 1/4, (+): microfluidized peanut yoghurt 1/3.5, (*): microfluidized and milk powder peanut yoghurt 1/3.5, (□):microfluidized peanut yoghurt 1/3, (Δ): microfluidized and milk powder peanut yoghurt 1/3.

The shear stress versus shear rate data gives information about viscosity of peanut yogurts. As can be seen from Figure 3.15 the higher viscosity values were obtained from microfluidized and milk powder added peanut yogurt and lowest viscosity values were measured for non-microfluidized peanut yoghurt groups. Water concentration of peanut milks effect on viscosity of peanut yogurts as water increased while viscosity decreased. Both microfluidization and adding skimmed milk powder had enhance the viscosity. Applying microfluidization increased shear stress versus shear rate of the samples, hence improved the viscosity by reformation of inner structure as changing particle distribution of the dispersed phase and reduced in particle size (Jafari, He, and Bhandari 2007) which explains the higher viscosity values of microfluidized peanut yogurts. The viscosity of the water in oil emulsions increased with an increase in internal water phase content (Kobayashi et al. 2005) as microfluidization increased water binding capacity (Cikrikci 2013). Moreover, microfluidization for high fat content of peanut milk made the fat globules are primarily active components in network by reduction in fat globule size, even some of the fat globules turn into gel-forming elements, incresing number of particles with increased the surface area, produced the emulsified fat as more active participant in the formation of gel network and the fat globules were connected to the proteins and associated with the protein matrix and provide forming highly interconnected networks (Ciron et al. 2011). Also adding milk powder microfluidized peanut yoghurt samples enhanced gel structure due to complex synergistic interaction between peanut proteins and milk proteins (Glibowski and Rybak 2016).

Elastic and viscous moduli values of peanut yogurt samples were represented in Figures 3.15 and 3.16. If elastic modulus (G') is higher than the viscous modulus (G'') which present a solid like behavior of sample or viscous modulus (G'') is higher than elastic modulus (G') which present a liquid like behavior of sample (Seth, Mishra, and Deka 2018). Analysis of parameters from figures, elastic modulus value was dominated than viscous modulus value for same concentrations, which was an indicator for elastic gel-like emulsion. Dominance of elastic over viscous characteristics (G’ > G”) in the case of yoghurt was demonstrated in the literature. (Glibowski and Rybak 2016; Ciron et al. 2011; Marafon et al. 2011). Treatements microfluidization or adding milk powder or changing concentration effected the elastic (G') and viscous (G") modulus values in same way. Both elastic (G') and viscous (G") modulus values increased with microfluidization, adding milk powder and low concentration. Thus, the highest values were obtained in the peanut yogurt samples as milk powder added microfluidized peanut yoghurt 1/3. The observed moduli values were in the following increasing order; non-microfluidized peanut yoghurt 1/4, non-microfluidized peanut yoghurt 1/3.5, non-microfluidized peanut yoghurt 1/3, microfluidized peanut yoghurt 1/4, microfluidized and milk powder peanut yoghurt 1/4, microfluidized peanut yoghurt 1/3.5, microfluidized and milk powder peanut yoghurt 1/3.5, microfluidized peanut yoghurt 1/3, microfluidized and milk powder peanut yoghurt 1/3. These results were consistent with the literature; Mert (2012) repoted that, microfluidization process creates higher shear rates for longer periods of time with consistent pressure which causes to higher moduli values in the samples and Liu et al. (2011) indicated similar findings obtained by microfluidization technique on whey protein emulsions.

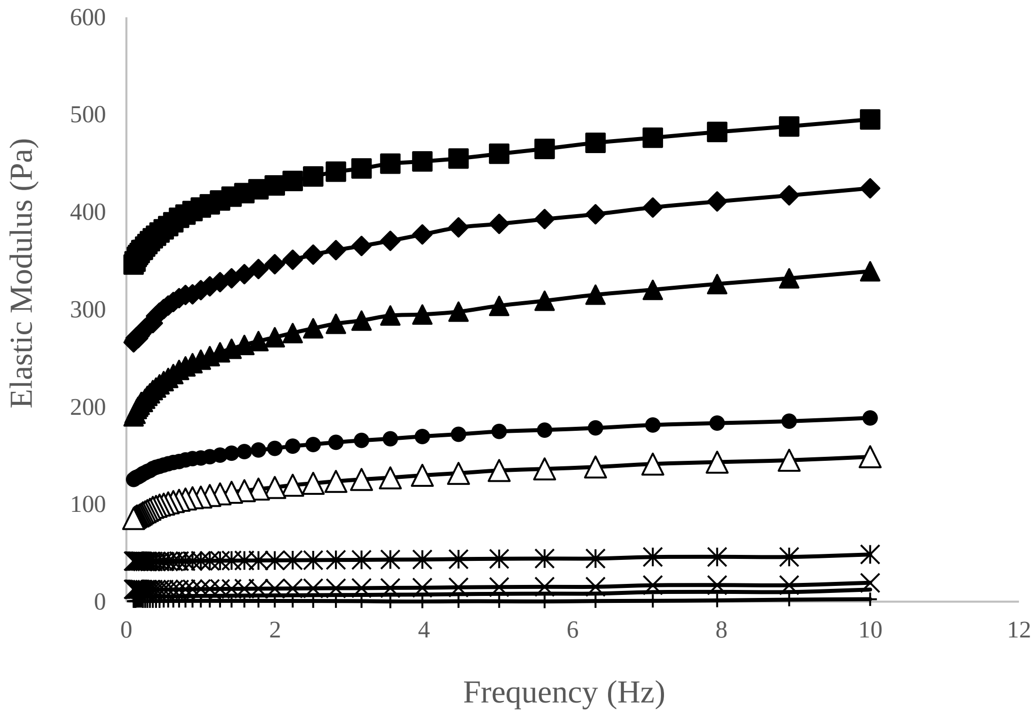

Figure 3.16 Elastic modulus obtained for peanut yogurt samples**.** (+): non-microfluidized peanut yoghurt 1/4, (-): non-microfluidized peanut yoghurt 1/3.5, (x): non-microfluidized peanut yoghurt 1/3, (*): microfluidized peanut yoghurt 1/4, (∆): microfluidized and milk powder peanut yoghurt 1/4, (●): microfluidized peanut yoghurt 1/3.5, (▲): microfluidized and milk powder peanut yoghurt 1/3.5, (◆):microfluidized peanut yoghurt 1/3, (■): microfluidized and milk powder peanut yoghurt 1/3.

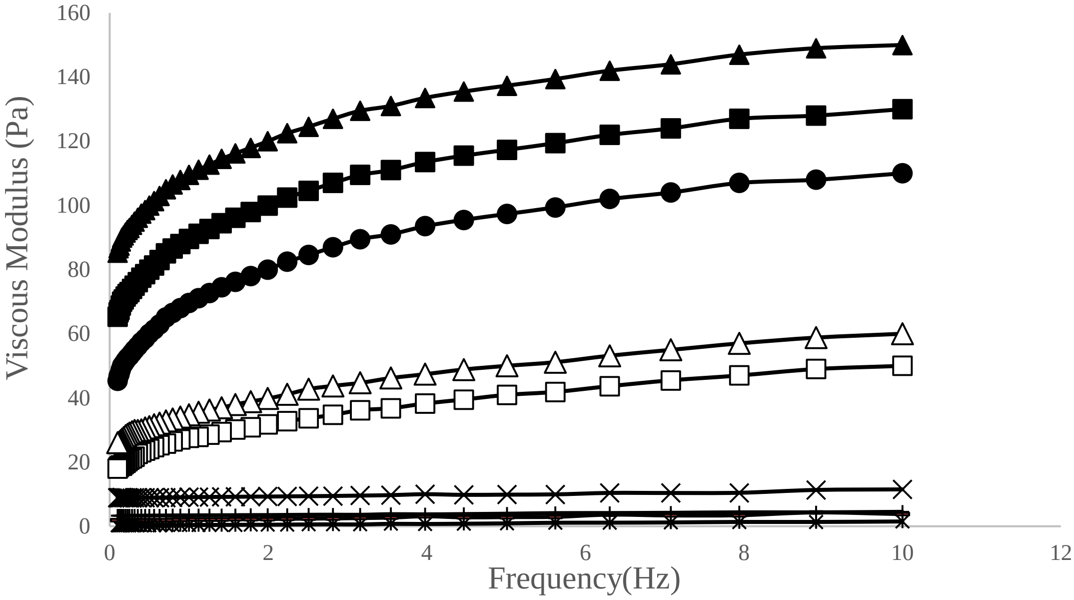

Figure 3.17 Viscous modulus obtained for peanut yogurt samples**.** (*): non-microfluidized peanut yoghurt 1/4, (-): non-microfluidized peanut yoghurt 1/3.5 , (+): non-microfluidized peanut yoghurt 1/3, (x): microfluidized peanut yoghurt 1/4, (□): microfluidized and milk powder peanut yoghurt 1/4, (Δ): microfluidized peanut yoghurt 1/3.5, (●): microfluidized and milk powder peanut yoghurt 1/3.5 , (■): microfluidized peanut yoghurt 1/3, (▲): microfluidized and milk powder peanut yoghurt 1/3.

3.2 Peanut Kefir Physicochemical, Textural and Rheological Properties

3.2.1 Dry Matter Content Determination

Dry matter contents of peanut kefir samples were presented in Table 3.6.

Sample	DM Content (%)
peanut kefir 1/4	19.25±0.11[a]
peanut kefir 1/5	16.67±0.08[b]
peanut kefir 1/6	13.75±0.09[c]
peanut kefir 1/7	10.98±0.12[d]

Table 3.6 Dry matter contents of peanut kefir samples. Standard deviations were also indicated. Different letters show significant difference ($p \leq 0.05$).

