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Preparation and Properties of Functional Milk Beverage Fortified with Kiwi Pulp and Sesame Oil.

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ABSTRACT

The aim of this study is to develop a functional milk beverage fortified with kiwi pulp and sesame oil. Skim milk was fortified with kiwi pulp (20.0% w/w), sesame oil (0.5, 1.5 and 3%), pectin (0.1% w/w), monoglyceride (0.1% w/w) and sucrose (10% w/w), homogenized, pasteurized and then kept cool. Beverage samples from different treatments were cold stored for 14 days and analyzed for their chemical composition, rheological and sensory properties when fresh, and after 7 and 14 days of storage. The viscosity of the beverages increased while the sedimentation and serum separation decreased with the increase of added sesame oil. Scores for the different sensory attributes showed that the beverage containing 1.5% sesame oil recorded the highest preference then other treatments. Results exhibited a new functional beverage rich in total phenolic compounds and high in antioxidant activity which increased with increase of sesame oil addition. The prepared beverage was characterized by high nutritional value and potential health effects.
Keywords: Functional milk beverage; Kiwi; fruit; sesame oil; sensory properties; antioxidant activity.

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INTRODUCTION

The growing interest in functional foods with special characteristics and health properties has encouraged industry to the development of new functional beverage. In this way, functional milk based beverages containing fruit can provide humans with necessary nutrients for potential health promotion and disease prevention [1]. The health benefits of functional foods are due to enrichment with various physiologically active ingredients, such as omega-3 fatty acids, antioxidant compounds, fibers, photochemical present in fruits as well as in milk bioactive peptides. These functional ingredients may reduce the risk of several diseases such as cardiovascular diseases, cancer, diabetes mellitus, Alzheimer's disease, cataracts and degeneration diseases [2].

Kiwi fruit was characterized by high nutritional value, rich in vitamin C, fibers, calcium, iron, and phosphorus [1]. Kiwi fruits are widely used in treatment of diseases such as hepatitis, edema, rheumatoid arthritis, gastric cancer and breast cancer [3]. Also consumption of kiwi fruit offers health benefits including anti-tumor and protective effects on acute hepatic injury in biological arrays [4]. A single kiwi fruit can provide the consumer with the minimum daily requirement for vitamin C [5] suggesting that kiwi fruit-derived products could be an excellent source of this essential vitamin. When fruit juice is mixed with milk, various interactions can occur between the constitutions of the two fluids [6]. The added fruit juice may change the pH of milk, which may lead to protein aggregation and precipitation [7, 8] and require careful management during the processing of milk beverage fortified with fruit juices or pulp.

Sesame oil is also widely consumed as a nutritious food of potential health effects [9]. Sesame oil has a good potential to prevent atherosclerosis by acting through multiple ways [10]**.** Thus sesame oil preserve good cholesterol (high density lipoprotein, HDL) and lower bad cholesterol (low density lipoprotein, LDL) [11]. Also, on diet containing sesame oil the fasting blood glucose levels were significantly lower and the blood lipid profile was significantly improved [12]. In addition, it is a very rich in lecithin and phospholipids that act as a powerful emulsifier, facilitating the dissolution of fat in an aqueous medium [13]. Sesame oil has been established to inhibit the growth of the propagation of human colon cancer cells. Compared with other oils, sesame oil is highly resistant to oxidative deterioration. Sesame oil showed effective hepatoprotective action against lead acetate induced hepatotoxicity in albino mice. So, the populations of high risk to lead should be advised to take sesame oil, being useful as a protective agent against heavy metals toxicity [14]**.**

Regarding to the insufficient safety evaluation; sesame oil should be used with caution within the diet of children and pregnant or lactating women and also for the patients with existing liver or kidney diseases. Additionally, in case of diarrhea the use of this oil should be avoided because of its laxative effect. While considering these factors the judicious daily use of sesame oil will definitely help reduce the occurrence of hypertension or atherosclerosis. So the oil from sesame plant seed (*Sesamum indicum*) belonging to pedaliaceae family is considered as a nature's gift to mankind [10]. The oil is used in the production of sesame ice cream by using soy milk and sesame oil to remove beany taste and flavor of sample and also as fat substitute in yoghurt [15]**.**

This study aimed to develop a new functional milk beverage product through incorporating kiwi fruit pulp and sesame oil is nutritive and flavoring agents, their ability to prevent certain diseases, which might suggest their inclusion in the functional foods group.

