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A Study of the Physical, Chemical, and Biologically Active Properties of Avocado Pulp (*Persea americana*), and Its Use in the Preparation of Some Functional Dairy Products

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Abstract: This research conducted with the aim of manufacturing healthy products (yoghurt and local cream cheese) rich in bioactive compounds and healthy fatty acid using avocado fruit pulp. Avocado pulp used in the manufacture of yoghurt at two, four, and six percent, and the yoghurt stored at 4° C for seven days. Local cream cheese was handmade by replacing animal butter with 15% avocado pulp. The content of phenolic compounds in fresh avocado pulp determined using HPLC, where it was found to be rich in kaempferol 30.88 ppm, ferulic acid 30.25 ppm, apigenin 22.58 ppm, quercetin 18.98 ppm, and P-coumaric acid 12.66 ppm, as well as rich in some fatty acids: oleic 59.58%, palmitic 17.58%, and α-linolenic 18.05%. Compared to the control sample at the first day of storage, the avocado-fortified yoghurt led to an increase in antioxidant activity by 10.86%, 25.12%, and 34.63%, and in total phenolic content by 129.55%, 343.18%, and 404.55%. The yoghurt sample at four percent was the most accepted in texture, taste, flavor, and general acceptance, and the avocado added a buttery, astringent, and distinct taste to the avocado-fortified samples. Also, the manufactured of local cream cheese by avocado led to a decrease in moisture and fat, and an increase in acidity and total solids, and it was possible to obtain a low-fat functional food with high nutritional value. Results showed that supporting yoghurt with avocado had a positive effect on reducing the total number of microorganisms and was free of molds, yeasts, and coliform growths during storage.

Keywords: Avocado pulp, Chemical and physical properties, Fatty acid, Healthy products, Microbial load, Sensory properties.

Introduction

Cow's milk is suitable for the manufacture of many dairy products. Yoghurt and cheese are the most popular fermented dairy products that obtained from fermented milk. Milk and dairy products are considered healthy foods rich in the most important components of the human diet worldwide, such as nutrients and Energy, and are rich sources of mineral elements (calcium, phosphorus, potassium, zinc, and phosphorous), vitamins (A, B_2, B_{12}, and D), proteins, and essential fatty acid (Al-Garory & Al-Kaabi, 2020; Ghazal *et al.*, 2021; Hadjimbei *et al.*, 2022). Studies indicate that dairy products should consume frequently to maintain a healthy body. Fortifying dairy products with fruits may increase their nutritional value and increase their acceptance by the consumer. Cheese is a popular dairy product, and consumers demand new types of cheese with lower levels of additives, such as flavorings and colouring agents, so many studies have conducted to enrich cheese with different nutrients and dietary fibre (El-Sayed, 2020; Salehi, 2021). Due to the high rate of dairy consumption (cheese, ice cream, and yoghurt) in the countries of the Arab world, particularly in Syria, the fortification of these products with fruit (fresh fruits, juice, powder, puree and extracts) will reduce or prevent diseases associated with undernourishment, and will contribute to giving the desired taste, improving colour and odor, and raising their content of raw fibre, vitamins, natural colourants, minerals, polyphenols, and carotenoids, as some fruits are also considered a potential stabilizer for dairy products due to their desired functionality (Salehi, 2021). Fruits are considered perishable foods due to their high moisture content, which reduces their shelf life and lowers their nutritional value (Bovi *et al*., 2016), so fruits converted to other, more stable forms to extend their shelf life (Singh *et al*., 2018). Plants contain many chemicals with important nutritional properties for human health (Al-Temimi *et al*., 2020).

Avocado is a nutritious fruit, known as avocado pear, with a creamy texture and butyric flavor and is rich in unsaturated fatty acid, especially monounsaturated acids such as oleic and palmitoleic acids, as well as omega-three and six polyunsaturated fatty acid that provide health benefits to consumers and linoleic acid, and it also contains fat-soluble vitamins (E, B_6 and carotene), fibre, potassium, protein, antioxidants, lutein, beta-sitosterol, and folic acid, and 100 grams of avocado also provides six-point seven grams of dietary fibre, about 18% of the recommended daily intake, and many studies have confirmed that avocado is a source of energy and vitamins, and offers physiological benefits that promote health, and for this, it is considered a "functional food" (Hettige *et al*., 2013; Amado *et al*., 2019; Velderrain-Rodríguez *et al*., 2021; Brooks & Hesse, 2023). Reddy & Marid (2022) stated that the addition of avocado to the shake yoghurt gave higher sensory acceptance by the arbitrators than with the normal yoghurt, and the product supported with 10% avocado had more nutritional and therapeutic value. While a study by Ali (2020) aimed at producing fresh, healthy, good-quality labneh made from cow's milk and supported by avocado puree to create functional food, this study pointed to a satisfactory conclusion that its labneh product could be successfully made and meet intended health purposes based on fortification with five percent avocado paste with impressive health benefits with the aim of developing functional food.

The avocado (Persea americana) considered a perishable fruit after it is harvested. Therefore, this research aimed to study the effect of the avocado pulp on the chemical, physical, and sensory properties of some dairy products (yoghurt, and cheese) during refrigerated storage for seven days after manufacturing to create healthy and functional products.

Materials & Methods

Materials

Fresh cow's milk (good quality and free of foreign tastes) was obtained from the local dairy farmer in Damascus Countryside Governorate, Syria. The starter culture, which consists of a mixture of (Lactobacillus bulgaricus and Streptococcus thermophiles) obtained from Hansan Company, Denmark. Avocado fruits (Fuertes variety, the weight of one grain was 240 grams), lemon fruits, salt

(Sodium chloride), and animal butter purchased from the Syrian market, Syrian.

Methods

The products manufactured in the laboratories of the Department of Food Sciences, College of Agriculture, and University of Damascus during the extended period between 2022 and 2023.

Preparation of avocado pulp

The method described by (Atmanaji *et al.*, 2019) followed in the manufacture of avocado pulp, as avocado fruits of the (Fuertes variety) were selected. The fruits washed well, and then divided lengthwise into two halves. The pulp of avocado was cut into pieces and then blended well using an electric blender (French, Moulinex, LM 207125) until a smooth texture was obtained.

Yoghurt manufacturing

Fresh cow's milk pasteurized at 85° C for 15 minutes, and the hot milk was divided into five samples as follows:

The first sample (control) was free of avocado pulp. The second sample contains avocado pulp at a concentration of two percent. The third sample contains avocado pulp at a concentration of four percent. The fourth sample contains avocado pulp at a concentration of six percent. Avocado pulp added to the hot milk to sterilize the avocado. The milk was cooled to 45° C (Alhalfi, 2018), and the starter bacteria added at three percent. It was mixed well to ensure that the starter was evenly distributed within the sample, and it was filled in clean and sterile glass containers with a capacity of 250 ml. The samples were then incubated at 45° C until they completely coagulated and transformed into yoghurt when the pH reached four-point six (Hozzein *et al.*, 2023). After incubation, the containers removed from the incubator and left at room temperature for 25 minutes, then refrigerated at 4° C for seven days. The experiment was carried out with three replications for each treatment.

Local cheese manufacturing (homemade)

Local cream cheese was prepared manually (homemade, control) by heating the selected milk (four litres) to a temperature of (95° C), then adding fresh lemon juice (200 ml) to the milk just before boiling and stirring gently for one minute. The mixture was left for 10 minutes until a thrombus formed, then the formed thrombus was placed in a special cotton cloth and pressed with a certain weight for half an hour to separate the resulting serum from the thrombus. 100 grams of the formed thrombus were taken; salt (two percent) and animal butter (43%) were added to it, and it was mixed using a French electric mixer to obtain a soft, and smooth, creamy texture. The other cream cheese sample was prepared by replacing all the animal butter with (15%) of the avocado pulp. The samples stored at 4°C until analysis. Yoghurt and local cream cheese samples were prepared in the laboratories of the Food Sciences Department, Faculty of Agricultural Engineering at Damascus University.

Chemical analysis

Chemical analysis conducted in the laboratories of the Food Sciences Department, Faculty of Agricultural Engineering at Damascus University.