As can be seen in the Table 3.6, dry matter contents were changed between 19.25 and 10.98 for peanut kefir 1/4 and peanut kefir 1/7, respectively. Concentration had significant effect on dry matter content of peanut kefir samples ($p \leq 0.05$). When concentration was decreased dry matter contents of samples decreased too. The total dry matter content of kefir has been reported by several authors as between 8.88 and 16.73 for commercial milk kefir which is made from cow milk (Altay et al. 2013). A novel kefir formulation was found by Bensmira and Jiang which made from peanut milk/ skimmed milk in ratio of 7/3 (Bensmira and Jiang 2012) however, in this study only microfluidized peanut milk was used without skimmed milk powder or any other additives. The desirable dry matter content was obtained using microfluidization process intead of the filter step. The solids were embedded into peanut milk instead of discarded with muslin cloth which improved the physicochemical properties of fermented peanut products.

3.2.2 Water Holding Capacity and Syneresis

Water holding capacity (WHC) and syneresis of peanut kefir samples were presented in Table 3.7 below**.**

Sample	WHC (%)	Syneresis (%)
peanut kefir 1/4	34.97±0.15[a]	33.73±0.18[d]
peanut kefir 1/5	30.53±0.12[b]	40.36±0.20[c]
peanut kefir 1/6	25.48±0.09[c]	47.15±0.11[b]
peanut kefir 1/7	20.92±0.11[d]	53.68±0.15[a]

Table 3.7 Water holding capacity (WHC) and syneresis of peanut kefir samples. Standard deviations were also indicated. Different letters show significant difference ($p \leq 0.05$).

Water holding capacity of peanut kefir samples changed significantly with concentration. All samples was represented different pattern from each other ($p \leq 0.05$). When concentration was decreased water holding capacity of peanut kefir samples decreased due to the reduction amount of water. Water holding capacity value of whole milk kefir was reported between 25-31 (%) (Montanuci et al. 2012). Peanut kefir 1/4 had higher water holding capacity with its more rigid structure, peanut kefir 1/5 and peanut kefir 1/6 water holding capacity values were same as cow milk kefir and when concentration decreased water holding capacity values were decreased and phase separation was occurred on the bottom of the vessels in peanut kefir 1/7.

Syneresis value of peanut kefir samples were obtained highest for peanut kefir 1/7 and lowest for peanut kefir 1/4 as 53.68 and 33.73 respectively. Syneresis value of milk kefir was reported between 35-50 (%) (Wang et al. 2016) and peanut kefir 1/5 and peanut kefir 1/6 syneresis values were obtained same as kefir. According to ANNOVA results concentration had significant effect on syneresis of peanut kefirs ($p \leq 0.05$). When concentration was decreased syneresis values of peanut kefirs inceased related with water content, therefore results for water holding capacity and syneresis were confirmative for each other.

Water holding is usually related with restriction of the mobility of free water molecules in terms of hydrophilic molecules. Microfluidization often enhanced water holding ability and elevated colloidal stability of products (Demirkesen, Vilgis, and Mert 2018). Microfluidization produced peanut milk as an homogenous emulsion (Farahmand 2014) and the maintain quality in emulsions related with the concentrations of raw materials as water, oil content and also the treatment method as freezing (Sloan 2003). In all cases, peanut to water ratio of peanut milk change greatly from one producer to another due to properties of desirable product. Lower water content increased the viscosity of emulsion as peanut kefir 1/4, adding water increase the viscous properties of emulsion resulted the optimum water holding capacity and syneresis in peanut kefir 1/5 and peanut kefir 1/6 and adding more water disrupted the emulsion stability in peanut kefir 1/7 by separation of water from emulsion. The dispersed emulsion phase, separation occurs due to the force of gravity; thus, droplets float or settle and with respect to this typical phenomenon, kinetic stability is related with the dispersion level (Sjöblom 2006).

3.2.3 Titratable Acidity and pH Determination

Peanut kefir samples' TTA were presented in Figure 3.18 for 21 days at 4 °C.

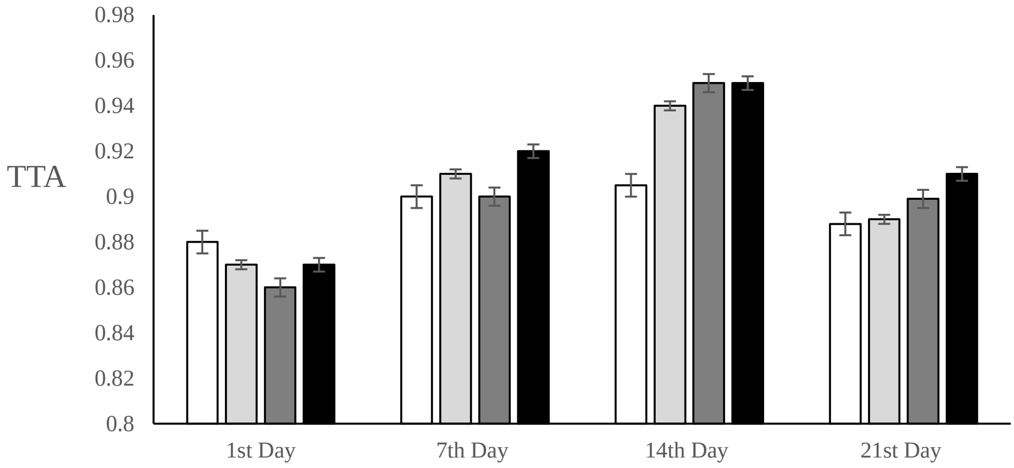

Figure 3.18 Total titratable acidity (TTA) values of peanut kefirs during the storage period. (white bar): peanut kefir 1/4, (light gray bar): peanut kefir 1/5, (dark gray bar): peanut kefir 1/6, (black bar): peanut kefir 1/7. Bars show standard deviation of the replicates.

Total titratable acidity values of peanut kefirs changed as the lowest and the highest between 0.86 and 0.88 at 1st day; 0.90 and 0.92 at 7th day; 0.91 and 0.95 at 14th day lastly 0.88 and 0.91 at 21th day. Total titratable acidity numbers for kefir was reported as between 0.8 -1 (Montanuci et al. 2012) and in this study measurements were between 0.86 – 0.95 for all samples during storage period. According to results, concentration has no effect on TTA of kefirs for 21 days.

pH values were obtained at peanut milk 1/4, peanut milk 1/5, peanut milk 1/6 and peanut milk 1/7 as 6.60, 6.62, 6.64 and 6.67, respectively before fermantation. During 21 days of storage at 4 °C peanut yogurt samples' pH were presented in Figure 3.19.

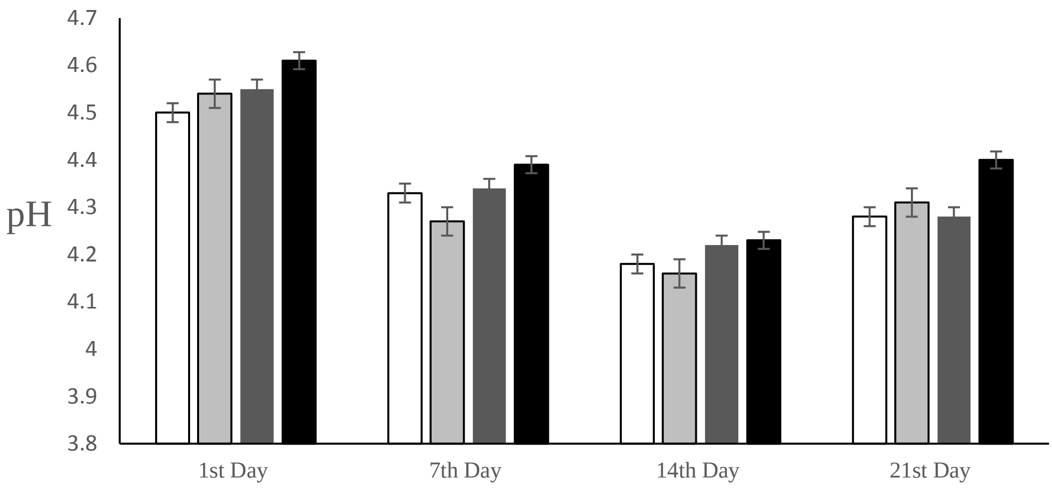

Figure 3.19 pH values of peanut kefir samples during the storage period. (white bar): peanut kefir 1/4, (light gray bar): peanut kefir 1/5, (dark gray bar): peanut kefir 1/6, (black bar): peanut kefir 1/4. Bars show standard deviation of the replicates.

pH values for all of peanut kefir samples changed as the highest and the lowest between 4.61 and 4.50 at 1st day; 4.39 and 4.27 at 7th day; 4.23 and 4.16 at 14th day lastly 4.40 and 4.28 at 21th day. The desirable pH number was declared for different kind of milk kefirs like peanut, walnut, cow, goat that is around 4.5 end of fermentation (Öner et al. 2010) and in these study pH measurements were between 4.61 - 4.23 for all samples for 21 days. According to results, concentration has no effect on pH of kefirs during storage period.

pH and TTA values were remained in a certain range during storage represented that *Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* ssp. *lactis* biovar *diacetylactis*, *Leuconostoc mesenteroides*, *Lactobacillus acidophilus*, *Streptococcus thermophilus* bacteria and *Saccharomyces cerevisiae* yeasts growth maintained and these co-culture produced acids from sugar for storage period. Lactic acid, acetic acid, pyruvic acid, hippuric acid, propionic acid, butyric acid, diacetyl and acetaldehyde were generated during kefir fermentation. Also these compounds determined to contribute taste and aroma in kefirs.