MATERIALS AND METHODS

Materials

Fresh skim milk (protein 3.5%, fat 0.5% and T.S. 11.2%) was obtained from the Faculty of Agriculture Cairo Univ. Giza, Egypt. High quality Kiwi fruits were obtained from local market. Sesame oil was obtained from the unit of pressing and extracting natural oil, National Research Center, El-Dokki, Egypt. Emulsifier mono and diglyceride 60% was obtained from Misr for Food Additives (MISAD), Giza, Egypt. Pectin was obtained from Sisco Research Laboratories (SRL) Mumbai, India. Trichloroacetic acid (TCA) and Triflouroacetic acid (TFA) were obtained from Sigma-Aldrich (Seeize, Germany), methanol (HPLC grade) from (Fisher Scientific Limited, UK). Potassium hydroxide, sodium ascorbate, sodium sulphate anhydrous, and calcium chloride (Analytical Reagents) and ammonia solution (25%) were obtained from El Nasr Pharmaceutical Chemicals Co. (Cairo, Egypt), phenolphthalein and pyrogallol from (Alpha chemika, Bumbai, India), diethyl ether (extra pure) and absolute ethanol from (molekula, Dorset, UK), n-hexane, methylene chloride, methanol and acetonitrile (HPLC grade) from (Fisher Scientific Limited, UK). Milli-Q water was prepared using a Milli-Q water system (Millipore, MA, USA). Standards of thiamin (vitamin B1), riboflavin (vitamin B2), pyridoxine (vitamin B6), vitamin C and α-tocopherol (vitamin E) were purchased from Sigma Chemical Co., St Louis, MO, USA.

Method

Preparation of Kiwi Pulp

Kiwi fruits were washed with water to remove any external dirts. Both ends and the skin of each fruit were removed, cut to pieces and then homogenized in a blender, the resultant pulp was packaged in polyethylene bags and stored at -18°C until used.

Preparation of flavored milk beverage

Fresh skimmed milk was heated to 45°C mixed with the stabilizer-emulsifier mixture (pectin 0.1% and monoglyceride 0.1% w/w), and then blended. Sesame oil was added at the levels of 0.5, 1.5 and 3% w/w, respectively to the fresh skimmed milk and then homogenized using high speed blander. Twenty percent of the Kiwi pulp was blended in filled milk containing sodium ascorbate (0.1%) to avoid discoloration before thermal processing. Sucrose (10% w/w) was added to the prepared flavored milk mixed well, the mixture was mixed again, heated up to 60-70°C, homogenized using high speed blender at 18,000/min. for 5 min. The prepared beverage was pasteurized at 72°C for 15 Sec. and immediately cooled down to 10°C, filled into dark glass bottles, and stored at 5°C until analyzed. Beverage samples were, chemically analysis and evaluated for rheological and sensory properties when fresh and during storage for 14 days.

Physical properties of the flavored milk beverage

Sensory evaluation

Beverages were sensory evaluated by 15 members of the Dairy Dept., National Research Center, using scale of 40 points for appearance, 20 points for color and 40 points for flavor.

Apparent viscosity of flavored milk beverage (cP.s)

Beverage samples were gently stirred 5 times in clockwise direction with a plastic spoon prior to viscosity measurements. Apparent viscosity was measured at 7ºC using a Brookfield digital viscometer (Middleboro, MA 02346, U.S.A). The sample was subjected to shear rates ranging from 3 to 100 S-0 for upward curve. Viscosity measurements were expressed as centipoise **(**cP.**s)** and were performed in triplicate.

Storage stability

The physical stability of the products was analyzed by measuring separation layer and the sediment during storage.

Flavoured milk beverage samples were placed in 5 mL disposable pipettes sealed at both ends with parafilm and samples were stored at 7°C for 2 weeks old to assess serum separation under gravity. The height of a separated layer (SL) was recorded and was expressed as a percentage of the total fluid height according to the following equation [16].

$$SL\ (\%) = (\text{Separate layer height} \div \text{Total fluid height}) \times 100$$

Sedimentation of the prepared beverages was assessed, according to Medermott [17] by centrifugation at 3000x g for 20 min at ambient temperature. Sedimentation was calculated as a percentage of the Sediment weight to the total sample weight.