Moisture and dry matter determination

Moisture was estimated by drying at 105°C until constant weight using a hot air oven (Köttermann, model 2701), according to the method given in (Obi *et al.*, 2016).

Dry matter calculated from the following equation:

$$\%\text{Dry matter} = 100 - \text{moisture}$$

Fat determination

Fat estimated in the milk, yoghurt, and cheese samples by using Gerber method according to the method mentioned in (Kleyn *et al*., 2001), and in avocado pulp according to (Gatbonton *et al*., 2013).

Acidity determination

Titratable acidity estimated by the alkaline titration. The results expressed as tartaric acid in avocado (Ferreira da Vinha *et al*., 2013), and as lactic acid in milk (Abbas *et al*., 2020; Eljagmani & Altuner, 2020).

Crude fibre determination

Crude fibre in avocado pulp was estimated according to the method mentioned in (Tlay *et al*., 2023), by treating the sample with hot diluted sulfuric acid, 12.5%, as the first stage (acid digestion stage), then treating the sample with diluted hot NaOH 12.5% (alkali digestion stage), then drying the sample, incinerating the precipitate, and calculating the percentage of fibre using the difference.

Total phenolic content determination

The method of Jayaprakasha *et al*. (2001) was employed to estimate the total phenolic content in avocado pulp and yoghurt samples, using the folin-ciocalteu methods, and the results were expressed as mg gallic acid equivalent. g^{-1} wet weight.

Antioxidant activity determination

Antioxidant activity in avocado pulp and yoghurt samples, was measured by estimating the free radical scavenging activity using a free radical assay 2,2`-diphenyl-1,1- picryl hydrazyl, (DPPH) according to the method mentioned in (Tlay *et al*., 2023), with some modifications as follows: The same volume of DPPH solution (60 µmol in absolute ethanol) was mixed with the ethanolic sample extract (one gram of sample in 30 ml of absolute ethanol). The mixture incubated for 30 minutes in a dark place, and the absorbance was measured at 517 nm.

Quantification of phenolic compounds by HPLC

Quantification of individual phenolic compounds of avocado pulp performed by reversed phase HPLC analysis, using a Sykamn HPLC chromatographic system equipped with a UV detector), Chemstation, a Zorbax Eclipse Plus-C18-OSD, 25cm, four-point six mm column. The column temperature was 30ºC the gradient elution method, with eluent A (methanol) and eluent B (one percent of formic acid in water (v/v)) was performed, as follows: initial zero to four minutes, 40% B; four to ten minutes, 50 % B; and flow-rate of point seven mL/min. The injected volume of samples was 100 µL, and standard was 100 µL and it was done automatically using an autosampler. The spectra acquired in the 280 nm (Radovanović *et al*., 2015). This test performed on a sample of avocado pulp in the Laboratory of Chromatography Techniques in Environment and Water Department of the Ministry of Science and Technology/Baghdad, Iraq.

The standards of phenolic compounds (apigenin, ferulic acid, kaempferol, p-coumaric acid, qurcetine, sinapic acid, and vanillic acid) were obtained from Sigma-Aldrich Darmstadt, Germany.

Fatty acid determination

Fat in avocado pulp estimated according to the method mentioned in (Bora *et al*., 2001), using the fat extraction device (Soxhlet). The test performed on an avocado pulp sample in the Laboratory of Chromatography Techniques, Environment and Water Department of the Ministry of Science and Technology/Baghdad, Iraq.

Fat esterification

The sample was prepared according to the method adopted by (Langueira & Pineda, 2012) and based on fat esterification by interacting with methanolic potassium hydroxide. It was prepared from dissolving 11.2 g of potassium hydroxide and dissolving it in 100 ml of methanol, then one gram of fat was taken and eight ml of methanolic potassium hydroxide was added to it with five millilitres of hexane and shaken quickly for 30 seconds and then left to separate into two layers. It was taken from the top layer (hexane layer) that contains the fat that has been esterilized, and injected into the device.

GC- Mass condition

GC-MS analysis conducted on a GC – Mass 5977A Series Agilent system auto. A sampler and gas chromatograph interfaced to a mass spectrometer (GC-MS) instrument employing the following conditions: Column Elite-one fused silica capillary column HP-5MS (30 mm× point two five mm I.D.) operating in the electron impact mode at 70 eV; helium (99.999%) was used as the carrier gas at a constant flow of one ml/min and an injection volume of point five UL was employed (split ratio of ten: one) injector temperature 250°C; ion source temperature 280˚C. The oven temperature was programmed from 60°C (isothermal for two minutes), with an increase of 10°C/min, to 270˚ C, then 5˚ C/min to 290˚C, ending with a nine minutes' isothermal at 310˚ C. Mass spectra were taken at 70 eV; a scan interval of point five seconds and fragments from 45 to 450 DA. The total GC running time is 60 min, according to (Eswaran *et al*., 2012).

Physical analysis

Physical analysis conducted in the laboratories of the Food Sciences Department, Faculty of Agricultural Engineering at Damascus University.

Viscosity determination

The viscosity of the yoghurt samples determined using the Brookfield viscometer (Brookfield, Myr: VII, Spanish) at 25˚˚˚ C, by using a spindle (L3), 30 rpm, and expressed in (CP, Centipoise) according to the method mentioned in (Đurđević-Denin *et al*., 2002).

pH Determination

The pH number measured using a pH-meter (model 5310, British Company-Jenway) according to the method mentioned in Eljagmani & Altuner (2020).

Determination of the microbial load

Microbial load conducted in the laboratories of the Food Sciences Department, Faculty of Agricultural Engineering at Damascus University.

Total counts of bacteria, yeasts and molds, and coliforms were estimated according to the methods mentioned in (Kunadu *et al*., 2018), and expressed as $cfu.g^{-1}$. The nutrient plate count agar was used for the total counts of bacteria after incubation at 37°C for 48 hours, potato dextrose agar was used for yeasts and mold count, after incubating at 25˚ C for 72 hours, and violet red bile agar was used for measuring the coliform counts after incubating at 37˚ C for 24 hours.

Sensory properties

Sensory properties of different processed yoghurt samples were conducted by a group of postgraduate students and professors at the Food Sciences Department, Damascus University using a nine-points hedonic scale, identifying five points (colour, appearance, taste, texture, and general acceptability) according to (Ranganna, 2007). Sensory evaluation scores were given as follows: poor (one), acceptable (two), good (three), very good (four), excellent (five).

Statistical analysis

The results analyzed by ANOVA using IBM SPSS Statistics (version 25), and expressed as mean ± standard error. Differences between means with a p-value ≤ point-zero five were considered to be significant.

Results & Discussion

The chemical composition of fresh raw milk and avocado pulp

The antioxidant activity affected by many mechanisms and factors (solvents used, temperature, phenolic compound structure, and pH) which can affect the accuracy of the determination of antioxidant activity. Table (1) presents the results of some chemical indicators for the studied samples (cow milk, and avocado pulp). The results show a higher antioxidant activity in the avocado pulp sample compared with cow milk 79%, three- point one four percent, respectively. These results are in agreement with Lyu *et al.* (2023) which indicated that the antioxidant activity of different varieties of avocado pulp ranged from point zero eight to point one six AAE/g, and the antioxidant activity and shelf life of the fruit can vary based on the part of the fruit under analysis, and the fruit nature (Arackal & Parameshwari, 2021). Also, these results were higher than those reported by (Ferreira da Vinha *et al.*, 2013), who showed that the antioxidant activity of avocado pulp was 23%.

Table (1): Chemical composition of cow milk and avocado pulp.

