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Research Article

Preparation and Quality Assessment of Fruit Yoghurt with Persimmon *(Diospyros kaki)*

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Abstract: Yoghurt is a fermented dairy product developed by fermentation of milk with *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. Assimilation of fruit pulp can boost the nutritional and health benefits of the yoghurt to many folds. The prime objective of preparing fruit yoghurt with the addition of persimmon pulp was to enhance the nutritional value and to improve overall acceptance. Yoghurt was prepared with the incorporation of persimmon in the concentration of 5%, 10% & 15% to assess the best combination. Evaluation of physico-chemical and organoleptic properties was performed during storage. The product was stored for 28 days at 4°C and quality parameters were assessed at an interval of 7 days. Acidity, total solids, and moisture content of fruit yoghurt increased while pH, lactose, protein, fat and textural profile values decreased significantly ($p < 0.01$) during storage. The phenolic content of the controlled sample was 175 mg GAE/g, which increased to 180, 214 and 250 mg GAE/g with 5%, 10% & 15% persimmon combinations respectively. Syneresis value for controlled sample was 2.49% which decreased to 2.45%, 1.94% & 1.10% in 5, 10 & 15% persimmon blends. Additionally, the sensorial properties of yoghurt blended with 10% fruit pulp gained higher acceptability during storage at 4°C.

Keywords: Fruit yoghurt, persimmon, syneresis, health benefits, organoleptic properties

1. INTRODUCTION

Changing lifestyles and increasing consumer's demands make it necessary to formulate new food products which have a better nutritional profile and have more consumer acceptability [1]. In this era, demand for milk-based fermented products and yoghurt has been increased due to its beneficial health consequence on consumers [2]. Yoghurt starts from countries around the Mediterranean Sea and Bulkan. According to FAO/WHO yoghurt is a coagulated dairy product developed from lactose fermentation due to the activity of starter culture such as *Lactobacillus dulbruicki* subsp. *bulgaricus* and *Streptococcus thermophillus* obtained from milk and milk products [3]. The lactic acid produced during the fermentation process changes the milk protein which provides a unique taste and pleasant flavour to the yoghurt [4]. During the formation of yoghurt, whey powder, skim milk powder and milk powder are incorporated into the milk to achieve desire characteristics [5]. The cultured organism in the finished product must be sustainable and should be in sufficient amount to perform its function [6]. Yoghurt has a huge amount of vitamins, minerals, proteins along with viable beneficial bacteria [6, 7]. A 100 g of yoghurt gave 257 KJ energy, carbohydrate (4.7 g), vitamin A (27 µg), fat content (3.3 g), protein (3.5 g) and riboflavin (0.14 mg) and also some proportions of vitamin B6 and vitamin B12. Yoghurt contained a high amount of salt, vitamins and major nutrients as compared to milk [8].

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Yoghurt improves the immune system, decreases cancer, prevent diarrhoea, help in absorptions of iron, protein and calcium [9]. Yoghurt lowers the blood cholesterol level and imparts many other health benefits owing to the presence of protein. Yoghurt strengthens the abdomen and provides assistance to the nervous system and decreases bowel cancer and inflammation effectively due to the availability of vitamins. Yoghurt also helps to reduce various disorders such as intestinal illnesses. Yoghurt promotes gut and vaginal fitness by providing probiotics (beneficial bacteria) [10]. Regular consumption of yoghurt suppressed the pathogenic bacteria like *Helicobacter pylori* which cause stomach ulcers [11]. The culturing organisms in yoghurt convert lactose into lactic acid that is easily digestible by lactose-intolerant persons [12]. Fruits contain a large number of minerals, vitamins, sugar content, dietary fibre and a smaller amount of fat content [13]. The bioactive substances required for the proper functioning of the body are provided by fruits because fruits are a rich supplier of natural antioxidants and dietary fibre [14].

Persimmon (*Diospyros kaki*) is an edible fruit that belongs to Ebenaceafamilywith a sweet/ slightly tangy taste and fibrous to the soft texture, originated from China and Japan [15]. Persimmon contains total lipid (0.19%), total carbohydrate (18.6%) water (80.3%), protein (0.58%) and several minerals such as copper, magnesium, manganese zinc and iron [16]. Total dietary fibre is 1.48% and ascorbic acid comprises 7.5mg. Persimmon contains a high amount of sugar 12.5 g/100 g than other highly consume fruit such as apple, peach, pear and orange [17, 18]. Persimmon fruit has several health benefits against diabetes, blood pressure, diuretics, cough, and a variety of viral and bacterial transmittable diseases, including dental caries [19]. The beneficial properties of persimmon are due to the availability of several bioactive compounds like carotenoid and polyphenol which play a vital role in anticipation of degenerative diseases [15]. Persimmon fruit furthermore utilizes in the development of numerous products because of its functional characteristics [19].

The yoghurt prepared with fruit is a fastidious variety of yoghurt which is mostly liked by all people around the world is fruit yoghurt [20]. Assimilation of different fruits makes the fruit yoghurt good-looking [21, 22]. Incorporation of fruit in yoghurt development improves formulation and increases the taste and results in a good flavour product which accompanied the refreshing and health-promoting effects [23, 24]. FAO/WHO recommended percentage of fruit in yoghurt should be in the range of 5 to 15% [25, 26]. In Pakistan Persimmon is also consumed extensively but unfortunately, it was not used in different dairy products. So in the current study fruit yoghurt was prepared with the following objectives: 1) To develop fruit yoghurt with supplementation of persimmon, and 2) To evaluate the acceptability, textural properties and shelf life of persimmon fruit yoghurt.

2. MATERIALS AND METHODS

2.1 Materials

Fresh whole buffalo milk was collected from the Dairy Farm of the University of Agriculture Faisalabad. Fresh Persimmon (*Diospyros kaki*, oriental persimmon) collected from Gilgit-Baltistan region, stabilizer and skim milk powder was purchased from local market of Faisalabad and starter culture was obtained from SAAF International Pvt. Lt.

2.2 Preparation of Persimmon Pulp

Fresh Persimmon (*Diospyros kaki*, oriental persimmon) which is non-astringent (sweet) collected from the Gilgit-Baltistan region. Fresh fruit was washed in tap water to remove dust and residue. Peel of persimmon was removed with a sharp knife, after peeling fruit pulp was extracted. Then fruit pulp was homogenized and blanched at 70^{o}C for 5 minutes to kill possible spores of pathogenic microorganisms. Then fruit pulp was stored at refrigeration temperature (4^{o}C) for further use.

2.3 Preparation of Yoghurt

Raw milk was standardized to 3.5% fat and 11.0% solid, not fat by adding skim milk powder and stabilizer 0.5% was added and 2% starter culture was inoculated. The yoghurt mixture was pasteurized for 10 minutes at 90^{o}C then cool to 45^{o}C. After that different concentration of fruit pulp such

as 5%, 10% and 15% was added into the yoghurt mixture and incubated at 42°C for four hours in the incubator. After that yoghurt was placed at 4°C in refrigeration temperature to evaluate physico-chemical parameters of fruit yoghurt during the storage period. The yoghurt was prepared with slight modification followed by the procedure of Arslan *et al.* [15]. The schematic diagram of fruit yoghurt was presented in figure 1 below.