Chemical composition of flavored milk beverage

The total solids (TS) content of the sample was determined by the drying over method according to method described by Ling [18]. pH values were measured using laboratory pH meter model (HANNA, Instrument, Portogal). Total nitrogen (TN), fat and ash contents were determined according to the standard methods [19]. Mineral contents were determined by atomic absorption spectrophotometer, perken Elemer 1100B as described by Saadatu and Mshelia [20]. The total carbohydrate values were obtained by calculation. All analyses were run in triplicate.

Determination of vitamins

Preparation of vitamin standards

A stock standard solution (100 µg mL^{-1}) of thiamin, riboflavin, and pyridoxine were prepared MQ water and a standard solution (100 µg ml^{-1}) of vitamin (E) α-tocopherol was prepared with acetonitrile. Standard ascorbic acid solution (1mg/ml) was prepared by dissolving 50mg of ascorbic acid in 40 ml of 3% HPO_3:HOAC solution and made up to 50 ml in a volumetric flask. All standards were stored at 4°C before use.

Determination of fat-soluble vitamin concentration (vitamin E-α-Tocopherol) by HPLC

Vitamin E (α-Tocopherol) was determined by HPLC analysis after extraction from the beverage as described by Escrivá et al [21]. HPLC analysis was performed with an Agilent 1260 HPLC system (Agilent Technologies, USA), equipped with a quaternary pump, auto sampler injector with 20 µl fixed loop injector, thermostat compartment for the column and photodiode array detector. The chromatographic column was ODS H optimal (150 mm x 4.6 mm, 5 µm film thicknesses). The column was kept at room temperature. Aliquot (20 µml) of the standard or a sample was injected and then eluted with the mobile phase of acetonitrile/methylene chloride/methanol (70:20:10, v/v/v) at an isocratic flow rate of 1 ml min^{-1} with a total runtime of 15 min. Detection wavelength for detection of α-tocopherol, was set at 250 nm. The retention time of α-tocopherol was about 9.644 min. The limit of detection was found to be 0.02 mg kg^{-1}. Vitamin E α-tocopherol content was further expressed in µg per 100 g of fresh weight.

Determination of water-soluble vitamin

Vitamin thiamin (B1), riboflavin (B2) and pyridoxine (B6)

Vitamins B1, B2, B6 were determined by HPLC analysis after extraction from the sample according to Albala-Hurtado et al [22]. HPLC analysis was performed with an Agilent 1260 HPLC system (Agilent Technologies, USA), equipped with a quaternary pump, auto sampler injector with 20 µl fixed loop injector, thermostat compartment for the column and photodiode array detector. The chromatographic column was C18 Zorbax XDB (250 mm x 4.6 mm, 5 µm film thicknesses). The column was kept at room temperature at a flow rate of 0.8ml/min with a total runtime of 12 min. Separation of vitamins was carried out by gradient elution with methanol (A) and 1% TFA containing water (B). the elute composition was initially 8 % A + 92 % B, held for 2 min, and changed linearly to 92 % A + 8 % B in the next 4 min and held for 6 min. Detection wavelength for detection of thiamin, riboflavin, and pyridoxine was set at 254 nm. The retention time of thiamin, pyridoxine, and riboflavin were about 5.974, 6.996 and 7.645 min.

Vitamin C

The vitamin C content of the beverage samples was determined using the metric titer method [19].

Gas-liquid chromatographic analysis of fatty acids methyl esters.

The fatty acid composition of the oil samples were identified and measured using gas liquid chromatography on a Hewlett Packard Model 6890 with a flame ionization detector using capillary column 30.0 m x 530 µm x 1.0µm. The carrier gas used was nitrogen set at a flow rate of 15ml/min and split-ratio of 8:1. Esterification of fatty acid for methyl ester preparation was carried out accordingly to luddy et al [23].