Indicators	**Cow milk**	**Avocado pulp**
Acidity%	0.25±0.01	0.89±0.03
Dry matter %	10.50±0.12	30.00±0.25
Moisture%	89.50±0.14	70.00±0.26
Fat%	2.30±0.02	20.00±0.23
Crude fibre%	0.00±0.00	3.00±0.20
pH	6.05±0.01	6.40±0.02
Total phenolic content (mg.100g^{-1} gallic wet base)	3.20±0.12	113±0.25
Antioxidant activity%	3.14±0.00	79±0.32

It can see from table (1) that the content of moisture, dry matter, fat, pH, acidity, and crude fibre in the sample of avocado pulp was 70%, 30%, 20%, six-point forty, and point eight nine percent as tartaric acid, and three percent, respectively. These results are in agreement with those in other studies. For example: The moisture content of the pulp of different cultivars of avocado ranged between 68.16-79.23%, and fat content ranged from 13.26% to 23.44% (Amado *et al.*, 2019). Astudillo-Ordóñez & Rodríguez (2018) indicated that the pH of samples of three different cultivars of avocado during different ripening stages ranged between six-point five eight to seven-point one four and acidity nine-point twenty nine percent to 19.47%, as the behavior of the pH number is related to the content of Organic acids present in the fruit, also, low acidity is associated with the consumption of organic acids in the various metabolic cycles in the fruit, including tartaric acid, which is predominant in avocados, and acids and carbohydrates are used to provide the energy required by the fruit during the ripening process (Taiti *et al.*, 2015).

The results shown in table (1) indicated that the content of moisture, dry matter, fat, pH, acidity, and fibre in the sample of cow milk was 89.50%, 10.50%, two-point thirty percent, six-point zero five, point twenty-five percent as lactic acid, and fibre free, respectively. These results are agreement with other studies. For example: The moisture was 87.15%, solids 12.85%, fat four-point three six percent, acidity point one nine percent, and the pH six-point seven (Rahman *et al*., 2020).

Also, it can be seen from table (1) that the total phenolic content in the studied sample of avocado pulp was higher compared with cow milk 113 mg.100 g^{-1} wet base, three point twenty mg.100g^{-1} wet base, respectively. These results are agreement with other studies. For example the total phenolic content ranged between (point twenty to point-twenty eight mg gallic acid. g^{-1} (Lyu *et al*., 2023), while the total phenolic content in avocado pulp was one-point zero nine mg gallic acid. g^{-1} fresh weight (King-Loeza *et al*., 2023). López-Cobo *et al*. (2016) indicated that the content of total phenols was low in the avocado pulp and ranged from 38.0 mg.100 g^{-1} DM to 41.0 mg.100 g^{-1} DM. Also, these results were lower than those reported by (Ferreira da Vinha *et al*., 2013), who showed that avocados were rich in phenolic compounds 410.2 mg.100 g^{-1}.

The phenolic compounds of avocado pulp

Table (2) demonstrated the content of fresh avocado pulp from phenolic compounds using HPLC, where the percentage of kaempferol compound was 30.88 ppm, followed by ferulic acid 30.25 ppm and apigenin 22.58 ppm, while other compounds (qurcetine, p-coumaric acid, vanillic acid, and sinapic acid) were found in lower proportions 18.98, 12.66, 11.58, and nine-point fifty eight ppm, respectively. These results are agreement with other studies. For example: The phenolic compounds content of avocado pulp, where the content of gallic acid ranged from point-zero zero eight to point-zero ten mg/g fresh weight, and the content of Hydroxy methody cinnamic acid ranged from zero to point-zero zero four mg/g fresh weight, while only traces of phenolic compounds (Dihydroxybenzoic acid, Hydroxybenzoic acid, Catechin Hydrate, Chlorogenic acid, Vanillic acid, Caffeic acid, Syringic acid, p-Coumaric acid) were observed (King-Loeza *et al*., 2023).

Fig. (1) showed the phenolic compounds present in avocado pulp using high-performance liquid chromatography (HPLC), where the retention time for peaks ranged between two-point eighteen and eight-point twenty minutes, the area of peaks ranged from 15982.65 to 17448.32 mAU.s, and the percentage of the area of peaks ranged from 10% to 17%.

Table (2): The phenolic compounds of avocado pulp.

Phenolic compound	Concentration
Apigenin	22.58
Ferulic acid	30.25
Kaempferol	30.88
p-Coumaric acid	12.66
Qurcetine	18.98
Sinapic acid	9.58
Vanillic acid	11.58

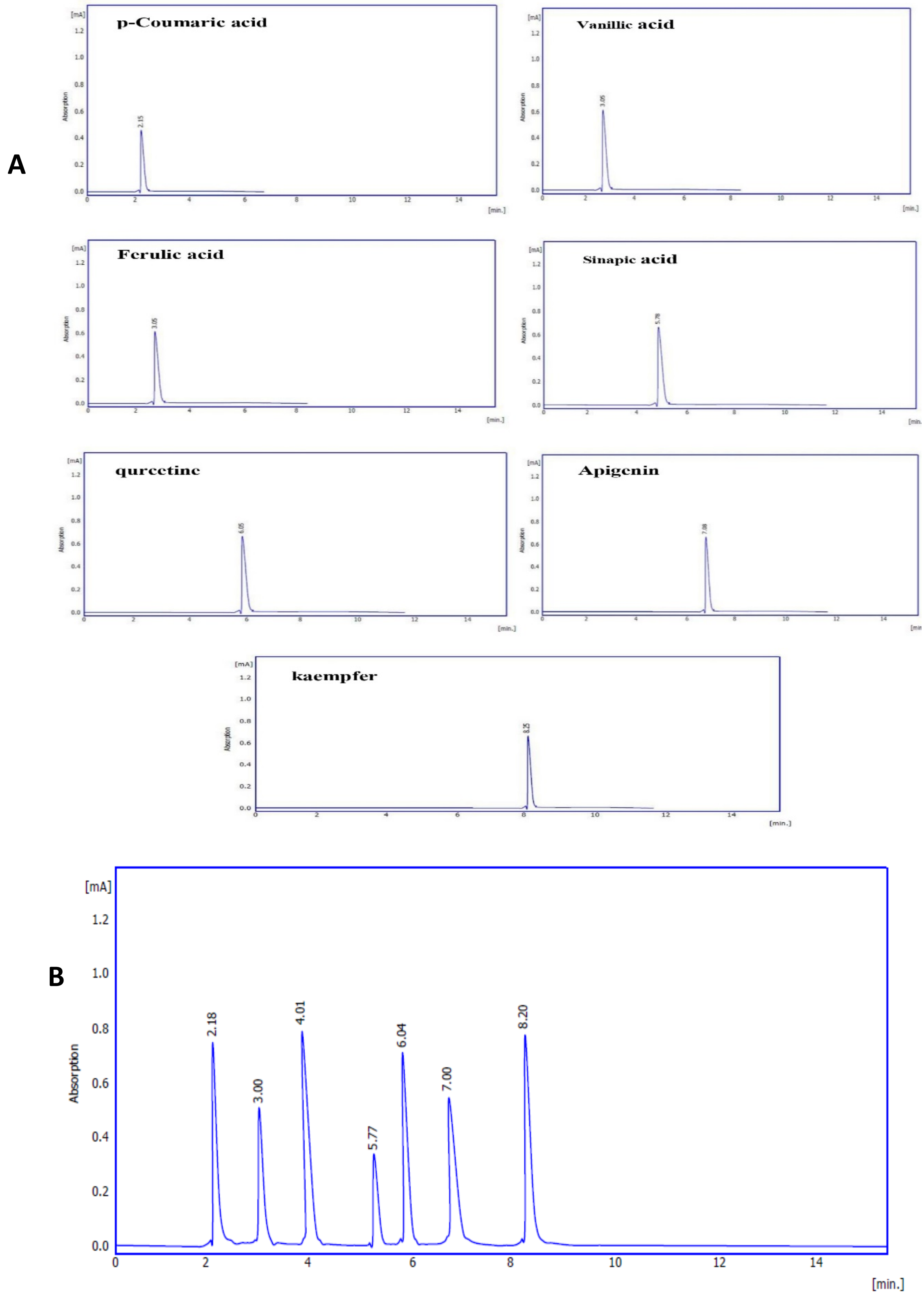

Fig. (1): A- Standard phenolic compounds. B- Phenolic compounds in avocado pulp by HPLC.