2.4 Physico-chemical Analysis of Raw Milk

The physico-chemical analysis of raw milk was performed for pH, total solids, crude protein, lactose, titratable acidity, total solid, solid not fat, moisture content and fat according to AOAC [26].

2.5 Physico-chemical Analysis of Fruit Yoghurt

Physico-chemical analysis for crude protein, pH, total solids, ash, moisture, titratable acidity, fat, lactose content was carried out according to AOAC [26]. Data obtained from all parameters were assessed by statistic 8.1 under CRD design [27].

2.5.1 Measurement of syneresis

Syneresis of yoghurt was determined by following the method of Amatayakul *et al.* [28]. The yoghurt sample of 5 ml was taken in the conical tube to measure the syneresis value and placed the sample in a centrifuge machine at 36000 rpm for 30 minutes. After that, the whey appeared on the surface of the conical tube which was removed with help of the syringe carefully to avoid mixing. Then measured the volume of that removed whey and recorded the value of syneresis in percentage.

2.5.2 Determination of total phenolic content

Total phenolic content in the yoghurt sample was determined by spectrophotometer through

Table 1. Physico-chemical analysis of raw milk

Parameter	Quantity (%)*
Ash	0.76%
Fat	7.6%
Protein	4.14%
pH	6.62
Acidity	0.14%
Lactose	5.02%
TS	16.70%
SNF	9.87%
Moisture content	84.16%

*The values are the means of three replications for each parameter

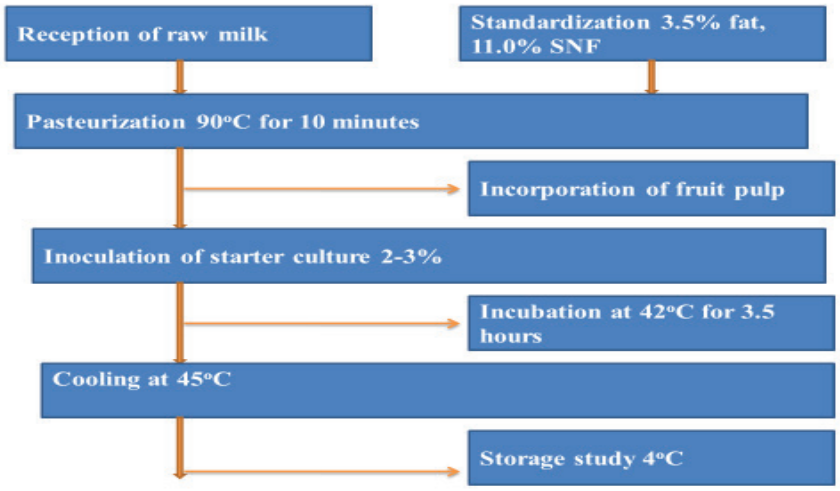

Fig. 1. Schematic diagram of yoghurt supplemented with persimmon

Ciocalteu reagent [29]. An amount of 10 ml of yoghurt sample was diluted with 20 ml of distilled water and mixed with 10 ml of 6% ethanol solution. The mixture was poured into a beaker and kept for 30 minutes at room temperature. The mixture was then stirred for 15 minutes at 15000 rpm in an electrical stirrer. After stirring the extracted sample was placed at room temperature at 25oC and 1.5 ml of 0.2 N Folin-Ciocalteu reagent was mixed with the sample. After 5 minutes, 1.2 ml of 0.7 N Sodium Carbonate was mixed with 0.3 ml of extracted yoghurt sample and poured into a beaker. The prepared sample was placed in the incubator for 2 hours at room temperature. After incubation, the sample was placed in a spectrophotometer to check the absorbance of the total phenolic content at 765 nm by using Gallic acid as standard and the values were expressed as GAE/g of yoghurt.

2.5.3 Determination of textural profile

The texture of prepared yoghurt was determined by a texture analyzer (Version 6.0, Hamilton, MA, USA) according to [26]. For this purpose, a cylinder probe, made of aluminium having a diameter of 35 mm was inserted into yoghurt at a speed of 5 mm/s to measure the body texture and noted reading in triplicates.

2.5.4 Analysis of organoleptic properties

The sensory characteristic of prepared yoghurt was determined by the method of Meilgaard *et al*. [30] by using 9 points hedonic score system. The parameters colour, aroma, taste, mouthfeel and overall acceptability was measured. The score contains numbers from 1 (dislike extremely) to 9 (like extremely).

3. RESULTS AND DISCUSSION

From table 1, it is revealed that fat content in whole raw buffalo milk was in the range of 6 - 7% [31 - 33]. Buffalo milk is considered healthier and more economical as compared to cow milk because of the higher concentration of unsaturated fatty content [34, 35]. Khedkar *et al.* also stated that the fat content (6.7%) of buffalo whole milk is the richest than other cattle milk [36]. Persimmon restrains total lipid (0.19%), total carbohydrate (18.6%), water (80.3%), protein (0.58%) and several minerals such as copper, magnesium, manganese zinc and iron [16]. Persimmon contains a high amount of sugar (12.5 g/100 g) than other highly consumed fruits such as apple, peach, pear and orange. Total dietary fibre is 1.48% and ascorbic acid comprises 7.5 mg [17, 18].

Persimmon contains a large number of antioxidants that provide shelter to various diseases. Among antioxidants; carotenoids, tocopherol, polyphenol is most abundant [37]. The leave and fruit of persimmon hold components as proanthocyanidin, flavonoid, tannin, catechin, phenolic acid etc and mainly exacting portions are carotenoid and tannin components [38]. The titratable acidity, pH and total soluble solids (TSS) were set up in the range of 0.12 g / 100 g, 5.52 and 11.5% respectively. Celik and Ersisli [39] stated the average content of titratable acidity, pH and total soluble solids were 2.06%, 5.40 and 17.1. Candir *et al.* reported that the content of TSS, pH and titratable acidity were like the results of previous experiments [40]. The overall sugar content of persimmon was 16.3 g / 100 g, while glucose and fructose contents were 10.2 and 6.13 g / 100 g respectively. Chen *et al.* reported that total phenolic content 32.3 mg / 100 g [41].

Table 2. Treatment plan of fruit supplemented yoghurt

Treatments	Yoghurt Mixture %	Fruit Pulp %
T_{0i}	100	-t
T_{1i}	95	5t
T_{2l}	90	10t
T_{3l}	85	15t

3.2 Physico-chemical Analysis of Yoghurt

The yoghurt mixture was incorporated with persimmon fruit to formulate nutritiously rich fruit yoghurt to fulfil the dietary requirements of consumers in the present study (Table 2). The purpose of this experiment was to find out the organoleptic as well as physico-chemical characteristics of fruit yoghurt which make it possible to meet the increasing market demand. The findings of all parameters from treatments were discussed below.