Öner et al. (2010) produced kefir from different kind of mammalian species milk with commercial starter culture, pH were 4.47, 4.63, 4.44 at cow milk, ewe milk and goat milk and they reported that starter culture type, storage period and mammalian species significantly affected changes in pH. Another study which made kefir from walnut milk (Cui et al. 2013) pH was 4.16 and in this study peanut milk kefir pH was 4.50.

3.2.4 Color Determination

Total Color Change (ΔE) values of kefir samples were presented in Table 3.8 below.

Sample	**ΔE**
peanut kefir 1/4	11.8±0.2[a]
peanut kefir 1/5	10.3±0.12[b]
peanut kefir 1/6	9.8±0.3[b]
peanut kefir 1/7	8.6±0.1[c]

Table 3.8 Total color change (ΔE) values of peanut kefir samples. Standard deviations were also indicated. Different letters show significant difference ($p \leq 0.05$).

As could be seen from Table 3.6 ΔE values were obtanined as 11.8, 10.3, 9.8 and 8.6 for peanut kefir 1/4, peanut kefir 1/5, peanut kefir 1/6 and peanut kefir 1/7, respectively. According to ANOVA results changing in concentration was effective in certain range. The diffences were observable between peanut kefir 1/4 and peanut kefir 1/5, however there was no significant diffence between peanut kefir 1/5 and peanut kefir 1/6, therefore amount of water used in peanut kefir was important. Kefir is characteristic with whitish color (Mistry, 2004), microfluidization provided color brighter by revealing phenolic content due to the change in structure (Ozturk and Mert 2018). Peanut kefir color may be obtained optimum concentration in peanut milk with microfluidization as the traditional kefir. This difference of concentration might be explained by the different water distribution (Ozturk 2014).

3.2.5 Scanning Electron Microscope (SEM) Analysis

Scanning electron microscopy (SEM) photographs of the microfluidized peanut kefir were illustrated in Figure 3.20 at 1000 and 4000 magnification levels.

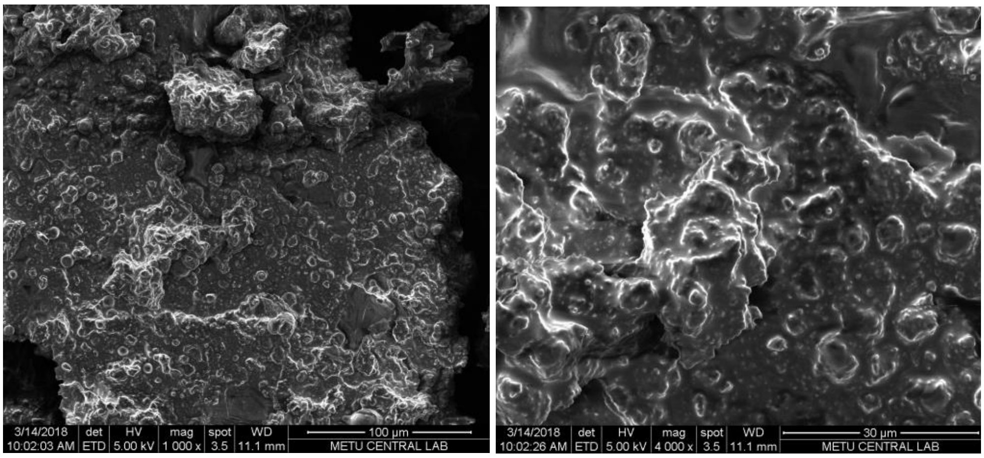

Figure 3.20 SEM image of kefir sample. Magnification: 1000x, 4000x.

The application of microfluidization to peanut milks provided generation of micro particles by such a high pressure resulted in formation homogenity with in continuous phase (Ketenoglu, Mert, and Tekin 2014). High pressure homogenizers obtained more uniform droplets size distribution (Bigikocin, Mert, and Alpas 2011) and smaller fat globules became integrated smaller proteins and produced a homogeneous network structure (Liu et al. 2011). The microfluidization process improved hydration properties as increase the surface area and dispersion through the surface of the sample which means more sites to bind water Chau et al. (2006) and increased water holding capacity (as can be seen from Table 3.7) which gave the smoother texture.

3.2.6 Texture Profile of Peanut Kefir Samples

The firmness cohesiveness and consistency values of peanut kefirs were presented in Figure 3.21.

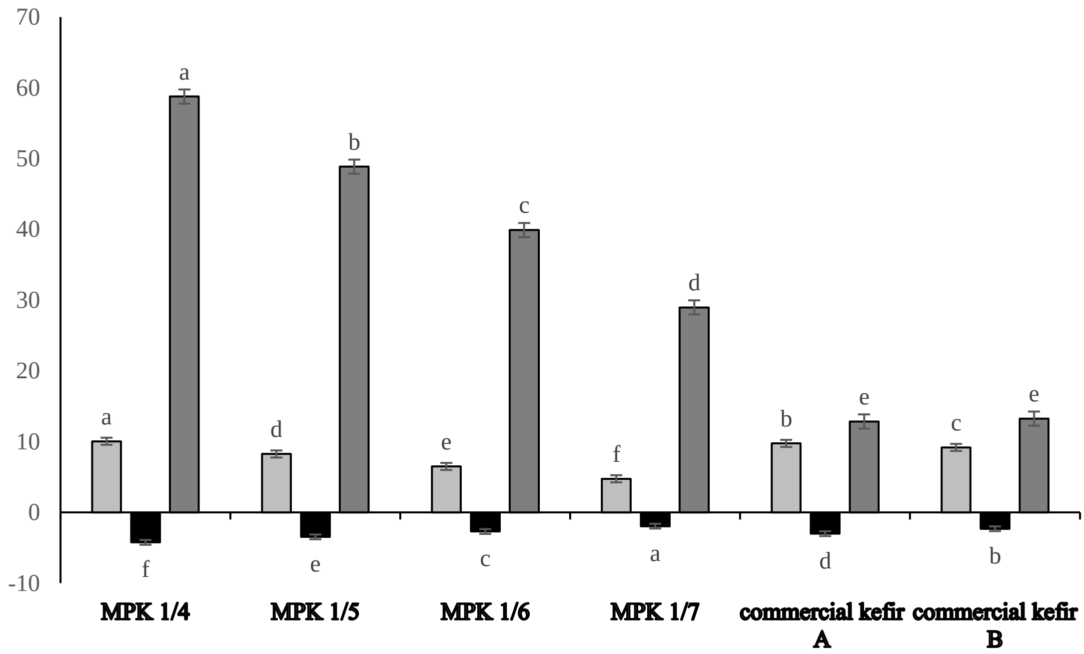

Figure 3.21 Firmness cohesiveness and consistency value of peanut kefirs. (light gray bar): Firmness(g); (black bar): Cohesiveness(g); (dark gray bar): Consistency(g.s). Bars show standard deviation of the replicates.

Firmness values were obtanined as 10.05, 8.25, 6.49, 4.75, 9.75 and 9.18 at peanut kefir 1/4, peanut kefir 1/5, peanut kefir 1/6, peanut kefir 1/7, commercial kefir A and commercial kefir B, respectively. According to ANOVA results, concentration affected the hardness results in peanut kefirs, significantly ($p \leq 0.05$) and when concentration of samples were decreased, firmness values of peanut kefirs decreased.

Cohesiveness values were measured as -4.24, -3.46, -2.70, -1.95, -3.01 ans -2.31 for peanut kefir 1/4, peanut kefir 1/5, peanut kefir 1/6, peanut kefir 1/7, commercial kefir A and commercial kefir B, respectively. According to ANOVA results, concentration affected significantly the cohesiveness results in peanut kefirs, ($p \leq 0.05$) and when concentration of samples were increased, cohesiveness values of peanut kefirs decreased.

Consistency values were found as 58.76, 48.85, 39.89, 28.96, 12.85 and 13.25 at peanut kefir 1/4, peanut kefir 1/5, peanut kefir 1/6, peanut kefir 1/7, commercial kefir A and commercial kefir B, respectively. According to ANOVA results, concentration had significant affect on the consistency results ($p \leq 0.05$) and when concentration of samples were decreased, consistency values of peanut kefirs decreased. Bensmira and Jiang (2012) reported that peanut kefir (which peanut milk was prepared in traditional way as filter peanut milk using a three-layered cheese cloth) had much higher firmness (between 3-4 g) than whole-milk kefir. In the current study firmness of peanut kefirs were found in range of 4.75-10.05 (g) which was superior than traditional peanut kefir and closed to cow milk kefir's firmness values which related with microfluidization process. With microfluidization process instead of filter step the amount of peanut was increased in peanut milk which means higher protein fat carbonhydrate content provided. Reducing fat content in dairy products may cause lack of consistency or texture (Guven et al. 2005) however microfludization step in kefir production created more fat globules. Also, microfluidization treatment to peanut milks provided smaller droplet size, homogenous dispersion, stability which resulted as smoother products (Joon et al. 2017). When peanut kefir texture profile was compared with the cow milk kefir, both similar in terms of firmness and cohesiveness values but consistency values of peanut kefirs higher than cow milk kefirs. The reason for that, microfluidization improved the consistency as a result of dispersion and disintegration of the solids by high pressure (Mert 2012).

Kefir is a sour milk produced by fermentation with mild aroma of fresh yeast and mild acid flavor of bacteria and its texture thick, creamy consistency (Powell et al. 2007). In kefir production improve the quality and consistency of commercial kefir is desirable. A good-quality kefir has slight foamy, pourable viscosity (Guzel-Seydim et al. 2011). The microfluidization process creates reducing the size of protein particles to less than 3-μm which forms smooth emulsion-like, creamy texture (Farahmand 2014) and smaller fat globules which provide continuous and homogeneous network structure (Nguyen et al. 2015). Regarding quality and consistency of kefir, microfludization support the texture of kefirs.