The fatty acid of avocado pulp oil

Table (3) showed the types of fatty acid present in avocado pulp oil and their percentages, which Oleic acid was the dominant fatty acid with a percentage of 59.58%, followed by a-linolenic acid 18.05%, palmitic acid 17.58%, linoleic acid nine-point five eight percent, eicosapentaenoic acid nine-point fourteen percent, docosahexaenoic acid eight-point twenty five percent, arachidonic acid three-point fifty eight percent, stearic acid three-point fifty eight percent, and gamma linoleic acid one-point twenty five percent. Several studies have pointed to the composition of fatty acid in avocado pulp oil, for example: The avocado pulp oil contains Oleic acid 43.23%, a dominant monounsaturated fatty acid, also rich in polyunsaturated fatty acid (omega-six); and linoleic acid 19.78%, and contains 35.31% saturated fatty acid, so it is considered a safe and healthy oil (Akusu *et al.*, 2021). Also, the fatty acid present in Hass avocado pulp were 32.6% Oleic acid, 31.7% palmitic acid, 16.6% linoleic acid, 16.3% palmitoleic acid, and point nine percent alpha-linolenic acid, and this is very important since humans cannot synthesize these acids, and the avocado pulp contains the highest concentration of fatty acid (Amado *et al.*, 2019). Donetti & Terry (2014) indicated that the major fatty acid in avocado oil were Oleic acid 53%, palmitic acid 20%, linoleic acid 14%, palmitoleic acid seven percent, and alpha-linolenic acid four percent. Okparauka *et al.* (2019) noted the avocado pulp oil content of fatty acid, whose peak retention time ranged between 21.07-33.59 minutes and 12 peaks (five major peaks, and seven small peaks) were identified, and the % peak areas were 1.23-45.69. The main peaks were nine-Octadecanoic acid (Z)-methyl ester (Oleic acid); 11-Otadecanoic acid methyl ester; Eicosanoic acid methyl ester; 9, 12-Octadecanoic acid methyl ester (E-E) (linoleic acid) and Docosanoic acid methyl ester. He noted that avocado contains 71% of monounsaturated fatty acid (MUFAs), 13% of polyunsaturated fatty acid (PUFAs) and 16% of saturated fatty acid (SFAs), as the Oleic acid content increases in mature acid. Fig. (2) showed the composition of fatty acid in avocado pulp oil using the GC-mass technique.

Table (3): The fatty acid of avocado pulp oil.

Peak	Name	Concentration%
2	Oleic acid	59.58
3	Stearic acid	3.58
4	Docosahexaenoi	8.25
5	Palmitic acid	17.58
6	a- linolenic acid	18.05
7	Linoleic acid	9.58
8	Gamma linoleic	1.25
9	Eicosapentaenoi	9.14
10	Arachidonic	3.58

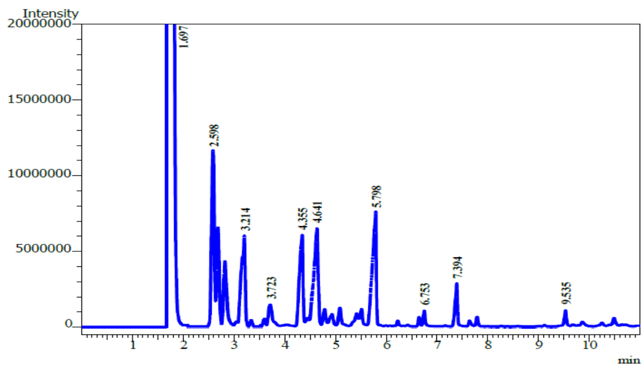

Fig. (2): GC-MS chromatogram of avocado pulp oil.

The chemical composition of yoghurt samples fortified with avocado pulp during the refrigerated storage period

The results shown in table (4) indicated the difference in the chemical composition of the avocado-fortified yoghurt and the control yoghurt, as the yoghurt fortified with six percent of avocado pulp was characterized by a higher percentage of acidity, fat, dry matter, and lower moisture point nine two percent, three-point two one percent, 11.12%, and 88.88%, respectively, compared to the control point seventy percent, two-point zero eight percent, 10.10%, and 89.90%, respectively. These results are agreement with other studies. For example: The avocado yoghurt was characterized by a higher percentage of fat, fibre, ash, protein and total solids three-point six percent, point three percent, point nine percent, three-point five percent, 16.10% compared to regular yoghurt three percent, zero, point seven percent, three point four percent, 14.24%, respectively (Kulasinghe & Abesinghe, 2016).

On the other hand, the refrigerated storage for seven days had a moral effect on increasing the acidity in all studied samples, as the acidity increased by 12.50%, 50%, and 75% in the stored samples compared to the control. These results are agreement with other studies. For example, Kulasinghe & Abesinghe (2016) reported that the titratable acidity of avocado-fortified yoghurt increased from point eight six percent to point nine four percent within 11 days of refrigerated storage, due to the presence of live lactic acid bacteria in the culture that ferment the lactose in the milk into lactic acid over time (Kilara & Chandan, 2013; Bintsis, 2018).

The pH decreased from four-point sixty percent in the control to four-point six four in the avocado yoghurt at six percent on the first day of storage, and to four-point four eight in the sample stored for seven days. These results are agreement with other studies. For example: The pH values range from three-point four to four according to the desired acidity and fruit kinds (Yousef *et al.*, 2013).

Table (4): The chemical composition of yoghurt.

Storage period at 4°C/day	Concentration of avocado pulp%	pH	Acidity%	Fat%	Dry Matter %	Moisture%
1	0 (control)	4.60^{a}±0.01	0.70^{e}±0.15	2.08^{d}±0.05	10.10^{e}±0.23	89.90^{a}±0.23
	2	4.62^{a}±0.02	0.80^{d}±0.06	2.48^{c}±0.06	10.85^{d}±0.25	89.15^{b}±0.25
	4	4.63^{a}±0.00	0.90^{c}±0.10	2.82^{b}±0.01	10.95^{d}±0.22	89.05^{b}±0.22
	6	4.64^{a}±0.01	0.92^{c}±0.09	3.21^{a}±0.05	11.12^{c}±0.23	88.88^{c}±0.23
7	0 (control)	4.49^{b}±0.02	0.80^{d}±0.02	2.05^{d}±0.03	11.18^{bc}±0.14	88.82^{c}±0.14
	2	4.40^{b}±0.02	0.90^{c}±0.14	2.45^{c}±0.03	11.58^{b}±0.11	88.42^{c}±0.11
	4	4.45^{b}±0.00	1.20^{b}±0.13	2.79^{b}±0.01	11.88^{b}±0.16	88.12^{d}±0.16
	6	4.48^{b}±0.03	1.40^{a}±0.18	3.18^{a}±0.02	12.00^{a}±0.20	88.00^{d}±0.20

Similar letters indicate that there are no significant differences between samples at a confidence level of $p \geq 0.05$.

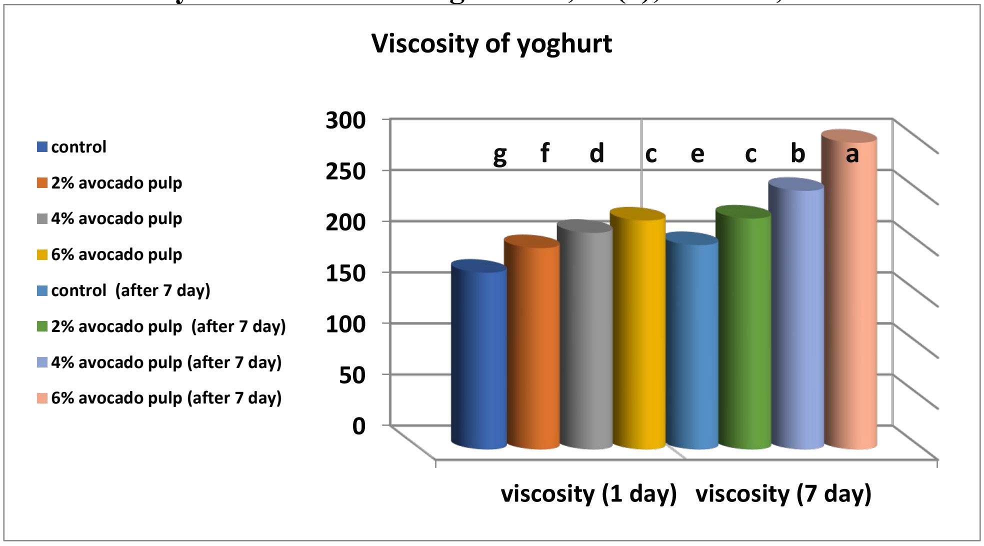

Fig. (3): The viscosity of yoghurt during refrigeration (CP).