3.2.1 Total Acidity (%)

The distinct acidic flavour in yoghurt is attributed to the action of lactic acid bacteria which breaks down lactose into lactic acid. The mean values regarding the acidity of yoghurt fortified with *Diospyros kaki* have shown a non-significant ($p < 0.01$) increasing trend during storage (Table 3). The acidity for the control sample (T_0) was noted as 1.10% which was lower than the treated samples with different concentrations of persimmon at zero days. The incorporation of fruit leads to a rise in the acidity level at different study intervals of 7 days in fruit yoghurt. From the present findings, higher acidity of 1.69% was found in sample T_3 with a higher amount of fruit at the end day of the storage study.

The acidity of fortified yoghurt was also low but the water holding capacity of fortified yoghurt was increased due to the presence of fibres and pectin in apple pulp, as compared to control. Anuyahong *et al.* reported that the accumulation of red rice into yoghurt did not influence pH and titratable acidity when compared to the control yoghurt [42]. Similar results were also found in other reports of yoghurt supplemented with grape, green coffee powder, and blueberry flower pulp [43 - 45]. Nguyen also demonstrated similar findings [46]. The level of titratable acidity of yoghurt blended with apple and tulsi leaf extract also meets the required criteria established by the Codex Alimentarius which defines that the titratable acidity (express as % lactic acid) of yoghurt should not be less than 0.6%. Comparable findings were revealed that the acidity content of fruit yoghurt increased with the increasing amount of fruit [47].

The higher acidity values of persimmon yoghurt in our study might be because of the function of lactic acid bacteria and the development of lactic acid during storage [6, 48]. Petridis *et al.* demonstrated that the acidity of the yoghurt prepared with honey and pomegranate juice increased along the storage period [49]. The lactic acid bacteria convert the lactose content into lactic acid which increased the acidity of fruit yoghurt. The incorporation of fruit and the amount of pulp increased the acid content of fruit yoghurt. The higher acidity values of persimmon yoghurt in our study might be because of the function of lactic acid bacteria and more production of lactic acid during storage. The varying results of the experiment indicated that the addition of different constituents and prolonged storage time increased the acidity of the fruit yoghurt and thus resulted in poor quality with sore taste.

3.2.2 pH

The pH of yoghurt indicates the shelf life of the product throughout storage. Results from mean values revealed that the addition of persimmon non-significantly influenced ($p < 0.01$) the characteristics of fruit yoghurt (Table 3). The mean value of the controlled sample was higher (4.66) than samples incorporated with fruit pulp. The mean values of pH decreased in all samples during storage at 4 °C, the lowest pH value was observed in sample T_3 with 15% fruit pulp followed by T_2, T_1 and T_0 respectively. Similar trends have been reported by previous studies that the addition of different fruits significantly lowers the pH during storage study [6, 50, 51].

De Moura *et al.* investigated that the pH value of fruit smoothies declined during storage intervals [52]. Buchilina *et al.* also demonstrated that the pH content of yoghurt declined with camel milk with monk fruit sweetener [53]. pH is the most imperative physicochemical parameter in yoghurt manufacturing, since the yoghurt production process is complete, by definition, when a pH (4.7) is reached (corresponding to the average isoelectric point for caseins) [54]. The main reason for the decrease in pH and increase in acidity during fermentation of yoghurt was the lactic acid produced by yoghurt starter culture [55]. Michael *et al.* reported that the pH of yoghurt ranged between 4.3 and 4.6 [56]. Supplementation of *H. sabdariffa*

calyx extract into the reconstituted low-fat milk yoghurt resulted in a significant reduction of pH 4.4-4.16 vs.4.54-4.31 as control [57].

Gunawardhana *et al.* observed higher acidity and lower pH of yoghurt incorporated with apple juice such that an increase in apple juice concentration in yoghurt leads to increased acidity [58]. It was noticed that the acid content and pH value of fruit yoghurt has an inverse relationship with each other, increasing acidic content leads to a lower pH value of fruit yoghurt. Yoghurt is an acidic dairy product with natural keeping quality. However, the quality deteriorates quickly with time as the acidity increases and pH value decreased over the storage period.

3.2.3 Ash (%)

Ash is the remaining substance comprised of minerals after charring the fruit yoghurt. In other words, ash content is the measure of the total amount of minerals present within the food. Minerals are the amount of specific inorganic components present within food such as Ca, Na, K and Cl. Results have shown a highly significant ($p < 0.01$) interaction between treatments and storage. The mean values (Fig. 2) for ash content of fruit yoghurt supplemented with persimmon pulp was recorded considerably in the range of 1.67%, 1.65%, 1.84% and 1.77% respectively within treatments at zero days. These values decreased along with the treatment with an increasing amount of fruit pulp as 5, 10 & 15%. The present outcomes indicated a reduction in ash content of yoghurt samples (T_0, T_1, T_2 and T_3) which were recorded as 0.47%, 0.20%, 0.14% and 0.08% respectively during the 28th day of storage. The present work was found in agreement with the previous finding of Roy *et al.* and Bakirci *et al*. stating that the ash content decreases with the addition of fruit pulp [51, 59].

According to the study conducted by Ismail *et al*. who reported that the ash content increased in yoghurt developed with the fortification of apricot juice than red grape juice [60]. These reports propose that the ash content in fruit fortified yoghurt is affected by the type of fruits. Those blended fruits having higher ash content will result in increased values of ash while lower ash containing fruits will have fewer values in the end product. Thus, the current results show that the ash content of fruit yoghurt blended with persimmon is low due to the lower ash contents of persimmon fruit. The declining trend in ash content of fruit yoghurt was possibly due to the profound influence of persimmon pulp during the development of fruit yoghurt because persimmon has a low amount of ash content. Ash content reduced could be attributed to loss, water carries off the mineral during refrigeration storage. During storage and processing operations, inorganic salt leach off due to inappropriate storage condition.

3.2.4 Protein

It was revealed from the results (Fig. 3) that the persimmon had a noteworthy effect ($p < 0.01$) on the protein content of yoghurt due to different concentrations of fruit pulp along with treatments. The protein content showed a declining trend non-significantly along with the storage at 4^0C. The mean value of protein of the control yoghurt sample was recorded maximum of 4.78% while the yoghurt sample with fruit pulp has a low content of protein

Table 3. Effect of persimmon on acidity and pH of fruit yoghurt

Parameters	Samples	Storage (days)				
		0	7	14	21	28
pH	T_0	1.10±0.04	1.31±0.04	1.45±0.04	1.57±0.06	1.60±0.06
	T_1	1.11±0.03	1.37±0.05	1.42±0.06	1.48±0.07	1.53±0.08
	T_2	1.14±0.05	1.41±0.07	1.46±0.07	1.51±0.05	1.56±0.07
	T_3	1.19±0.06	1.47±0.05	1.56±0.05	1.59±0.05	1.69±0.05
	T_0	4.66±0.16	4.62±0.14	4.46±0.14	4.38±0.18	4.32±0.1
	T_1	4.64±0.14	4.61±0.19	4.54±0.18	4.38±0.22	4.34±0.22
	T_2	4.52±0.18	4.50±0.22	4.38±0.22	4.26±0.13	4.31±0.12
	T_3	4.44±0.22	4.42±0.15	4.37±0.13	4.35±0.14	4.30±0.17

within treatments at zero-day of storage. On the 28th day of the storage study lowest protein content was recorded as 0.08% in the yoghurt sample with 15% of fruit pulp due to the low content of protein in fruit. The current study was supported by Bakirci *et al.* [59] and Mohamed *et al*. [61]. Brodziak *et al.* stated that the protein content of fruit yoghurt reduces during the storage study [62].