As a consequent microfluidization exhibited higher firmness as less cohesive and more consistent peanut kefirs.

3.2.7 Rheological Analysis

Rheological properties of peanut kefirs were discussed as analysis of flow behavior and deformation of food systems, also two commercial cow milk kefir were used to understand diffrence between vegetable milk source kefirs and animal source milk kefirs.

Foods are generally classified as Newtonian or non-Newtonian based on the relationship between shear stress and shear rate and fermented non-alcoholic lactic acid beverages are known as non-Newtonian in the literature (Altay et al. 2013) therefore peanut kefir data can be modeled using a power-law equation.

The microfluidized peanut kefir data was fitted to the power law model. The power law model is given as (Eq. (3.1)):

$$\sigma = K(\dot{\gamma})^n$$

Where σ is shear stress (Pa), γ is the shear rate (s^{-1}), n represents flow behavior index and K is the consistency index (Pas^n). The power law parameters for peanut kefir were presented in the Table 3.9.

Sample	K (Pa.s^n)	n
peanut kefir 1/4	15.308	0.19
peanut kefir 1/5	7.516	0.32
peanut kefir 1/6	3.359	0.47
peanut kefir 1/7	0.620	0.68
commercial kefir A	0.071	0.42
commercial kefir B	0.022	0.64

Table 3.9 The Power Law parameters for kefir samples at 5 ºC.

The consistency index value K, gives information about structural rigidity and microfluidized peanut kefirs of K was found between 0.62 and 15.308 at peanut kefir 1/7 and peanut kefir 1/4, respectively and for commercial kefirs K was found 0.049 and 0.021 at commercial kefir A and commercial kefir B, respectively. K decreased with water content. Water increased the viscous properties of peanut kefirs and decreased the dense of products. In the present study, n value was found $n<1$ which means peanut kefirs demonstrated shear thinning (pseudoplastic) behaviour as cow milk kefirs. The flow behavior index obtained between 0.19 and 0.68 for peanut kefirs and 0.42 and 0.64 was found for commercial kefir A and commercial kefir B, respectively. Peanut kefir 1/4 represented the lowest n value as 0.19 which indicated the most complex structure (Gómez et al. 2010).

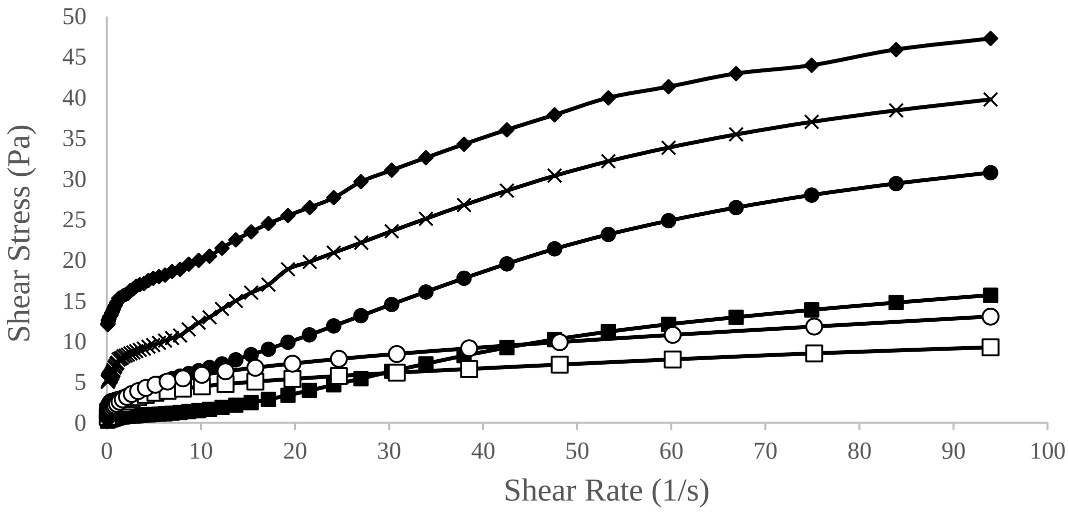

Figure 3.22 Flow curves obtained for peanut kefirs. (♦):peanut kefir 1/4, (x): peanut kefir 1/5, (●):peanut kefir 1/6, (■): peanut kefir 1/7, (□): commercial kefir A, (❍): commercial kefir B.

As can be seen in Figure 3.22, the shear stress versus shear rate data gives information about viscosity of samples. Peanut kefir 1/4 had higher viscosity then peanut kefir 1/7, decreasing viscosity wherefore water increasing. Microfluidization process reshapes as fine particles with more interconnectivity (Sfakianakis and Tzia 2014) and larger surface area which results more water can be bound due to the presence of hydroxyl groups in structure and this effect diminishes available water content in the product (Demirkesen et al. 2010) however its true untill a certain range, after certain range excess of water in content cannot bind with microfluidization and cause leak out as peanut kefir 1/7. As can be seen viscosity values of cow-milk kefirs were considerably lower than peanut-milk kefir. These results may be attributed to the high protein and fat contents in peanut-milk kefir. It has been reported as unpublished data in Bensmira's study (Bensmira and Jiang 2012). The composition of cow-milk kefir has been reported by several authors as the protein 3.10–4.72% and fat contents 1.11–2.77% (Altay et al. 2013). Microfluidization technique proved higher apparent viscosity values due to physical, chemical and microstructural changes (Demirkesen, Vilgis, and Mert 2018).

Elastic and viscous moduli values of peanut kefir samples were represented in Figures 3.22 and 3.23 as a function of frequency. As can be seen from figures elastic modulus (G') is higher than the viscous modulus (G") which present that kefir samples form a biopolymer gel (Ross-Murphy 1984). The concentration changing had been effect on the elastic (G') and viscous (G") modulus values in peanut kefir. The obtained moduli values were in the following increasing order; peanut kefir 1/4, peanut kefir 1/5, commercial kefir A, peanut kefir 1/6, commercial kefir B, peanut kefir 1/7. The highest moduli values were occurred in peanut kefir 1/4, it can be related that the compact packing of oil droplets into network effects elastic properties and deformation resistance of the related emulsion (Liu et al. 2006). Rheological parameters depends on structure of product. Microfluidization process altered size and the distribution of the oil particles by high pressure, and modified interaction between particles consequently different rheological properties occurred as higher moduli values in the samples (Mert 2012).

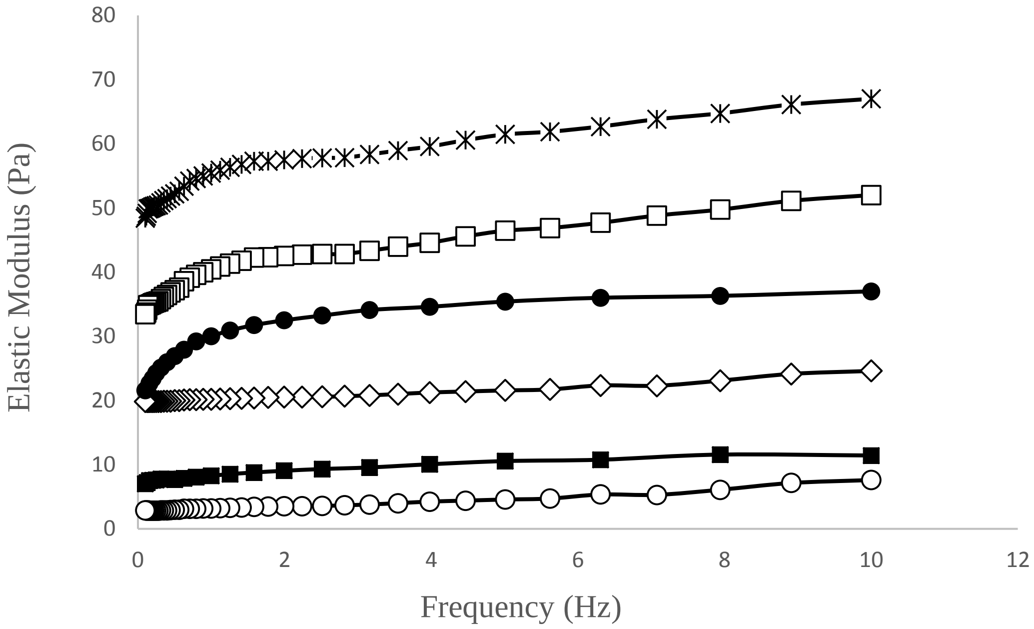

Figure 3.23 Elastic modulus obtained for peanut kefir. (*):peanut kefir 1/4, (□): peanut kefir 1/5, (◊):peanut kefir 1/6, (❍): peanut kefir 1/7, (●):commercial kefir A, (■):commercial kefir B.