Kulasinghe & Abesinghe (2016) indicated that the pH of avocado yoghurt decreased from three-point five two to three-point three five and from four to three-point nine one, respectively, during the first day to the eleventh day of refrigerated storage, this is due to increased acidity leading to a decrease in the pH level of the product. Soliman & Shehata (2019) indicated a decrease in pH values during refrigerated storage and an increase in acidity in all samples of avocado-fortified yoghurt, and avocado yoghurt samples characterized by a high content of total solids and fat with a high percentage of fortification. Also, Rahman *et al*. (2020) observed that the moisture content and acidity increased in the yoghurt prepared with strawberry juice because the fruit contained higher moisture and acidity, and the pH decreased with the addition of strawberry juice.

The viscosity of yoghurt samples

The viscosity is a very important indicator in determining the quality of yoghurt.

The results shown in the fig. (3) indicated that fortifying yoghurt with avocado pulp had a moral effect on the viscosity of the yoghurt samples with an increase in the percentage of avocado pulp, as the viscosity of the samples increased significantly from 173.00 in the control to 224.00 in the fortified yoghurt with avocados pulp by six percent, as the last sample had a higher viscosity compared to the other studied samples. The reason for the higher viscosity of the avocado-fortified yoghurt compared to the control samples is attributed to the higher content of fibre and fat in this fruit, which acts as a thickening agent.

These results are agreement with other studies. For example: The viscosity of fermented camel milk increased with the increase in the percentage of fortification with avocado and during refrigerated storage for a period of 21 days, and its values ranged from 37 to 1238 1/s (Soliman & Shehata, 2019).

The microbial load of yoghurt samples

The results in table (5) showed that fortifying yoghurt with avocado pulp had a positive effect on the total count of microorganisms, as the total count in the samples decreased from 3.5×10^{6} $cfu.g^{-1}$ in the control group to 1.4×10^{6} $cfu.g^{-1}$ in the yoghurt sample supplemented with six percent of avocado pulp, while the samples were free of mold, yeasts, and coliform growths on the first and seventh days of refrigerated storage.

These results are in agreement with several studies that have been conducted with the aim of determining the microbial load of dairy products that have been fortified with avocados, for example: The total account of yeasts, fungi, and coliforms in avocado-fortified yoghurt did not exceed approved SLS standards for yoghurt during 11 days of refrigerated storage (Kulasinghe & Abesinghe, 2016). The reason for promoting the growth of bacteria during the refrigerated storage period may be due to the availability of some nutrients in avocado such as soluble oligosaccharides (fructooligosaccharides), and the addition of fibre promotes the survival of probiotic bacteria in fermented milk, and this is due to the stimulating effect of avocado on probiotics because it contains a high percentage of fibre soluble (Marín *et al*., 2007; Sendra *et al*., 2008). Also, Soliman & Shehata (2019) indicated that no growths of yeasts and fungi were detected in the control when it was fresh and during refrigerated storage for 14 days of refrigerated storage, and it was shown that the absence of coliform indicates that the milk samples were free of fecal contamination due to observance of hygienic conditions during production and because of the role of lactic acid bacteria in preserving the product due to the ability of some of them to produce antimicrobial compounds.

Table (5): Microbial load of yoghurt during refrigeration.

Storage period at 4°C. day^{-1}	Concentration of avocado pulp%	Coliform ($cfu.g^{-1}$)	Total account ($cfu.g^{-1}$)	Molds and yeasts ($cfu.g^{-1}$)
1	0 (control)	Nill	$3.5x10^6$	Nill
	2	Nill	$2.6x10^6$	Nill
	4	Nill	$2.2 x10^6$	Nill
	6	Nill	$1.4 x10^6$	Nill
7	0 (control)	Nill	$6.7x10^7$	Nill
	2	Nill	$6.8x10^7$	Nill
	4	Nill	$7.2 x10^7$	Nill
	6	Nill	$7.0 x10^7$	Nill

Sensory characteristics of yoghurt samples

The results in fig. (4) indicated that there was a moral effect on most of the sensory characteristics of the yoghurt samples with a higher percentage of avocado pulp compared with the control, as the control samples obtained the best sensory acceptance.

All manufactured samples had a desirable odor, as the addition of avocado pulp did not significantly affect the characteristic yoghurt smell, and the control sample had a white colour, while the yoghurt samples fortified with avocado pulp had a light green colour, and this is due to the chlorophyll pigment in the avocado fruits, and the addition of avocado pulp at six percent increased the colour preference. It was noted that the addition of avocado pulp led to a slight increase in the consistency of the yoghurt, as the four percent sample was the most acceptable in the texture.

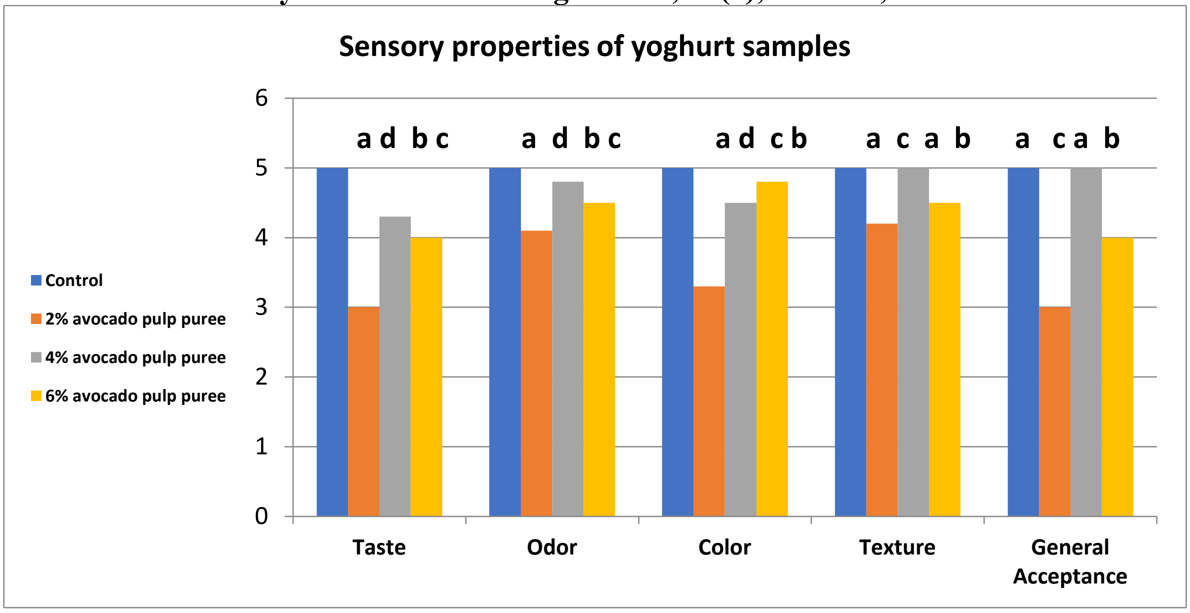

Fig. (4): Sensory characteristics of yoghurt.

Adding avocado pulp did not affect the distinctive acidic flavor of the yoghurt resulting from lactic acid bacteria, but it added a distinctive buttery, astringent taste to the avocado-fortified samples. The taste was more pronounced at a concentration of six percent, and four percent sample was the most acceptable in taste, flavor, texture and general acceptability. These results are agreement with other studies. For example: The camel yoghurt fortified with four percent of avocado met with great sensory acceptance, and the control was white in colour, while the avocado yoghurt was light green in colour due to the avocado fruit containing chlorophyll (Soliman & Shehata., 2019).