Ismail *et al.* researched fruit yoghurt and evaluated that the protein content decline during cold storage [60]. Similar results were reported by Roy *et al.* [51], Mbaeyi-Nwaoha *et al.* [63] and Desouky *et al.* [64] that protein content was decreased in the fruit-flavoured treatment with the accumulation of fruit juices because fruit juices are full of lower protein than milk. Escalating the amount of fruit juices significantly decreased the protein percentage. The declining trend in protein content was might be due to the proteolytic activity of microorganisms which degrades the protein content due to the high amount of acid content of fruit yoghurt during storage as demonstrated by [33, 50]. Scientists investigated that the addition of fruit pulp significantly reduced ($p < 0.01$) the protein content of yoghurt due to less content of protein in fruit [65].

3.2.5 Fat

Fat content is considered an important component of milk, it builds up organoleptic characteristics

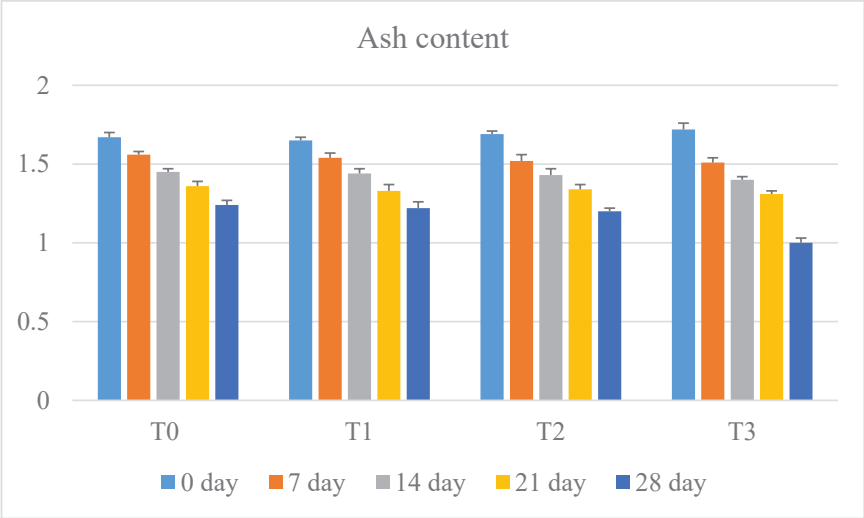

Fig. 2. Effect of persimmon on the ash of yoghurt

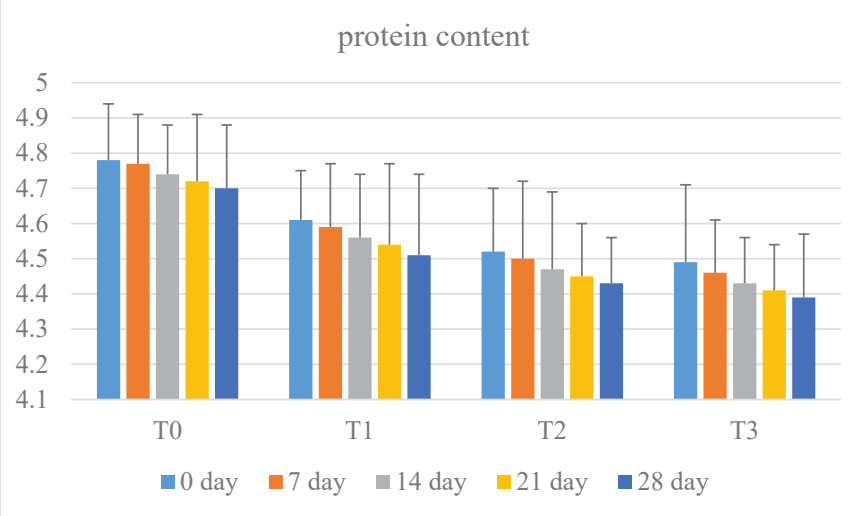

Fig. 3. Effectof persimmon on the protein content of yoghurt

like appearance and texture of milk as well as it plays a major role in products development. It was evaluated from the finding (Fig. 4) that persimmon had a considerable effect on yoghurt quality due to the difference in concentration of fruit. The storage interval revealed a decline trend non-significantly ($p < 0.01$) in the fat content of fruit yoghurt. The mean value of fat of control yoghurt was a maximum of 3.48% and the mean values of the fat content of yoghurt samples with fruit pulp decreased along with treatments at 0 days of storage. The lowest fat content 2.95% was recorded in the yoghurt sample with 15% fruit pulp at 28 days of storage study.

These results agree with previous studies which confirmed these outcomes [66 - 69]. Increasing the number of fruit juices were significantly declined the fat percent for all yoghurt treatments because the fruit juices contain low-fat content than milk [60]. Palka and flis [70] stated that yoghurt formulated with various vegetable and fruit extracts and studied the storage period which shows lower fat content throughout the period.

The researcher reported that the addition of pumpkin reduced the fat content [59] while on the other hand, another study observed that supplementation of apricot (3, 6 & 9%) reduced the fat content in fruit yoghurt [6]. Brodziak *et al.* analyses that the fat content of fruit yoghurt gradually declines during the storage interval of 21 days [61]. The declining trend in fat content of fruit yoghurt might be due to the formation of volatile fatty acids as a result of the breakdown of fat content which caused to significantly reduce the fat content of fruit yoghurt, thus the fat is split due to the function of lactic acid bacteria in yoghurt. Another reason behind the low amount of fat content in fruit yoghurt might be due to less amount of fat in fruit.

3.2.6 Syneresis

Syneresis is the collection of whey on the surface of the yoghurt. It was observed from the results (Fig. 5) that the addition of persimmon fruit had the potential effect ($p < 0.01$) on syneresis due to different concentrations of fruit. The syneresis for the control sample was noted as 2.49% which was greater as compared to yoghurt prepared with the addition of fruit as 2.45, 1.90 and 1.10%. The addition of persimmon fruit reduced the syneresis value along with the treatments and mean values gradually reduced during storage intervals. The lowest value 3.00% for syneresis of yoghurt was found in sample (T_3) after the 28th day of storage study because of the high concentration of fruit pulp.