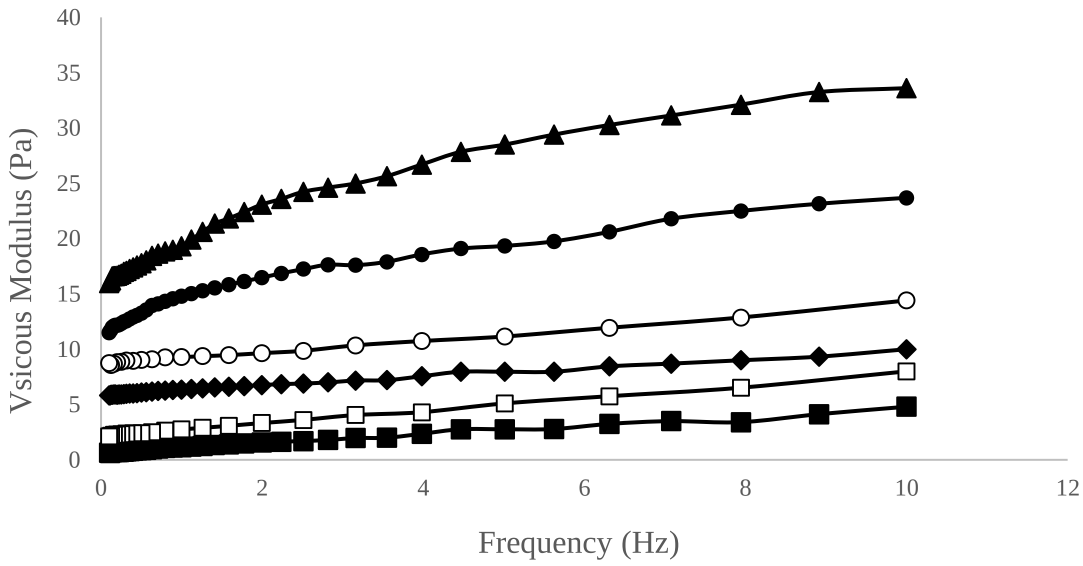

Figure 3.24 Viscous modulus obtained for peanut kefir. (▲):peanut kefir 1/4, (●): peanut kefir 1/5, (◆):peanut kefir 1/6, (■): peanut kefir 1/7, (❍):commercial kefir A, (□): commercial kefir B.

3.3 Particle Size Measurements in Peanut Milk

Particle sizes were measured before microfluidization process and after microfluidization process for all the ratios of peanut milk used in experiments [1:3, 1:3.5, 1: 4; 1:5, 1:6, 1:7; peanut(g): water(g)] and volume based mean diameter D [4,3] results was represented in Figure 3.25.

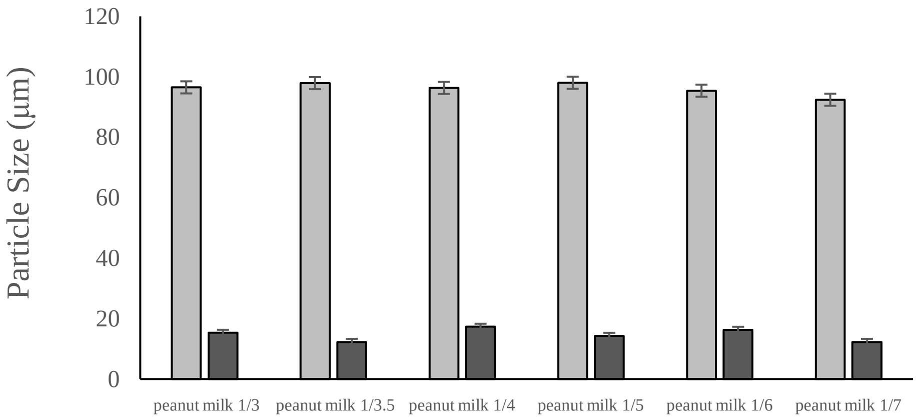

Figure 3.25 Particle size of peanut milk. (light gray bar): non-microfluidized peanut milk, (dark gray bar): microfluidized peanut milk. Bars presentstandard deviation of the replicates.

Particle size of peanut milk after colloidail mill was obtained around 96 µm and after microfluidization process it reduced to 14.6 µm. The results presented that, concentration has no effect on particle size. Since interactions between components are broken down under the action of shear so, size of particle depends on raw metarials.

Size is an important physical feature of foods evaluating the quality of food materials even it can be critical for particulate foods. Microfluidization generates high velocity microstreams as a fluid accelerates into an interaction chamber, generating high shear and impact forces that cause the creation of fine emulsions (McCrae 1994). As results in the reduction particle size several attributes of the final product changes, therefore microparticulation have great importancy in the food industry (Sahin and Sumnu 2006). One of them is the stability of fluids which depend on concentration, particle size, shape and any attraction with the continuous phase in which they are suspended. Microfluidization process provide to obtain more homogeneous and stable emulsions by reducing particle size (Ketenoglu, Mert, and Tekin 2014).

Application of microfluidization process provide formation of more complex network through more particle interactions of smaller particles and alters rheological and textural properties of food samples.

CHAPTER 4

CONCLUSION AND RECOMMENDATIONS

In this study it was aimed to analyze physicochemical, textural and rheological properties of the peanut yogurt and kefir.

Peanut yogurts were produced from non-microfluidized peanut milk, microfluidized peanut milk and adding skimmed milk powder to microfluidized peanut milk in three different concentrations 1:3, 1:3.5 and 1:4 (peanut(g): water(g)) for three formula.

Physicochemical parameters for peanut yogurts were obtained as dry matter content, water holding capacity, synersis, pH, titratable acidity and color. Microfluidization application provided increasing in dry matter content, higher water holding capacity and lower synersis which are desirable for yogurt production. Microfluidization decreased ΔE values of the peanut yogurts which means that peanut yogurts were significantly whiter with microfluidization of peanut milk. Adding milk powder to microfluidized peanut milk enhanced the quality parameters of peanut yogurts. The changing in concentrations or treatments on peanut milk has no effect on acidity of peanut yogurts. Scanning electron microscopy of the samples clearly revealed the structural differences in process. Microfluidization provided reformation of inner structure as particle size reduction with high pressure and resulted more homogenous structure.

When the texture profiles of peanuts were investigated in terms of firmness, cohesiveness and consistency, it was seen that microfluidization increased the firmness and consistency and decreased cohesiveness of peanut yogurts. Besides, higher firmness, cohesiveness and lower consistency values were obtained in peanut yogurts containing milk powder.

In rheological measurements, peanut yogurts results were fitted to power law model and all samples exhibited shear thinning behavior with different model constants.

Microfluidization process with milk powder addition was resulted higher values of shear stress, elastic modulus and viscous modulus. Moreover, in all peanut yogurts samples elastic (G') modules were higher than viscous (G") modules indicating solid like behavior.

Peanut kefirs were produced from microfluidized peanut milk in four different concentrations as 1:4, 1:5, 1:6 and 1:7 (peanut(g): water(g)) without any additive.

Dry matter content, water holding capacity, synersis, pH, titratable acidity, color were measured of peanut kefirs as physicochemical parameters. Scanning Electron Microscope (SEM) analysis represented the microstructural property of peanut kefirs. Exprimental results represented that peanut kefir 1/4 was strict, peanut kefir 1/5 and peanut kefir 1/6 were found as optimum concentration and adding more water disrupted the emulsion stability as peanut kefir 1/7 by separation of water from emulsion.

Textural parameters were obtained as higher firmness, less cohesive and more consistent peanut kefirs. In rheological measurements, peanut kefir results were fitted to power law model and all samples exhibited shear thinning behavior and resulted higher values of shear stress, elastic modulus and viscous modulus with microfluidization process. Also, in all peanut kefir samples elastic (G') modules were higher than viscous (G") modules indicating solid like behavior.

The experimental results showed that microfluidization process offers considerable facilitation when producing peanut milk products as yogurt and kefir. Rheological properties of products has been affected in positive ways due to their viscosity increasing, texture improving, higher water binding, stabilizing and emulsifying properties. Loosing texture and serum separation are the main physical problems in yogurt and kefir production which can be solved by microfluidization in process or addition of some additives based on consumers preference. Also yogurt and kefir production with microfluidization could be preferable from economic aspect.

It can be concluded that when mechanical treatment was combined with the chemical agent as milk powder it was found that the final effect was more strong than the individual effects however, its possible to produce fermented products from peanut milk with only sucrose and culture, using microfluidization technique with the optimization of process conditions.

As a future study, sensory analysis could be done in peanut yogurt and kefir to see the point of view of consumers in terms of consumption.

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APPENDIX A

PICTURES OF PEANUT YOGURT SAMPLES

Figure A.1 Picture of peanut yogurt samples in 1/4 (peanut/water; w/w) concentaration. From left to right pictures show non-microfluidized peanut yoghurt, microfluidized peanut yoghurt and milk powder added microfluidized peanut yoghurt.

Figure A.2 Picture of peanut yogurt samples in 1/3.5 (peanut/water; w/w) concentaration. From left to right pictures show non-microfluidized peanut yoghurt, microfluidized peanut yoghurt and milk powder added microfluidized peanut yoghurt.

Figure A.3 Picture of peanut yogurt samples in 1/4 (peanut/water; w/w) concentaration. From left to right pictures show non-microfluidized peanut yoghurt, microfluidized peanut yoghurt and milk powder added microfluidized peanut yoghurt.