The total phenolic content and antioxidant activity of yoghurt samples

The results in table (6) shown that fortifying yoghurt with avocado pulp had a positive effect on the content of total phenols and antioxidant activity, as the percentages of avocado pulp increased. Antioxidant activity also increased on the first day of storage by 24.64%, 45.30%, and 60.04%, with the avocado percentages (two percent, four percent, and six percent), respectively, compared to control 10.31%, while the antioxidant activity increased on the seventh day of storage by 37.71%, and 55.42%, 67.23% with the avocado percentages two percent, four percent, and six percent, respectively, compared with control eight-point thirty percent. Storage of fortified samples with avocado for seven days resulted in a significant increase in antioxidant activity by 10.86%, 25.12%, and 34.63% compared to the control on the first day of refrigerated storage 10.31%.

Adding avocado pulp to yoghurt in different proportions two percent to six percent led to a positive increase in the total phenolic content by 129.55%, 343.18%, and 404.55% compared to the control point forty four mg.100g^{-1} fresh weight on the first day of refrigerated storage, while the total phenol content increased on the seventh day of storage by 193.33%, 373.33%, and 466%, when the fortification percentage was two percent, four percent, and six percent, respectively, compared with the control point thirty mg.100 g^{-1} fresh weight.

Table (6): Total phenolic content and antioxidant activity of yoghurt during refrigeration.

Storage period at 4°C/day	Concentration of avocado pulp (%)	Antioxidant activity (%)	Total phenolic ($mg.100g^{-1}$ FW)
	0 (control)	$10.31^{f}\pm0.15$	$0.44^{g}\pm0.22$
	2	$12.85^{d}\pm0.26$	$1.01^{e}\pm0.36$
	4	$14.98^{b}\pm0.11$	$1.95^{b}\pm0.14$
	6	$16.50^{a}\pm0.35$	$2.22^{a}\pm0.26$
7	0 (control)	$8.30^{g}\pm0.13$	$0.30^{h}\pm0.34$
	2	$11.43^{e}\pm0.06$	$0.88^{f}\pm0.13$
	4	$12.90^{d}\pm0.41$	$1.42^{d}\pm0.11$
	6	$13.88^{c}\pm0.22$	$1.70^{c}\pm0.32$

Similar letters indicate that there are no significant differences between samples at a confidence level of $p\leq0.05$

Also, the refrigerated storage of the control for seven days resulted in a significant decrease in the total phenolic content and antioxidant activity by 31.82% and 19.50%, respectively, compared with the control on the first day of refrigerated storage. These results are agreement with other studies. For example: The lower total phenolic content and antioxidant activity in control compared to avocado-fortified camel yoghurt during 21-day refrigerated storage, had a higher total phenolic content and antioxidant activity during its storage period (Soliman & Shehata, 2019).

The chemical composition of local cream cheese samples

The results in table (7) showed that manufacturing local cream cheese by completely replacing animal butter with avocado pulp resulted in a decrease in the moisture by 15.48%, and 16.68%, fat by 48.33%, and 48.33%, fat in dry matter by 38.18%, and 37.37%, and an increase in the acidity by 340%, and 24%, and in dry matter by 19.70% and 21.23%, with a similar creamy texture and a decrease in the percentage of animal fats. Thus, it was possible to obtain a product from avocado, which is a low-fat functional food, and has high nutritional value, due to the high content of antioxidants, healthy fatty acid, and fibre found in avocado. These results are agreement with other studies. For example: The fortification of cream cheese with avocado puree by 10, 20, and 30% led to an increase in the percentage of moisture, fat and ash, and a decrease in protein, carbohydrates, and total solids in the resulting cheese. Also, the pH of the avocado-cream cheese increased slightly four-point sixty six to four-point sixty nine compared with the control four-point sixty one, these differences are due to the different in cream cheese types, the method of its manufacture, and the different ingredients involved in its manufacture (Hu, 2021).

Table (7): Chemical composition of local cream cheese samples.

Samples	Moisture%	Dry matter%	pH	Acidity%	Fat %	Fat in total solid%
C	56.00^c±0.23	44.00^a±0.13	5.20^a±0.02	0.25^c±0.01	30.00^a±0.01	13.20^a±0.01
C1	47.33^a±0.13	52.67^c±0.23	4.90^c±0.03	1.10^a±0.02	15.50^b±0.02	8.16^b±0.02
C2	46.66^b±0.22	53.34^b±0.26	5.18^b±0.03	0.31^b±0.03	15.50^b±0.04	8.27^b±0.03

Similar letters indicate that there are no significant differences between samples at a confidence level of $p \leq 0.05$, C: Control, C1: 15 avocado pulp %+5ml fresh lemon juice, C2: 15% avocado pulp +5g white pepper.

Conclusions and Recommendations

The avocado pulp was characterized by low moisture content, and high acidity, fat, fibre, total solids, antioxidant activity, phenolic compounds, and healthy fatty acid compared to fresh milk. The highest percentage of avocado pulp led to a significant increase in dry matter percentage, acidity, viscosity, total phenols, and antioxidant activity, and a decrease in the total count of microorganisms in yoghurt samples, and the yoghurt sample (four percent) had the best sensory acceptance. Storage of fortified samples with avocado for seven days led to a significant increase in antioxidant activity, and total phenol content compared to the control. A low-fat, high-nutrition local cream cheese product was made by completely replacing animal butter with avocado pulp. We recommend the use of avocado pulp in the manufacture of functional low-fat dairy products for its richness in healthy fatty acid, and natural antioxidants.

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Contributions of authors

R.H.T., sample preparation and analysis, laboratory methodology, and writing the manuscript.

A.M.B., analyzed data, suggest a title of the research, graphs, and statistical analysis**.**

A.A.Y., sample preparation, and statistical analysis.

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Conflicts of Interest

The authors have not declared any conflict of interest.

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References

Arackal, J. J., & Parameshwari, S. (2021). Identification of antioxidant activity and shelf life assay of avocado fruit pulp incorporated chapattis. *Materials Today: Proceedings*, *45*(2), 2589-2594. https://doi.org/10.1016/j.matpr.2020.11.337

Abbas, R. J., Mohammed, A. A., & Hussan, M. A. (2020). Effect of dried and processed yoghurt addition on the sites of protein digestibility along gastro-intes-tinal tracts of broiler chickens. *Advances in Animal and Veterinary Sciences*, *8*(5), 484-489. http://doi.org/10.17582/journal.aavs/2020/8.5.484.489

Akusu, O. M., Obinna-Echem, P. C., & Chibor, B. S. (2021). Comparative analysis of the physicochemical characteristics, phytochemical components and fatty acid profile of avocado pear (*Persea americana* L.) pulp and seed oil. *European Journal of Agriculture and Food Sciences*, *3*(1), 11-17. https://doi.org/10.24018/ejfood.2021.3.1.212

Al-Garory, N. H., & Al-Kaabi, W. J. (2020). Determination of some heavy metals concentration in some dairy products from three different regions of Basrah, Iraq. *Basrah Journal of Agricultural Sciences*, *33*(2), 1-13. https://doi.org/10.37077/25200860.2020.33.2.01

Alhalfi, N. A. (2018). Metabolic activity of lux-marked *Escherichia coli* O157: H7 during production and storage of yogurt. *Basrah Journal of Veterinary Research*, *17*(2), 277-291. https://www.iasj.net/iasj/article/169920

Ali, H. M. (2020). Comparative study on Labneh cheese made from milk fat and avocado paste. *Al-Azhar Journal of Agricultural Research*, *45*(2), 86-90. https://doi.org/10.21608/ajar.2020.175224

Al-Temimi, W. K., Al-Garory, N. H., & Khalaf, A. A. (2020). Diagnose the bioactive compounds in flaxseed extract and its oil and use their mixture as an antioxidant. *Basrah Journal of Agricultural Sciences*, *33*(1), 172-188. https://doi.org/10.37077/25200860.2020.33.1.13