Literature showed that supplementation of *H. sabdariffa* Calyx extract into the probiotic yoghurt resulted in syneresis 18.85 to 24.90 ml / 50 gm of the sample [71]. Yoghurts enriched by *H. polyrhizus* resulted in a higher syneresis percentage

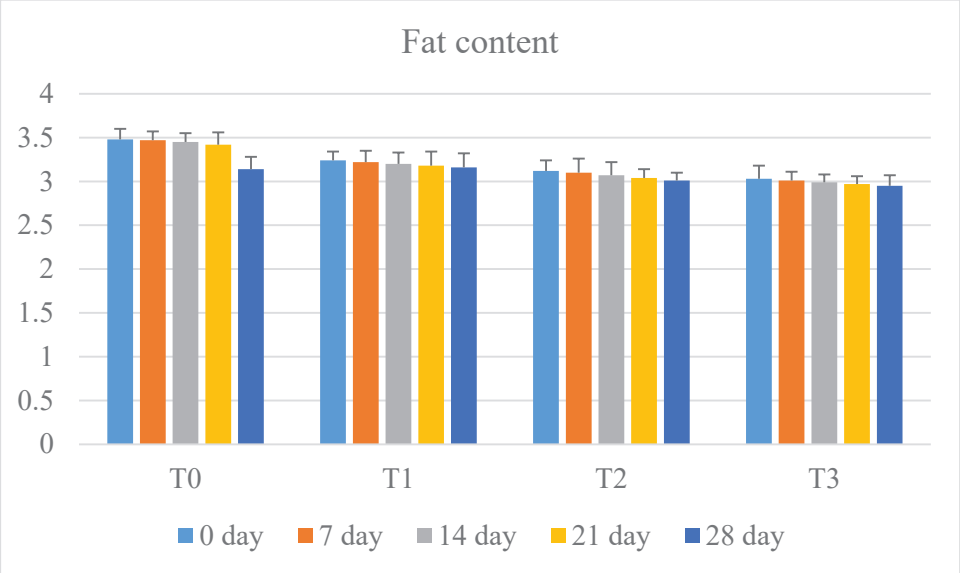

Fig. 4. Effect of persimmon on the fat content of yoghurt

(57.19 - 70.32%) compared to plain yoghurt (52.93%) [56]. Nguyen stated yoghurt developed with *H. sabdariffa, H.polyrhizus* and *P. bivalvis* extract that syneresis value increase during the storage time [57]. Similar results were found that the addition of fruit considerably reduced the syneresis value during the storage periods [51, 59, 61]. While a study reported that the addition of concentrated grape juice in yoghurt caused to increase in the syneresis value at 4 °C after 15 days of storage period [72]. The increasing trend might be due to inappropriate storage condition that leads to increase the syneresis value of yoghurt during the storage period. The low pH and high acid content lose the water holding capacity in yoghurt with storage which possibly be the reason to increase the syneresis value in refrigeration conditions.

3.2.7 Total phenolic content

The menace of diseases such as cardiovascular diseases and cancer is reduced because of consumption of fruit and vegetables regularly because they are comprised of natural antioxidants like ascorbic acid, phenolic content. The natural antioxidant has proved to reduce the chances of occurrence of coronary heart diseases. The current findings (Fig. 6) revealed that the persimmon had a significant effect ($p < 0.01$) on the total phenolic content of yoghurt due to variation in concentration of fruit within treatments. The total phenolic content for the control yoghurt sample (T_0) was lowest (157%) as compared to the yoghurt sample containing persimmon fruit (180, 214 and 250%). The addition of persimmon fruit caused to increase in the total phenolic content of yoghurt along the storage period at refrigeration temperature 4°C. The yoghurt sample with a high concentration of fruit pulp (T_3) gained higher total phenolic content because of the higher amount of total phenolic content of persimmon fruit.

Yoghurt supplemented with *H. sabdariffa* had the highest total phenolic content (9.4 - 9.7 mg GAE / 100 gm). Meanwhile, the control yoghurt had the lowest total phenolic content (3.0 - 3.4 mg GAE / 100 gm). *H. sabdariffa* L. flowers marmalade significantly increased total phenolic content (5.57 - 14.69 mg GAE / 100 gm) of formulated yoghurt [73]. Dimitra *et al.* conducted a similar study and find out the results which show resemblance [74]. The addition of different fruit leads to an increase in the total phenolic content of fruit yoghurt during the period [15, 75]. The high concentration of phenolic content in persimmon fruit could be the possible reason for the increasing amount of phenolic content in fruit yoghurt as well as the higher antioxidant potential caused to raise the total phenolic content of fruit yoghurt. The antioxidant potential is attributed to phytochemicals that scavenge the free radicals. Any fruit high in phytochemicals will show high activity.

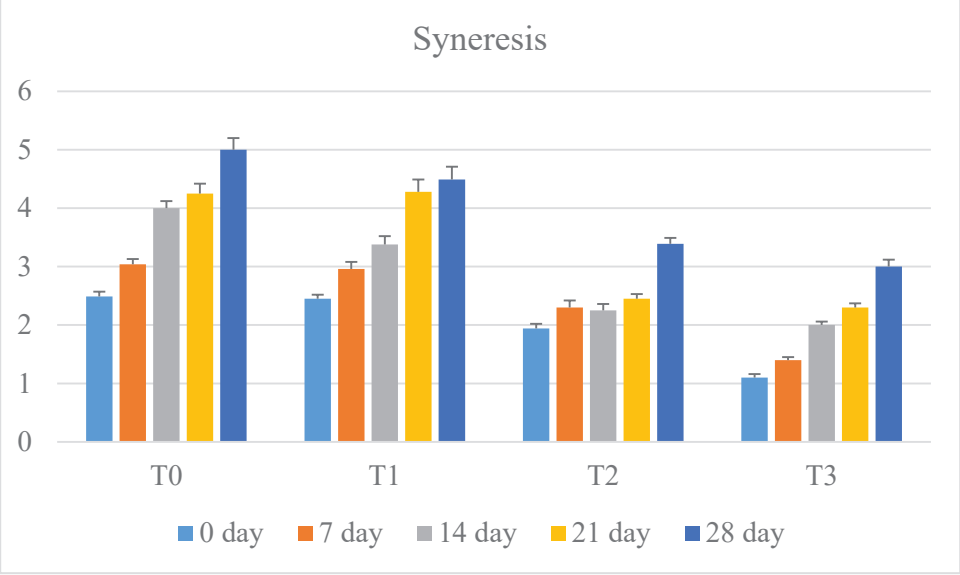

Fig. 5. Effect of persimmon on syneresis of yoghurt

3.2.8 Total solid content

The mean values for total solids of fruit yoghurt have shown that the addition of persimmon fruit highly affects ($p < 0.01$) the total solid content of yoghurt because of various concentrations of fruit within treatment (Fig. 7). The mean value of total solid content of the control sample (T_0) was found lowest at 15.70% than other yoghurt samples supplemented with persimmon fruit. The yoghurt samples were evaluated at 7 day's intervals to check the effect of persimmon on the total solid content of yoghurt. The finding revealed that total solid content increased within treatments due to increasing amounts of persimmon fruit as 5%, 10% and 15% respectively. During the storage study, the total solid content was increased to 16.60%, 16.75% and 16.80% respectively. From current results (Fig. 7), it was concluded that yoghurt containing 15% persimmon pulp had a maximum concentration of total solids (16.80%) at the end day of storage.