Total Phenolic compounds

The extract solution prepared by diluting 2g from beverage with methanol overnight filtered and then completed to 50 ml with methanol. Aliquot of the extract (1 mL) was mixed with Folin-Ciocalteu reagent (5 mL, previously diluted with water 1:10, v/v) containing sodium carbonate (75 g/L, 4 mL). The tubes were vortexed for 15 s and allowed to stand for 30 min at 40 °C for color development. Absorbance was then measured at 765 nm. Gallic acid was used to obtain the standard curve (9.4×10^{-3}–1.5×10^{-1} mg/mL), and the results were expressed as mg of gallic acid equivalents (GAE) per g of extract [24].

Antioxidant activity

The free radical scavenging activity (FRS) of the sample was measured using DPPH (2,2-Diphenyl-1-picrylhydrazy). Estimation of FRS activity: (2,2-Diphenyl-1-picrylhydrazy (DPPH)) according to Elmastas et al [25]. The 2, 2-Diphenyl-1-picrylhydrazy (DPPH) solution (0.1mM) was prepared in absolute methanol. One ml of 0.1mM solution of DPPH was added to 3ml of the beverage methanolic extract at different concentrations (100, 300 and 500 µg/ml). The mixture was shaken vigorously and allowed to stand at room temperature in darkness for 30 min. The absorbance was measured spectrophotometerically at 517nm. Butylated hydroxyl toluene (BHT) was used as positive control. Lower absorbance of the reaction mixture indicates higher free radical scavenging activity. The capability to scavenge the DPPH radical was calculated using the following equation:

$$\text{DPPH scavenging effect (\%)} = [(A_0 - A_1/ A_0) \text{ X } 100]$$

Statistical analysis

All measurements were done in triplicates and analyzed according to Statistical Analysis System **SAS** [26].

RESULTS AND DISCUSSION

Chemical composition of flavored milk beverage

The data presented in **Table (1)** refers to chemical composition of beverage fortified with sesame oil rich in oleic and linoleic acids. The proximate composition of beverage treatments ranged between 23.99 – 24.74 total solids, 2.45 – 2.85 protein, 1.1 – 3.5 fat, 0.46 – 0.56 ash, 75.26 – 76.01 moisture and 18.33 – 19.51% carbohydrates **(Table 1)**. The moisture, ash, protein and total carbohydrate significant decrease by increasing the fat (sesame oil) and total solids. The results indicate that with increasing the levels of added sesame oil, the content of total solids of flavored milk beverage increased. The results of this study are in agreement with that reported by Ahanian et al [15] on ice cream fortified with sesame oil.

Table 1: Chemical composition of flavored milk beverage rich in oleic and linoleic Acids

Treatments	Moisture	Ash	Fat	Protein	Total carbohydrate	Total Solids
0.5%	76.01^{A}	0.53^{B}	1.10^{C}	2.85^{A}	19.51^{A}	23.99^{C}
1.5%	75.61^{B}	0.56^{A}	2.00^{B}	2.65^{B}	19.18^{B}	24.39^{B}
3.0%	75.26^{C}	0.46^{C}	3.50^{A}	2.45^{C}	18.33^{C}	24.74^{A}

A,B,C: Means with the same letter among treatments are not significantly different ($p \leq 0.05$)

Fatty acid profile of sesame oil

Figure 1 illustrates the fatty acid profile of sesame oil obtained from GC. Sesame oil was containing Palmitic 9.18%, Oleic acid 44.25%, Linoleic acid 39.80% and Linolenic acid 2.58% this is agreement with results reported by [27]**.** The high level of PUFAs in sesame oil was claimed to reduce blood cholesterol, high blood pressure and play an important role in preventing atherosclerosis, heart diseases and cancers [28, 29].