Amado, D. A. V., Detoni, A. M., De Carvalho, S. L. C., Torquato, A. S., Martin, C. A., Tiuman, T. S., Aguiar, C. M., & Cottica, S. M. (2019). Tocopherol and fatty acids content and proximal composition of four avocado cultivars (*Persea americana* Mill). *Acta Alimentaria*, *48*(1), 47-55. https://doi.org/10.1556/066.2019.48.1.6

Astudillo-Ordóñez, C. E., & Rodríguez, P. (2018). Physicochemical parameters of avocado *Persea americana Mill*. cv. Hass (Lauraceae) grown in Antioquia (Colombia) for export. *Ciencia y Tecnología Agropecuaria*, *19*(2), 383-392. https://doi.org/10.21930/rcta.vol19_num2_art:694

Atmanaji, Hertanto, B. S., & Pramono, A. (2019). Physical and hedonic properties of cow milk yoghurt containing different levels of avocado pulp (*Persea americana*, Mill). In IOP Conference Series: *Materials Science and Engineering*, *633*, 012049. IOP Publishing. https://doi.org/10.1088/1757-899x/633/1/012049

Bintsis, T. (2018). Lactic acid bacteria as starter cultures: An update in their metabolism and genetics. *AIMS microbiology*, *4*(4), 665-684. https://pubmed.ncbi.nlm.nih.gov/31294241/

Bora, P. S., Narain, N., Rocha, R. V., & Paulo, M. Q. (2001). Characterization of the oils from the pulp and seeds of avocado (cultivar: Fuerte) fruits. *Grasas y Aceites*, *52*(3-4), 171-174. https://grasasyaceites.revistas.csic.es/index.php/grasasyaceites/article/view/353

Bovi, G. G., Caleb, O. J., Linke, M., Rauh, C., & Mahajan, P. V. (2016). Transpiration and moisture evolution in packaged fresh horticultural produce and the role of integrated mathematical models: A review. *Biosystems Engineering*, *150*, 24-39. https://doi.org/10.14279/depositonce-9718

Brooks, R. M., & Hesse, C. O. (2023). *Western fruit gardening: a handbook for the home gardener on fruit varieties; climatic adaptations; soil, water, and nutrient requirements; pruning and propagation; control of diseases and pests.* University of California Press's mission, 430pp. https://www.ucpress.edu/book/9780520349407/western-fruit-gardening

Donetti, M., & Terry, L. A. (2014). Biochemical markers defining growing area and ripening stage of imported avocado fruit cv. Hass. *Journal of Food Composition and Analysis*, *34*(1), 90-98. https://doi.org/10.1016/j.jfca.2013.11.011

Đurđević-Denin, J. D., Maćej, O. D., & Jovanović, S. T. (2002). Viscosity of set-style yoghurt as influenced by heat treatment of milk and added demineralized whey powder. *Journal of Agricultural Sciences, Belgrade*, *47*(1), 45-56. https://doi.org/10.2298/JAS0201045D

Eljagmani, S., & Altuner, E. M. (2020). Effect of storage temperature on the chemical and microbiological properties of white cheese from Kastamonu, Turkey. *Cogent Food & Agriculture*, *6*(1), 1829270. https://doi.org/10.1080/23311932.2020.1829270

El-Sayed, S. M. (2020). Use of spinach powder as functional ingredient in the manufacture of UF-Soft cheese. *Heliyon*, *6*(1), e03278. https://doi.org/10.1016/j.heliyon.2020.e03278

Eswaran, R., Anandan, A., Doss, A., Sangeetha, G., & Anand, S. P. (2012). Analysis of chemical composition of *Cissus quadrangularis* Linn by GC-MS. *Asian Journal of Pharmaceutical and Clinical Research*, *5*(2), 139-40.

Ferreira da Vinha, A., Moreira, J., & Barreira, S. (2013). Physicochemical parameters, phytochemical composition and antioxidant activity of the algarvian avocado (*Persea americana* Mill.). *Journal of Agricultural Science*, *5*(12), 100-109. http://hdl.handle.net/10284/9735

Gatbonton, G., De Jesus, A., Lorenzo, K. M. L., & Uy, M. M. (2013). Soxhlet extraction of Philippine avocado fruit pulp variety 240. *Chemical Engineering Journal*, *1*, 1-8.

Ghazal, M. M., Al-Hilfy, N. A. A., & Ali, H. I. (2021). Production of functional soft cheese and studying its chemical and sensory evaluation properties. *Basrah Journal of Agricultural Sciences*, *34*(1), 67-83. https://doi.org/10.37077/25200860.2021.34.1.07

Hadjimbei, E., Botsaris, G., & Chrysostomou, S. (2022). Beneficial effects of yoghurts and probiotic fermented milks and their functional food potential. *Foods*, *11*(17), 2691. https://doi.org/10.3390/foods11172691

Hettige, K. D. T., Ranadheera, C. S., Jayawardena, N. W. I. A., & Vidanarachchi, J. K. (2013). Quality evaluation of avocado (*Persea americana*) fruit yoghurt made from buffalo milk. In ISAE 2013. *International Symposium on Agriculture and Environment, University of Ruhuna, Sri Lanka*, 51-54. http://repository.rjt.ac.lk/handle/123456789/480

Hozzein, W. N., Hisham, S. M., & Alkhalifah, D. H. M. (2023). A Sustainable method: Production of the fermented rice milk yoghurt by using three efficient lactic acid bacteria. *Applied Sciences*, *13*(2), 907. https://doi.org/10.3390/app13020907

Hu, Y. (2021). *Preparation and characterisation of avocado cream cheese: effects of different treatments and ratios of avocado puree*. M. Sc. Thesis, Massey University, Auckland, New Zealand, 124pp. http://hdl.handle.net/10179/17145

Jayaprakasha, G. K., Singh, R. P., & Sakariah, K. K. (2001). Antioxidant activity of grape seed (*Vitis vinifera*) extracts on peroxidation models in vitro. *Food Chemistry*, *73*(3), 285-290. https://doi.org/10.1016/s0308-8146(00)00298-3

Kilara, A., & Chandan, R. C. (2013). *Manufacturing yoghurt and fermented milks*. HandBook, 2nd edition, 477pp. https://doi.org/10.1002/9781118481301

King-Loeza, Y., Ciprián-Macías, D. A., Cardador-Martínez, A., Martín-del-Campo, S. T., Castañeda-Saucedo, M. C., & del Pilar Ramírez-Anaya, J. (2023). Functional composition of avocado (*Persea americana* Mill. Var Hass) pulp, extra virgin oil, and residues is affected by fruit commercial classification. *Journal of Agriculture and Food Research*, *12*, 100573. https://doi.org/10.1016/j.jafr.2023.100573

Kleyn, D. H., Lynch, J. M., Barbano, D. M., Bloom, M. J., & Mitchell, M. W. (2001). Determination of fat in raw and processed milks by the Gerber method: collaborative study. *Journal of AOAC international*, *84*(5), 1499-1508. https://doi.org/10.1093/jaoac/84.5.1499

Kulasinghe, W. M. A. A., & Abesinghe, A. M. N. L. (2016). Development of avocado (*Persea americana*) incorporated set yoghurt. *Proceedings of the Research Symposium of Uva Wellassa University,* 1-6. http://www.digital.lib.esn.ac.lk/handle/123456789/14004

Kunadu, A. P. H., Holmes, M., Miller, E. L., & Grant, A. J. (2018). Microbiological quality and antimicrobial resistance characterization of *Salmonella* spp. in fresh milk value chains in Ghana. *International Journal of Food Microbiology*, *277*, 41-49. https://doi.org/10.1016/j.ijfoodmicro.2018.04.025

Langueira, E., & Pineda, J. (2012). Determination of fatty acid methyl esters (fames) in olive oil using automated sample preparation. *Agilent Technologies*, *24*, 1-7.