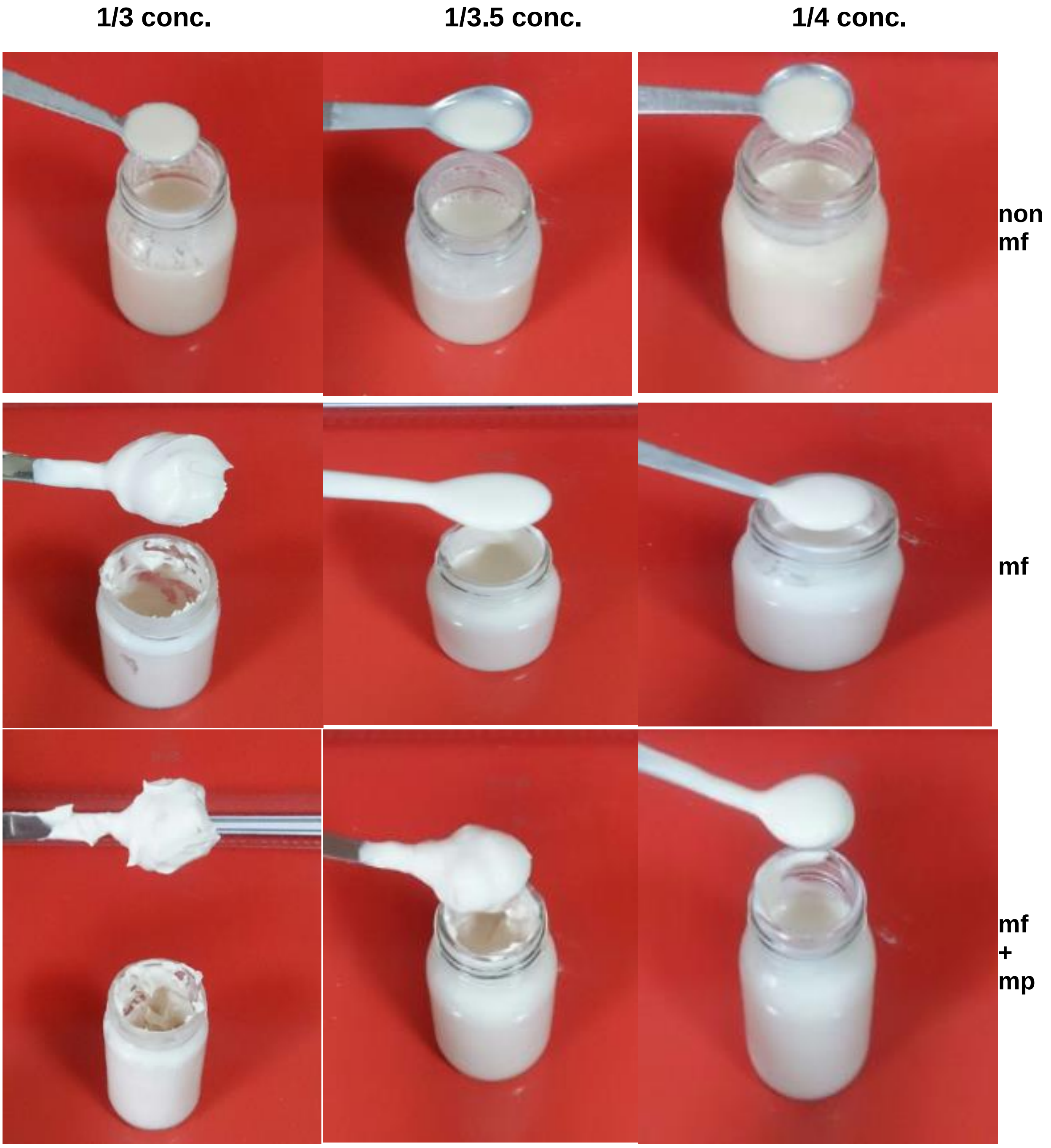

Figure A.4 Picture of all peanut yogurt samples. From left to right pictures represent; first row non-microfluidized peanut yoghurt, second row microfluidized peanut yoghurt and third row milk powder added microfluidized peanut yoghurt. From top to bottom pictures showsame concentrations values whics is indicated.

PICTURES OF PEANUT KEFIR SAMPLES

Figure A.5 Picture of peanut kefir sample. The non-microfluidized peanut kefir is on the left side and microfluidized peanut kefir is on the right side.

Figure A.6 Picture of peanut kefir samples. From left to right pictures peanut kefir 1/7, peanut kefir1/6, peanut kefir1/5 and peanut kefir 1/4, respectively.

Peanut kefir 1/4

Peanut kefir1/5

Peanut kefir 1/6

Peanut kefir1/7

Figure A.7 Picture of all peanut kefir samples.

APPENDIX B

STATISTICAL ANALYSES

General Linear Model: DM Content (%) of peanut yogurt versus Concentration; MF

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	3	0,25; 0,285; 0,33
MF	Fixed	3	minus; plus; plus and mp

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	2	49,163	24,5817	430,81	0,000
MF	2	78,246	39,1229	685,65	0,000
Concentration*MF	4	0,668	0,1669	2,92	0,050
Error	18	1,027	0,0571		
Total	26	129,104			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,238871	99,20%	98,85%	98,21%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	26,8722	0,0460	584,55	0,000	
Concentration					
0,25	-0,5700	0,0650	-8,77	0,000	1,33
0,285	-1,2922	0,0650	-19,88	0,000	1,33
MF					
minus	-1,3389	0,0650	-20,59	0,000	1,33
plus	-1,0633	0,0650	-16,36	0,000	1,33
Concentration*MF					

0,25 minus	0,2433	0,0919	2,65	0,016	1,78
0,25 plus	-0,0822	0,0919	-0,89	0,383	1,78
0,285 minus	-0,2844	0,0919	-3,09	0,006	1,78
0,285 plus	0,0867	0,0919	0,94	0,358	1,78

Fits and Diagnostics for Unusual Observations

Obs	DM Content (%)	Fit	Resid	Std Resid	
10	23,450	23,957	-0,507	-2,60	R
12	24,420	23,957	0,463	2,38	R

R Large residual

Comparisons for DM Content (%)

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping		
0,33	9	28,7344	A		
0,25	9	26,3022		B	
0,285	9	25,5800			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: MF

Grouping Information Using the Tukey Method and 95% Confidence

MF	N	Mean	Grouping	
plus and mp	9	29,2744	A	
plus	9	25,8089		B
minus	9	25,5333		B

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Concentration*MF

Grouping Information Using the Tukey Method and 95% Confidence

Concentration*MF	N	Mean	Grouping			
0,33 plus and mp	3	31,1000	A			
0,25 plus and mp	3	28,5433		B		
0,285 plus and mp	3	28,1800		B	C	
0,33 plus	3	27,6667			C	D
0,33 minus	3	27,4367				D

0,25 minus	3	25,2067	E	
0,25 plus	3	25,1567	E	
0,285 plus	3	24,6033	E	F
0,285 minus	3	23,9567		F

Means that do not share a letter are significantly different.

Table B.1 Results for Tukey's mean comparison test for DM (%) of peanut yogurt samples.

General Linear Model: WHC (%)of peanut yogurt versus Concentration; MF

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	3	0,25; 0,285; 0,33
MF	Fixed	3	minus; plus; plus and mp

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	2	446.95	223.477	4178.88	0.000
MF	2	1950.82	975.410	18239.53	0.000
Concentration*MF	4	2.93	0.732	13.69	0.000
Error	18	0.96	0.053		
Total	26	2401.67			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.231253	99.96%	99.94%	99.91%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	63.5119	0.0445	1427.09	0.000	
Concentration					
0,25	-5.0130	0.0629	-79.65	0.000	1.33
0,285	0.0604	0.0629	0.96	0.350	1.33
MF					
minus	-10.9541	0.0629	-174.04	0.000	1.33
plus	1.1893	0.0629	18.90	0.000	1.33
Concentration*MF					
0,25 minus	-0.1281	0.0890	-1.44	0.167	1.78

0,25 plus	0.5252	0.0890	5.90	0.000	1.78
0,285 minus	0.1219	0.0890	1.37	0.188	1.78
0,285 plus	-0.5615	0.0890	-6.31	0.000	1.78

Fits and Diagnostics for Unusual Observations

Obs	WHC (%)	Fit	Resid	Std Resid	
1	47.800	47.417	0.383	2.03	R

R Large residual

Comparisons for WHC (%)
Tukey Pairwise Comparisons: Concentration
Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping		
0,33	9	68.4644	A		
0,285	9	63.5722		B	
0,25	9	58.4989			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: MF
Grouping Information Using the Tukey Method and 95% Confidence

MF	N	Mean	Grouping		
plus and mp	9	73.2767	A		
plus	9	64.7011		B	
minus	9	52.5578			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Concentration*MF
Grouping Information Using the Tukey Method and 95% Confidence

Concentration*MF	N	Mean	Grouping								
0,33 plus and mp	3	78.1867	A								
0,285 plus and mp	3	73.7767		B							
0,33 plus	3	69.6900			C						
0,25 plus and mp	3	67.8667				D					
0,285 plus	3	64.2000					E				
0,25 plus	3	60.2133						F			
0,33 minus	3	57.5167							G		
0,285 minus	3	52.7400								H	
0,25 minus	3	47.4167									I

Means that do not share a letter are significantly different.

Table B.2 Results for Tukey's mean comparison test for WHC (%) of peanut yogurt samples.

General Linear Model: Syneresis (%)of peanut yogurt versus Concentration; MF

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	3	0,25; 0,285; 0,33
MF	Fixed	3	minus; plus; plus and mp

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	2	4441,3	2220,67	4051221,02	0,000
MF	2	11165,0	5582,51	10184306,84	0,000
Concentration*MF	4	23,1	5,78	10553,05	0,000
Error	18	0,0	0,00		
Total	26	15629,5			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0234126	100,00%	100,00%	100,00%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	35,1522	0,0045	7801,64	0,000	
Concentration					
0,25	13,1433	0,0064	2062,64	0,000	1,33
0,285	4,25333	0,00637	667,49	0,000	1,33
MF					
minus	28,4778	0,0064	4469,14	0,000	1,33
plus	-10,7689	0,0064	-1690,01	0,000	1,33
Concentration*MF					
0,25 minus	0,81667	0,00901	90,62	0,000	1,78
0,25 plus	-1,25333	0,00901	-139,08	0,000	1,78
0,285 minus	0,47667	0,00901	52,90	0,000	1,78
0,285 plus	0,84000	0,00901	93,21	0,000	1,78

Fits and Diagnostics for Unusual Observations

Obs	Syneresis %	Fit	Resid	Std Resid	
16	20,3400	20,3800	-0,0400	-2,09	R
18	20,4200	20,3800	0,0400	2,09	R

R Large residual

Comparisons for Syneresis %

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping		
0,25	9	48,2956	A		
0,285	9	39,4056		B	
0,33	9	17,7556			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: MF

Grouping Information Using the Tukey Method and 95% Confidence

MF	N	Mean	Grouping		
minus	9	63,6300	A		
plus	9	24,3833		B	
plus and mp	9	17,4433			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Concentration*MF

Grouping Information Using the Tukey Method and 95% Confidence

Concentration*MF	N	Mean	Grouping								
0,25 minus	3	77,5900	A								
0,285 minus	3	68,3600		B							
0,33 minus	3	44,9400			C						
0,25 plus	3	36,2733				D					
0,25 plus and mp	3	31,0233					E				
0,285 plus	3	29,4767						F			
0,285 plus and mp	3	20,3800							G		
0,33 plus	3	7,4000								H	
0,33 plus and mp	3	0,9267									I

Means that do not share a letter are significantly different.