Addition of apricot fruit in concentration (3, 6 and 9%) caused to raise total solid of yoghurt as 16.15% to 16.55%, 16.29% to 16.06% and 16.44% to 16.88% [6]. These findings found a resemblance with the literature [58,71, 76, 77, 78]. It was analyzed that addition of fruit juice caused to increase in the total solid content of yoghurt. The researcher examined that total solid content was significantly increased ($p < 0.01$) by the treatments due to variation in quantities of fruit [15]. Another study supported the present study that the addition of banana caused to significantly increase ($p < 0.01$) in the total solid contents of yoghurt during storage [47]. Ritu *et al.* observed that the addition of 5% and 15% pineapple juice increased the total solid content of yoghurt as compared to plain yoghurt [79]. The total solid content was the increase in yoghurt developed with the fortification of red grape juice [60]. It was concluded that the addition of sweetened fruit might be one of the majors caused to increase total solid of fruit yoghurt. The reduction in the pH value of fruit yoghurt might be a possible reason to upraise the total solids contents of fruit yoghurt.

3.2.9 Lactose content

Mean values have shown the lactose content of yoghurt prepared with persimmon fruit (Fig. 8). The lactose content of simple yoghurt was 5.17% which was highest than other mean values of fruit yoghurt samples T_1, T_2 and T_3 such as 5.11 5.03 and 4.86%. The lactose contents of the yoghurt sample fortified with persimmon fruit as 5%, 10% and 15% were noted as 5.11%, 5.03% and 4.86% respectively at 0 days. Results have shown that the lactose content reduced considerably with the increasing amount of persimmon fruit in yoghurt.

On the 28th day of the storage study, the

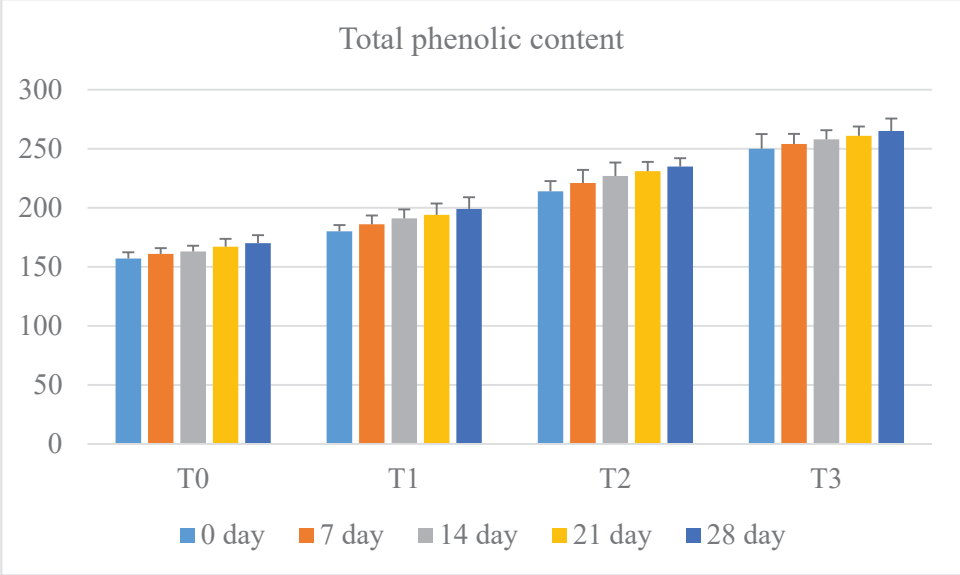

Fig. 6. Effect of persimmon on total phenolic of yoghurt

lactose contents were recorded in the range of 5.02%, 4.89% and 4.80% noticeably. A prominent reduction was observed in the yoghurt sample with 15% of persimmon fruit which was 4.80% (Fig. 8). The fruit yoghurt developed with 5% and 15% pineapple juice has the maximum amount of carbohydrate along the storage period [79]. Carbohydrates content (CHO) was significantly diminished within the evolution of the cold storage period of all yoghurt treatments reaching the lowest values at the end of the storage period (21 days). This decrease is due to the carbohydrate's hydrolysis, which is attributed to the growth and activity of lactic acid bacteria and acid development that increased greatly throughout storage. These findings agree with the findings obtained by Kauser *et al* [6].

The lactose content of the sample with 3%, 6% and 9% apricot pulp was reduced from 5.12%, 5.04% and 4.96% to 5.04%, 4.92% and 4.82% respectively after 22 days of storage study [6]. The fruit yoghurt mostly has a negligible amount of lactose which was might be due to breaks down of lactose into lactic acid by the function of lactic acid bacteria during storage. The fermentation process and production of lactic acid bacteria minimized the amount of lactose content.

3.2.10 Moisture content

The addition of fruit pulp has a highly significant effect on the moisture content of yoghurt during storage (Fig. 9). The incorporation of fruit pulp profoundly affects ($p < 0.01$) the moisture contents of yoghurt because of various concentrations of persimmon fruit pulp. The moisture content of the control sample (T_0) was (52.32%) the lowest as compared to other treatments prepared with the addition of persimmon. The present finding revealed that the moisture content of fruit yoghurt increased with the increasing amount of persimmon fruit within treatments along with the storage at refrigeration temperature 4°C. The moisture content of yoghurt samples (T_1, T_2 and T_3) with 5%, 10% and 15% were recorded as 54.36%, 56.41% and 58.46% respectively at 0 days of study. During storage periods moisture contents of fruit yoghurt significantly increased to 88.61%, 89.48% and 89.76% on the 28th day of storage respectively. Higher moisture content was found in the yoghurt sample with 15% persimmon pulp because of the high concentration of fruit in yoghurt (Fig. 9). The yoghurt prepared with sweet lemon and apple juice (5%, 10% and 15%) had a higher concentration of moisture than the yoghurt prepared with pineapple juice 10%.