López-Cobo, A., Gómez-Caravaca, A. M., Pasini, F., Caboni, M. F., Segura-Carretero, A., & Fernández-Gutiérrez, A. (2016). HPLC-DAD-ESI-QTOF-MS and HPLC-FLD-MS as valuable tools for the determination of phenolic and other polar compounds in the edible part and by-products of avocado. *LWT*, *73*, 505-513. https://doi.org/10.1016/j.lwt.2016.06.049

Lyu, X., Agar, O. T., Barrow, C. J., Dunshea, F. R., & Suleria, H. A. (2023). Phenolic compounds profiling and their antioxidant capacity in the peel, pulp, and seed of Australian grown avocado. *Antioxidants*, *12*(1), 185. https://doi.org/10.3390/antiox12010185

Marín, F. R., Soler-Rivas, C., Benavente-García, O., Castillo, J., & Pérez-Alvarez, J. A. (2007). By-products from different citrus processes as a source of customized functional fibres. *Food Chemistry*, *100*(2), 736-741. https://doi.org/10.1016/j.foodchem.2005.04.040

Obi, O. F., Ezeoha, S. L., & Egwu, C. O. (2016). Evaluation of air oven moisture content determination procedures for pearl millet (*Pennisetum glaucum* L.). *International Journal of Food Properties*, *19*(2), 454-466. https://doi.org/10.1080/10942912.2015.1038566

Okparauka, I. I., Ojimelukwe, P. C., & Effiong, B. N. (2019). Comparison of the proximate composition of avocado pear food spread and fatty acid profile of its oil extract with margarine. *American Journal of Food Sciences and Nutrition*, *1*(3), 1-8. https://www.sdippress.com/article/comparison-of-the-proximate-composition-of-avocado-pear-food-spread-and-fatty-acid-profile-of-its-oil-extract-with-margarine

Radovanović, B., Mladenović, J., Radovanović, A., Pavlović, R., & Nikolić, V. (2015). Phenolic composition, antioxidant, antimicrobial and cytotoxic activities of *Allium porrum* L. (Serbia) extracts. *Journal of Food and Nutrition Research*, *3*(9), 564-569. http://www.sciepub.com/JFNR/abstract/5140

Rahman, M. T., Zubair, M. A., Shima, K., & Chakma, M. P. (2020). Development of quality parameters for yoghurt with strawberry juice. *Food and Nutrition Sciences, 11*(12), 1070-1077. https://doi.org/10.4236/fns.2020.1112075

Ranganna, S. (2007). *Analysis and quality control for fruit and vegetable products*. Handbook. 2nd edition, Tata McGraw Hill Publication Company limited, New Delhi. 1112pp. https://search.worldcat.org/title/Handbook-of-analysis-and-quality-control-for-fruit-and-vegetable-products/oclc/692163756

Reddy, P. M., & Marid, T. (2022). Study on the development of avocado (*Persea Americana*) Stirred Yoghurt. *International Journal of Economic Plants*, *9*(3), 210-213. https://ojs.pphouse.org/index.php/IJEP/article/view/4739

Salehi, F. (2021). Quality, physicochemical, and textural properties of dairy products containing fruits and vegetables: A review. *Food Science & Nutrition*, *9*(8), 4666-4686. https://doi.org/10.1002/fsn3.2430

Sendra, E., Fayos, P., Lario, Y., Fernández-López, J., Sayas-Barberá, E., & Pérez-Alvarez, J. A. (2008). Incorporation of citrus fibers in fermented milk containing probiotic bacteria. *Food Microbiology*, *25*(1), 13-21. https://doi.org/10.1016/j.fm.2007.09.003

Singh, B., Suri, K., Shevkani, K., Kaur, A., Kaur, A., & Singh, N. (2018). *Enzymatic browning of fruit and vegetables: A review.* Pp, 63-78. In Kuddus, M. (Editor). *Enzymes in food technology: Improvements and innovations,* Springer Nature Singapore Pte. Ltd. 419pp. http://doi.org/10.1007/978-981-13-1933-4_4

Soliman, T. N., & Shehata, S. H. (2019). Characteristics of fermented camel's milk fortified with kiwi or avocado fruits. *Acta Scientiarum Polonorum Technologia Alimentaria*, *18*(1), 53-63. https://doi.org/10.17306/j.afs.0602

Taiti, C., Costa, C., Menesatti, P., Caparrotta, S., Bazihizina, N., Azzarello, E., Petrucci, W. A., Masi, E., & Giordani, E. (2015). Use of volatile organic compounds and physicochemical parameters for monitoring the post-harvest ripening of imported tropical fruits. *European Food Research and Technology*, *241*(1), 91-102. https://doi.org/10.1007/s00217-015-2438-6

Tlay, R. H., Abdul-Abbas, S. J. El-Maksoud, A. A. A., Altemimi, A. B., & Abedelmaksoud, T. G. (2023). Functional biscuits enriched with potato peel powder: Physical, chemical, rheological, and antioxidants properties. *Food Systems*, *6*(1), 53-63. https://doi.org/10.21323/2618-9771-2023-6-1-53-63

Velderrain-Rodríguez, G. R., Quero, J., Osada, J., Martín-Belloso, O., & Rodríguez-Yoldi, M. J. (2021). Phenolic-rich extracts from avocado fruit residues as functional food ingredients with antioxidant and antiproliferative properties. *Biomolecules*, *11*(7), 977. https://doi.org/10.3390/biom11070977

Yousef, M., Nateghi, L., & Azadi, E. (2013). Effect of different concentration of fruit additives on some physicochemical properties of yoghurt during storage. *Annals of Biological Research*, *4*(4), 244-249.

دراسة الخصائص الفيزيائية والكيميائية والنشطة بيولوجياً للب الأفوكادو (*Persea americana*) واستخدامه في تحضير بعض الأغذية الوظيفية

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المستخلص: أجري هذا البحث بهدف تصنيع منتجات صحية (اللبن والجبن الكريمي محلي الصُنع) غنية بالمركبات النشطة بيولوجياً والأحماض الدهنية الصحية باستخدام لب ثمرة الأفوكادو. استُخدم لب الأفوكادو في تصنيع اللبن بنسبة اثنان، أربعة، وستة بالمائة، وخُزن الزبادي عند درجة حرارة 4ْم لمدة سبعة أيام. صُنع الجبن الكريمي محلي الصُنع يدوياً عن طريق استبدال الزبدة الحيوانية بـ 15% من لب الأفوكادو. حُدد المحتوى من المركبات الفينولية في لب الأفوكادو الطازج باستخدام HPLC، إذ وجدت الدراسة الحالية أنه غني بالكامبيفيرول 30.88 جزء في المليون، وحامض الفيروليك 30.25 جزء في المليون، والأبيجينين 22.58 جزء في المليون، والكويرستين 18.98 جزء في المليون، وحامض الكوماريك 12.66 جزء في المليون، كما أنه غني ببعض الأحماض الدهنية: الأوليك 59.58%، البالمتيك 17.58%، وألفا لينولينيك 18.05%. مقارنة بعينة الشاهد في اليوم الأول للتخزين، أدى تدعيم اللبن بالأفوكادو إلى زيادة النشاط المضاد للأكسدة بنسبة 10.86%، 25.12%، و34.63%، وزيادة المحتوى الفينولي الكلي بنسبة 129.55%، 343.18%، و404.55%. كانت عينة اللبن 4% هي الأكثر قبولاً من حيث القوام والطعم والنكهة والقبول العام، كما أضاف الأفوكادو طعماً زبدياً وقابضاً ومميزاً للعينات المدعمة به. أدى تصنيع الجبن الكريمي المُصنع محليًا باستخدام الأفوكادو إلى انخفاض نسبة الرطوبة والدهن وزيادة في الحموضة والمواد الصلبة الكلية، وأمكن الحصول على غذاء وظيفي منخفض الدهون ذو قيمة غذائية عالية. أظهرت النتائج أن تدعيم اللبن بالأفوكادو كان له تأثير إيجابي في تقليل التعداد العام للأحياء الدقيقة، وكان خاليًا من الأعفان والخمائر ونموات الكوليفورم أثناء التخزين.

الكلمات المفتاحية: لب الأفوكادو، الخصائص الكيميائية والفيزيائية، الأحماض الدهنية، المنتجات الصحية، الحمولة الميكروبية، الخواص الحسية.