Table B.3 Results for Tukey's mean comparison test for Syneresis (%) of peanut yogurt samples.

General Linear Model: ΔE of peanut yogurts versus Concentration; MF

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	3	0,250; 0,285; 0,330
MF	Fixed	3	minus; plus; plus and mp

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	2	0,001	0,0005	0,41	0,667
MF	2	175,969	87,9844	76385,17	0,000
Concentration*MF	4	0,008	0,0020	1,77	0,178
Error	18	0,021	0,0012		
Total	26	175,999			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0339389	99,99%	99,98%	99,97%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	14,7778	0,0065	2262,52	0,000	
Concentration					
0,250	-0,00778	0,00924	-0,84	0,411	1,33
0,285	0,00667	0,00924	0,72	0,480	1,33
MF					
minus	3,57333	0,00924	386,85	0,000	1,33
plus	-1,34000	0,00924	-145,07	0,000	1,33
Concentration*MF					
0,250 minus	0,0133	0,0131	1,02	0,321	1,78
0,250 plus	0,0200	0,0131	1,53	0,143	1,78

0,285 minus	-0,0144	0,0131	-1,11	0,283	1,78
0,285 plus	-0,0044	0,0131	-0,34	0,738	1,78

Fits and Diagnostics for Unusual Observations

Obs	ΔE	Fit	Resid	Std Resid	
10	18,4000	18,3433	0,0567	2,04	R
12	18,2800	18,3433	-0,0633	-2,29	R
27	12,6300	12,5600	0,0700	2,53	R

R Large residual

Comparisons for ΔE

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping
0,285	9	14,7844	A
0,330	9	14,7789	A
0,250	9	14,7700	A

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: MF

Grouping Information Using the Tukey Method and 95% Confidence

MF	N	Mean	Grouping		
minus	9	18,3511	A		
plus	9	13,4378		B	
plus and mp	9	12,5444			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Concentration*MF

Grouping Information Using the Tukey Method and 95% Confidence

Concentration*MF	N	Mean	Grouping	
0,250 minus	3	18,3567	A	
0,330 minus	3	18,3533	A	
0,285 minus	3	18,3433	A	
0,250 plus	3	13,4500		B
0,285 plus	3	13,4400		B
0,330 plus	3	13,4233		B

0,285	plus and mp	3	12,5700	C
0,330	plus and mp	3	12,5600	C
0,250	plus and mp	3	12,5033	C

Means that do not share a letter are significantly different.

Table B.4 Results for Tukey's mean comparison test for color of peanut yogurt samples.

General Linear Model: Firmness of peanut yogurts versus MF; Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
MF	Fixed	3	minus; plus; plus and mp
Concentration	Fixed	3	0,25; 0,285; 0,33

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
MF	2	23302,7	11651,4	957,18	0,000
Concentration	2	11017,4	5508,7	452,55	0,000
MF*Concentration	4	5305,4	1326,3	108,96	0,000
Error	18	219,1	12,2		
Total	26	39844,6			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3,48892	99,45%	99,21%	98,76%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	46,913	0,671	69,87	0,000	
MF					
minus	-40,340	0,950	-42,48	0,000	1,33
plus	11,559	0,950	12,17	0,000	1,33
Concentration					

0,25	-23,479	0,950	-24,73	0,000	1,33
0,285	-2,354	0,950	-2,48	0,023	1,33
MF*Concentration					
minus 0,25	22,48	1,34	16,74	0,000	1,78
minus 0,285	2,59	1,34	1,93	0,070	1,78
plus 0,25	-10,58	1,34	-7,88	0,000	1,78
plus 0,285	-5,38	1,34	-4,01	0,001	1,78

Fits and Diagnostics for Unusual Observations

Obs	Firmness	Fit	Resid	Std Resid	
23	109,99	100,27	9,72	3,41	R
24	92,43	100,27	-7,83	-2,75	R

R Large residual

Comparisons for Firmness

Tukey Pairwise Comparisons: MF

Grouping Information Using the Tukey Method and 95% Confidence

MF	N	Mean	Grouping		
plus and mp	9	75,6934	A		
plus	9	58,4729		B	
minus	9	6,5739			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping		
0,33	9	72,7463	A		
0,285	9	44,5597		B	
0,25	9	23,4342			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: MF*Concentration

Grouping Information Using the Tukey Method and 95% Confidence

MF*Concentration	N	Mean	Grouping	
plus and mp 0,33	3	110,635	A	
plus 0,33	3	100,266		B

plus and mp 0,285	3	76,130	C
plus 0,285	3	50,739	D
plus and mp 0,25	3	40,315	E
plus 0,25	3	24,414	F
minus 0,33	3	7,337	G
minus 0,285	3	6,811	G
minus 0,25	3	5,574	G

Means that do not share a letter are significantly different.

Table B.5 Results for Tukey's mean comparison test for firmness of peanut yogurt samples.

General Linear Model: Cohesiveness of peanut yogurts versus MF; Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
MF	Fixed	3	minus; plus; plus and mp
Concentration	Fixed	3	0,25; 0,285; 0,33

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
MF	2	14034,1	7017,05	4,20929E+09	0,000
Concentration	2	4248,1	2124,05	1,27414E+09	0,000
MF*Concentration	4	2162,2	540,56	3,24265E+08	0,000
Error	18	0,0	0,00		
Total	26	20444,4			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0012911	100,00%	100,00%	100,00%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF

Constant	-31,3807	0,0002	-126291,03	0,000	
MF					
minus	30,0686	0,0004	85567,29	0,000	1,33
plus	-4,95559	0,00035	-14102,29	0,000	1,33
Concentration					
0,25	14,9159	0,0004	42446,55	0,000	1,33
0,285	0,857300	0,000351	2439,65	0,000	1,33
MF*Concentration					
minus 0,25	-14,9161	0,0005	-30014,67	0,000	1,78
minus 0,285	-0,857178	0,000497	-1724,85	0,000	1,78
plus 0,25	6,07848	0,00050	12231,34	0,000	1,78
plus 0,285	-0,205633	0,000497	-413,78	0,000	1,78

Fits and Diagnostics for Unusual Observations

Obs	Cohesiveness (N)	Fit	Resid	Std Resid	
13	-35,6880	-35,6847	-0,0033	-3,16	R
15	-35,6820	-35,6847	0,0027	2,53	R

R Large residual

Comparisons for Cohesiveness (N)

Tukey Pairwise Comparisons: MF

Grouping Information Using the Tukey Method and 95% Confidence

MF	N	Mean	Grouping		
minus	9	-1,3121	A		
plus	9	-36,3363		B	
plus and mp	9	-56,4938			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping		
0,25	9	-16,4649	A		
0,285	9	-30,5234		B	
0,33	9	-47,1539			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: MF*Concentration

Grouping Information Using the Tukey Method and 95% Confidence

MF*Concentration	N	Mean	Grouping
minus 0,285	3	-1,3120	A
minus 0,33	3	-1,3120	A
minus 0,25	3	-1,3123	A
plus 0,25	3	-15,3420	B
plus and mp 0,25	3	-32,7403	C
plus 0,285	3	-35,6847	D
plus and mp 0,285	3	-54,5737	E
plus 0,33	3	-57,9823	F
plus and mp 0,33	3	-82,1673	G

Means that do not share a letter are significantly different.

Table B.6 Results for Tukey's mean comparison test for cohesiveness of peanut yogurt samples.

General Linear Model: Consisteny of peanut yogurts versus MF; Concentrations

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
MF	Fixed	3	minus; plus; plus and mp
Concentrations	Fixed	3	0,25; 0,285; 0,33

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
MF	2	1513654	756827	*	*
Concentrations	2	680917	340459	*	*
MF*Concentrations	4	327464	81866	*	*
Error	18	0	0		
Total	26	2522035			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0	100,00%	100,00%	100,00%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	360,4	0,0	*	*	
MF					
minus	-315,5	0,0	*	*	1,33
plus	60,68	0,00	*	*	1,33
Concentrations					
0,25	-178,7	0,0	*	*	1,33
0,285	-28,40	0,00	*	*	1,33
MF*Concentrations					
minus 0,25	171,3	0,0	*	*	1,78
minus 0,285	31,03	0,00	*	*	1,78
plus 0,25	-65,64	0,00	*	*	1,78
plus 0,285	-42,37	0,00	*	*	1,78

Comparisons for Consisteny

Tukey Pairwise Comparisons: MF

Grouping Information Using the Tukey Method and 95% Confidence

MF	N	Mean	Grouping		
plus and mp	9	615,248	A		
plus	9	421,090		B	
minus	9	44,880			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Concentrations

Grouping Information Using the Tukey Method and 95% Confidence

Concentrations	N	Mean	Grouping		
0,33	9	567,539	A		
0,285	9	332,010		B	
0,25	9	181,668			C

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: MF*Concentrations

Grouping Information Using the Tukey Method and 95% Confidence

MF*Concentrations	N	Mean	Grouping								
plus and mp 0,33	3	916,665	A								
plus 0,33	3	736,226		B							
plus and mp 0,285	3	598,192			C						
plus 0,285	3	350,327				D					
plus and mp 0,25	3	330,888					E				
plus 0,25	3	176,716						F			
minus 0,33	3	49,726							G		
minus 0,285	3	47,512								H	
minus 0,25	3	37,402									I

Means that do not share a letter are significantly different.