The moisture content was slightly high because of fibres present in the yoghurt which holds the water and the setting time was similar to that of control, however, the setting time was less and it might be due to fast metabolizing culture [58]. The researcher explained a similar trend that the addition of fruit pulp significantly increased ($p < 0.01$) the moisture content of yoghurt and concluded that the

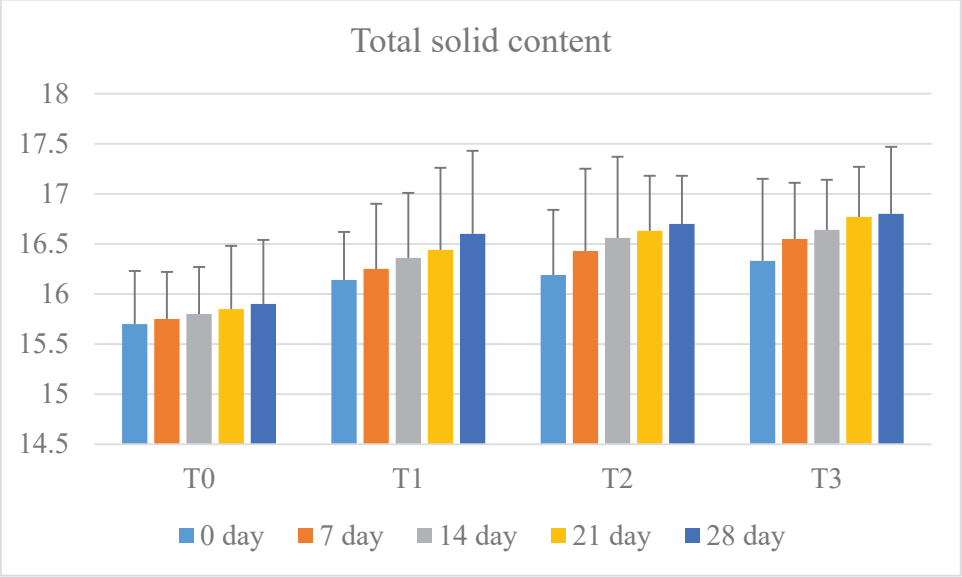

Fig. 7. Effect of persimmon on total solid content

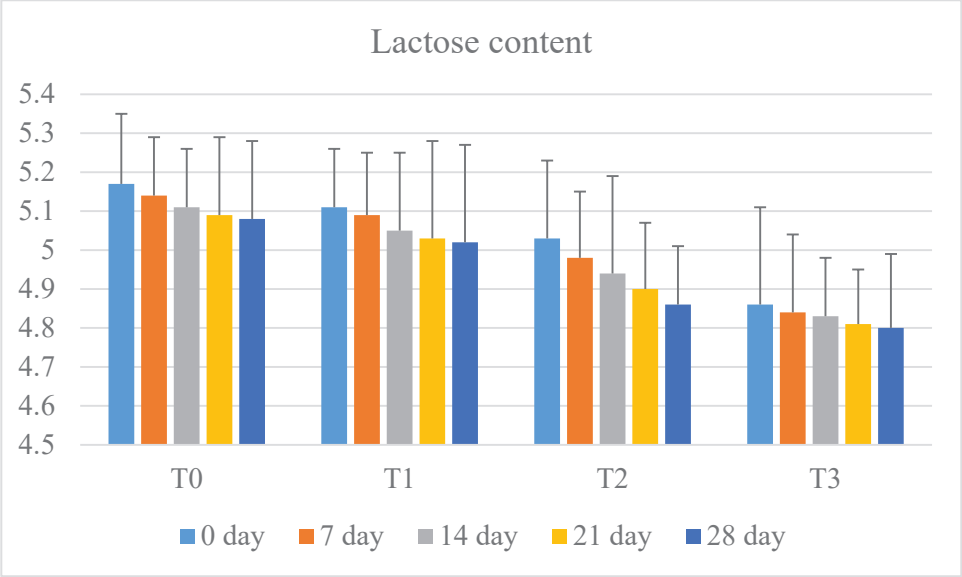

Fig. 8. Effect of persimmon on lactose content

moisture content of fruit yoghurt increased because of the high moisture content in fruit pulp [51].

3.2.11 Textural profile

The texture is related to the appearance and consistency of the surface of any product. Hardness, or firmness, is the most important characteristic in determining yoghurt texture. It is regarded as the force required to attain a certain deformation and is considered as a measure of the hardness of the yoghurt [80]. The addition of fruit non-significantly affects ($p > 0.05$) the textural profile of yoghurt (Fig. 10). The mean value of textural profile for control sample was lowest 5.87 N than other yoghurt sample prepared with incorporation of persimmon fruit as 5.88, 5.89 and 5.90 N respectively at zero days of storage. During the storage study, the mean values of fruit yoghurt decreased to 5.74, 5.77 and 5.75 N respectively at refrigeration temperature.

The same trend was analyzed that dadih prepared with papaya and pineapple has a noticeable effect on the textural properties of yoghurt [81]. They investigated those values for hardness was greater for papaya dadih as compared to dadih made from pineapple. Another research conducted by Mohammad *et al.* [82] was also following the present study that strawberry yoghurt developed with the fortification of red beet extract 1.25%, 2.5% and 4%.

Jaglan *et al.* [2] also reported that the mango pulp incorporated at 15% concentration was best due to sensory acceptability and the pH at that level was slightly acidic as compared to the market sample and moisture content was greater than that of the market sample. The researcher concluded the possible reasons that fruit pulp plays a crucial role in the maintenance of textural characteristics of finish product [51]. The fruit pulp has higher solids and fibre content which results to increase viscosity thus improve the textural profile of fruit yoghurt.

3.2.12 Sensory characteristics of yoghurt

The consumer's response in form of feedback can be gained by sensory or organoleptic characteristics such as aroma, colour, taste, the mouthfeel of the product which is an important factor for product acceptability. The mean value for the mouthfeel of fruit yoghurt was observed at different intervals to check the effect of persimmon fruit on yoghurt. The score of mouthfeel for the controlled sample was found highest compare to the yoghurt sample treated with fruit pulp at the storage study (Table 4). The incorporation of different fruit during storage influenced the characteristics of fruit yoghurt for mouthfeel [15, 16, 51].

The findings revealed that the addition of fruit has a considerable effect on the colour of fruit yoghurt. The various concentrations of