Table B.7 Results for Tukey's mean comparison test for consistency of peanut yogurt samples

General Linear Model: DM Content (%) of peanut kefirs versus Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	4	peanut kefir (1/4); peanut kefir (1/5); peanut kefir (1/6); peanut kefir (1/7)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	3	115,825	38,6083	75950,75	0,000
Error	8	0,004	0,0005		
Total	11	115,829			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)

0,0225462	100,00%	100,00%	99,99%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	15,1583	0,0065	2328,99	0,000	
Concentration					
peanut kefir (1/4)	4,0917	0,0113	362,96	0,000	1,50
peanut kefir (1/5)	1,5117	0,0113	134,09	0,000	1,50
peanut kefir (1/6)	-1,4083	0,0113	-124,93	0,000	1,50

Comparisons for DM Content (%)

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping
peanut kefir (1/4)	3	19,2500	A
peanut kefir (1/5)	3	16,6700	B
peanut kefir (1/6)	3	13,7500	C
peanut kefir (1/7)	3	10,9633	D

Means that do not share a letter are significantly different.

Table B.8 Results for Tukey's mean comparison test for DM (%) of peanut kefir samples.

General Linear Model: WHC (%) of peanut kefirs versus Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	4	peanut kefir (1/4); peanut kefir (1/5); peanut kefir (1/6); peanut kefir (1/7)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	3	323,055	107,685	1251,18	0,000
Error	8	0,689	0,086		

Total	11	323,743

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,293371	99,79%	99,71%	99,52%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	27,8783	0,0847	329,18	0,000	
Concentration					
peanut kefir (1/4)	6,778	0,147	46,21	0,000	1,50
peanut kefir (1/5)	2,652	0,147	18,08	0,000	1,50
peanut kefir (1/6)	-2,452	0,147	-16,71	0,000	1,50

Fits and Diagnostics for Unusual Observations

Obs	WHC (%)	Fit	Resid	Std Resid	
3	34,000	34,657	-0,657	-2,74	R

R Large residual

Comparisons for WHC (%)

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping			
peanut kefir (1/4)	3	34,6567	A			
peanut kefir (1/5)	3	30,5300		B		
peanut kefir (1/6)	3	25,4267			C	
peanut kefir (1/7)	3	20,9000				D

Means that do not share a letter are significantly different.

Table B.9 Results for Tukey's mean comparison test for WHC (%) of peanut kefir samples.

General Linear Model: Syneresis (%) of peanut kefirs versus Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	4	peanut kefir (1/4); peanut kefir (1/5); peanut kefir (1/6); peanut kefir (1/7)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	3	673,332	224,444	12121,19	0,000
Error	8	0,148	0,019		
Total	11	673,480			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,136076	99,98%	99,97%	99,95%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	43,7800	0,0393	1114,51	0,000	
Concentration					
peanut kefir (1/4)	-10,0333	0,0680	-147,47	0,000	1,50
peanut kefir (1/5)	-3,4500	0,0680	-50,71	0,000	1,50
peanut kefir (1/6)	3,5033	0,0680	51,49	0,000	1,50

Comparisons for Syneresis (%)

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping		
peanut kefir (1/7)	3	53,7600	A		
peanut kefir (1/6)	3	47,2833		B	
peanut kefir (1/5)	3	40,3300			C

peanut kefir (1/4)	3	33,7467	D

Means that do not share a letter are significantly different.

Table B.10 Results for Tukey's mean comparison test for Syneresis (%) of peanut kefir samples.

General Linear Model: ΔE of peanut kefirs versus Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	4	peanut kefir (1/4); peanut kefir (1/5); peanut kefir (1/6); peanut kefir (1/7)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	3	15,5000	5,16667	60,19	0,000
Error	8	0,6867	0,08583		
Total	11	16,1867			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,292973	95,76%	94,17%	90,46%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	10,1333	0,0846	119,82	0,000	
Concentration					
peanut kefir (1/4)	1,667	0,146	11,38	0,000	1,50
peanut kefir (1/5)	0,167	0,146	1,14	0,288	1,50
peanut kefir (1/6)	-0,333	0,146	-2,28	0,052	1,50

Fits and Diagnostics for Unusual Observations

Obs	ΔE	Fit	Resid	Std Resid

4 10,800 10,300 0,500 2,09 R

R Large residual

Comparisons for ΔE

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping		
peanut kefir (1/4)	3	11,8000	A		
peanut kefir (1/5)	3	10,3000		B	
peanut kefir (1/6)	3	9,8000		B	
peanut kefir (1/7)	3	8,6333			C

Means that do not share a letter are significantly different.

Table B.11 Results for Tukey's mean comparison test for color of peanut kefir samples.

General Linear Model: Firmness of kefirs versus Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	6	commercial kefir B; commercial kefir B; peanut kefir (1/4);peanutkefir(1/5); peanut kefir (1/6); peanut kefir (1/7)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	5	65,2573	13,0515	5514,31	0,000
Error	12	0,0284	0,0024		
Total	17	65,2857			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0486501	99,96%	99,94%	99,90%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	8,0764	0,0115	704,32	0,000	
Concentration					
commercial kefir B	1,0793	0,0256	42,09	0,000	1,67
commercial kefir A	1,6736	0,0256	65,27	0,000	1,67
peanut kefir (1/4)	2,0056	0,0256	78,22	0,000	1,67
peanut kefir (1/5)	0,1749	0,0256	6,82	0,000	1,67
peanut kefir (1/6)	-1,5824	0,0256	-61,71	0,000	1,67

Fits and Diagnostics for Unusual Observations

Obs	Firmness (g)	Fit	Resid	Std Resid	
1	10,1960	10,0820	0,1140	2,87	R
3	10,0000	10,0820	-0,0820	-2,06	R

R Large residual

Comparisons for Firmness

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping					
peanut kefir (1/4)	3	10,0820	A					
commercial kefir A	3	9,7500		B				
commercial kefir B	3	9,1557			C			
peanut kefir (1/5)	3	8,2513				D		
peanut kefir (1/6)	3	6,4940					E	
peanut kefir (1/7)	3	4,7253						F

Means that do not share a letter are significantly different.

Table B.12 Results for Tukey's mean comparison test for firmness of kefir samples.

General Linear Model: Cohesiveness of kefirs versus Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	6	commercial kefir B; commercial kefir A; peanut kefir (1/4); peanut kefir (1/5); peanut kefir (1/6); peanut kefir (1/7)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	5	10,5262	2,10524	1148,73	0,000
Error	12	0,0220	0,00183		
Total	17	10,5482			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0428097	99,79%	99,70%	99,53%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-2,9291	0,0101	-290,28	0,000	
Concentration					
commercial kefir B	0,7171	0,0226	31,78	0,000	1,67
commercial kefir A	-0,0843	0,0226	-3,74	0,003	1,67
peanut kefir (1/4)	-1,3036	0,0226	-57,78	0,000	1,67
peanut kefir (1/5)	-0,5319	0,0226	-23,58	0,000	1,67
peanut kefir (1/6)	0,2261	0,0226	10,02	0,000	1,67

Fits and Diagnostics for Unusual Observations

Obs	Cohesiveness (N)	Fit	Resid	Std Resid	
16	-2,3120	-2,2120	-0,1000	-2,86	R
17	-2,1120	-2,2120	0,1000	2,86	R

R Large residual

Comparisons for Cohesiveness

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping					
peanut kefir (1/7)	3	-1,95233	A					
commercial kefir B	3	-2,21200		B				
peanut kefir (1/6)	3	-2,70300			C			
commercial kefir A	3	-3,01333				D		
peanut kefir (1/5)	3	-3,46100					E	
peanut kefir (1/4)	3	-4,23267						F

Means that do not share a letter are significantly different.

Table B.13 Results for Tukey's mean comparison test for cohesiveness of kefir samples.

General Linear Model: Consisteny of kefirs versus Concentration

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Concentration	Fixed	6	commercial kefir B; commercial kefir A; peanut kefir (1/4);peanutkefir(1/5); peanut kefir (1/6); peanut kefir (1/7)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Concentration	5	5337,44	1067,49	34446,93	0,000
Error	12	0,37	0,03		
Total	17	5337,81			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,176038	99,99%	99,99%	99,98%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	33,6999	0,0415	812,19	0,000	
Concentration					
commercial kefir B	-20,4846	0,0928	-220,79	0,000	1,67
commercial kefir A	-20,9539	0,0928	-225,84	0,000	1,67
peanut kefir (1/4)	25,0531	0,0928	270,03	0,000	1,67
peanut kefir (1/5)	15,1651	0,0928	163,45	0,000	1,67
peanut kefir (1/6)	6,1814	0,0928	66,62	0,000	1,67

Fits and Diagnostics for Unusual Observations

Obs	Consisteny(N.s)	Fit	Resid	Std Resid	
12	28,260	28,739	-0,479	-3,33	R

R Large residual

Comparisons for Consisteny

Tukey Pairwise Comparisons: Concentration

Grouping Information Using the Tukey Method and 95% Confidence

Concentration	N	Mean	Grouping
peanut kefir (1/4)	3	58,7530	A
peanut kefir (1/5)	3	48,8650	B
peanut kefir (1/6)	3	39,8813	C
peanut kefir (1/7)	3	28,7387	D
commercial kefir B	3	13,2153	E
commercial kefir A	3	12,7460	E

Means that do not share a letter are significantly different.

Table B.14 Results for Tukey’s mean comparison test for consistency of kefir samples.