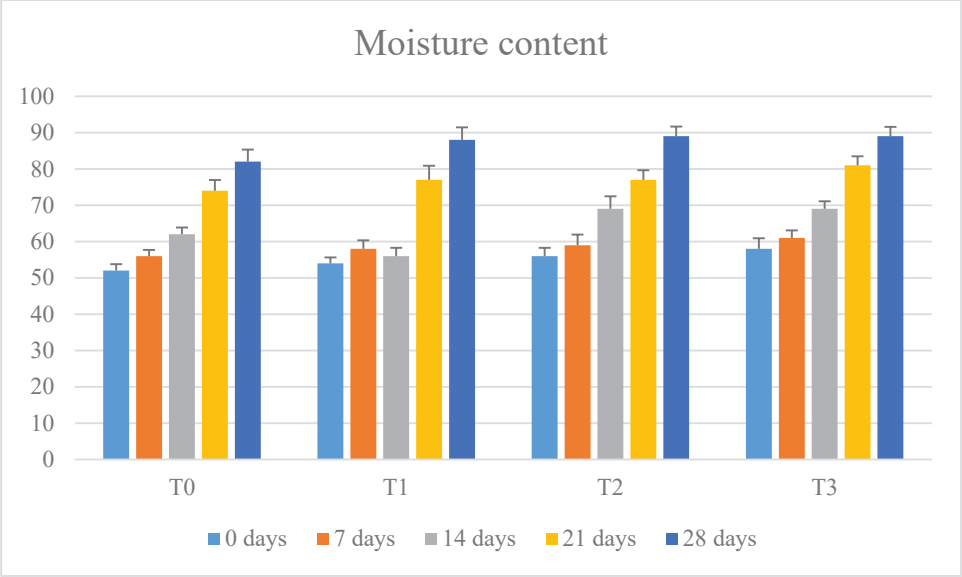

Fig. 9. Effect of persimmon on moisture content

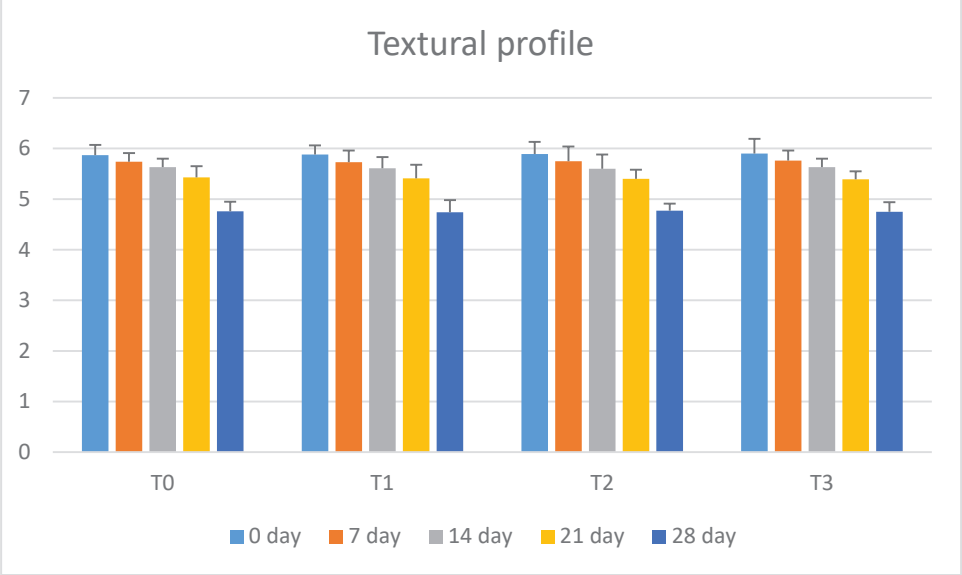

Fig. 10. Effect of persimmon on the textural profile of yoghurt

fruit in yoghurt effectively influence the colour of yoghurt within treatments ($p < 0.01$). During storage conditions the colour of fruit yoghurt. it was revealed that the reduction in the colour value of fruit yoghurt might be due to activities of bacteria with low pH and higher syneresis value of fruit yoghurt during the research period. The addition of fruit in various concentrations (T_1, T_2 and T_3) during yoghurt development considerably effect ($p < 0.01$) on the aroma of fruit yoghurt within treatments. The best score was found for treatment T_2 as compared to other treatments. Best score gained by the treatment T_2 while least score gained by T_3 with the maximum concentration of fruit (15%). The same results were presented that the mean values of yoghurt with cactus pear in the concentration of (5%, 10%, 15%) for aroma was decreased during storage [40, 75]. The lowest mean value for aroma was might be due to the reduction of pH value within the storage period which might be most likely leads to a lower flavour and aroma of fruit yoghurt.

The present study revealed that the addition of persimmon fruit on yoghurt considerably effect ($p < 0.01$) the taste of developed yoghurt because of various concentrations of fruit along with treatments (Table 4). The taste of the yoghurt sample reduced

Table 4. Effect of persimmon on sensory characteristics of yoghurt

Parameters	Samples	Storage (days)				
		0	7	14	21	28
Appearance	T_0	7.54±0.26	7.39±0.22	7.34±0.22	6.94±0.28	6.44±0.26
	T_1	6.54±0.20	6.49±0.26	6.24±0.25	6.09±0.30	5.94±0.30
	T_2	8.24±0.33	8.20±0.41	7.93±0.40	7.43±0.25	7.12±0.21
	T_3	4.39±0.22	4.84±0.16	4.69±0.14	3.29±0.10	3.53±0.14
Taste	T_0	7.4±0.25	7.39±0.13	7.34±0.22	6.84±0.27	5.79±0.23
	T_1	6.44±0.19	6.39±0.26	6.29±0.25	5.89±0.29	4.79±0.24
	T_2	8.29±0.33	824 ±0.41	8.09±0.40	7.79±0.26	6.89±0.21
	T_3	4.79±0.24	4.74±0.16	4.69±0.14	3.64±0.11	2.44±0.10
Overall acceptability	T_0	7.51±0.26	7.46±0.22	7.41±0.22	6.91±0.28	5.86±0.23
	T_1	6.66±0.20	6.51±0.26	6.36±0.25	5.96±0.30	4.86±0.24
	T_2	8.46±0.34	8.41±0.42	8.16±0.41	7.86±0.27	6.96±0.21
	T_3	4.86±0.24	4.81±0.16	4.66±0.14	3.76±0.23	2.51±0.10

considerably during storage conditions. Most excellent scores were observed for treatment T_2 with 10% of persimmon fruit supplementation. The reduction in values of taste for fruit yoghurt possibly due to the purification of milk protein because of the proteolytic activities of bacteria. The present finding revealed that the addition of persimmon has a highly significant influence ($p < 0.01$) on the overall acceptability of yoghurt due to various concentrations of persimmon during storage. It was noticed from the mean value that the yoghurt sample with 10% fruit pulp has the best overall acceptability than other samples with 5% and 15% persimmon. These current results were following Arslan and Bayrakci (2016) [15] that mean value of yoghurt with persimmon puree with (10, 12%) reduced from 6.30% to 6.00% and 6.10% to 5.50%, while yoghurt with persimmon marmalade with (10, 12%) reduced from 7.60% to 7.30% and 7.70% to 7.80% respectively. The declining trend in the overall acceptability of fruit yoghurt might be due to the low values of colour, aroma, and taste of fruit yoghurt considerably.

4. CONCLUSION

The current study supported the conclusion that supplementation of persimmon *Diospyros kaki* fruit leads to develop enriched yoghurt with the most desired features in comparison with yoghurt prepared without the addition of fruit. It was analyzed from the present study that the syneresis value declined effectively and total phenolic content increased with the increasing amount of persimmon fruit along with treatments. The total solid content also increased significantly with the increased amount of persimmon fruit. Furthermore, the organoleptic characteristics of fruit yoghurt (T2) prepared with 10% persimmon fruit have gained better acceptability as compared to other fruit yoghurt prepared with 5% and 15% fruit

5. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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