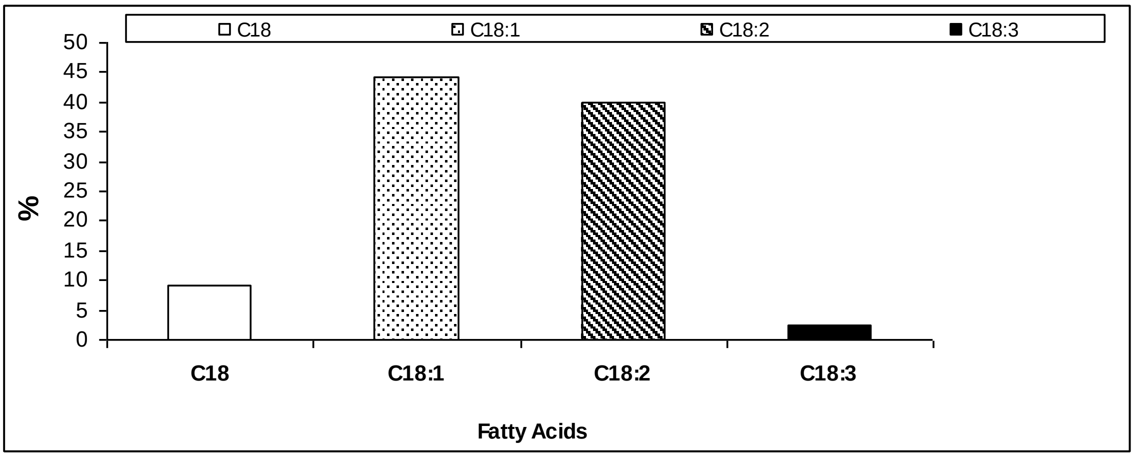

Figure 1: Fatty acid profile of sesame oil

pH value

The pH values of fresh flavored milk beverage and after storage for 2 weeks are presented in **Table (2)**. The pH value of fresh beverage decreased significantly with increasing the added sesame oil from 0.5 to 3% which may be attributed the free fatty acids in the sesame oil [30]. The pH value of flavored milk beverage during storage periods (7 and 14 days) slightly decreased all treatments as the pH values of compared with fresh samples, except for beverage containing 1.5% sesame oil of the 7 days being similar to the pH of its fresh sample.

Table 2: pH value for flavored milk beverage during stored for two weeks

Treatments	Fresh (0 day)	7 day	14 day
0.5%	5.75^{Aa}	5.71^{Ab}	5.68^{Ac}
1.5%	5.68^{Ba}	5.68^{Ba}	5.61^{Bb}
3.0%	5.63^{Ca}	5.61^{Cb}	5.54^{Cc}

A,B,C: Means with the same letter among treatments are not significantly different (p≤0.05)
a,b,c: Means with the same letter during storage period are not significantly different (p≤0.05)

Antioxidant activity of flavored milk beverage

The antioxidant activity of fresh flavored milk beverage (**Table 3)** increased with the increase of the added sesame oil. The total phenolic compounds content of fresh beverages increased with the increase of the added sesame oil being was 192.71, 208.85 and 210.94 for beverage containing 0.5, 1.5 and 3.0 %, of sesame oil respectively. Sesame oil is containing several antioxidants polyphenols such as sesamol which may be responsible for its increased antioxidant activity and total phenol contents of the prepared beverage [31].

Table 3: Antioxidant activity of flavored milk beverage

Treatments	Phenols	DPPH%
0.5%	192.71^{C}	21.03^{C}
1.5%	208.85^{B}	22.64^{B}
3.0%	210.94^{A}	24.13^{A}

A,B,C: Means with the same letter among treatments are not significantly different (p≤0.05)

The antioxidant activity (DPPH values) also increased from 21.03, 22.64 and 24.13 by increasing the added sesame oil from 0.5, 1.5 and 3.0%. The antioxidant components of sesame oil encompass sesamine, sesamolin, a phenolic substance sesamol and tocopherol [32, 33]. Presence of lignans; sesamin, sesamolin and traces of sesamol and tocopherol in the oil are believed to be responsible for beneficial health effects of sesame oil.

Viscosity of flavored milk beverage (cP.s)

Viscosity is an important quality factor of beverages. The prepared milk beverage showed increased viscosity with the increase of the added sesame oil Fig. (2). These data are in agreement with that reported by Alimoradi et al [30] who substituted milk fat with refined sesame oil in the manufacture of high-fat yoghurt. The increase in viscosity of the flavored beverage during storage may be attributed to changes to protein conformation and changes in acidity [34]. The addition of sesame oil in the flavored milk beverage can create some changes in the beverage matrix and interaction between protein and fatty acids resulting in more open texture and by reducing the interfacial tension which reduces the viscosity [35].

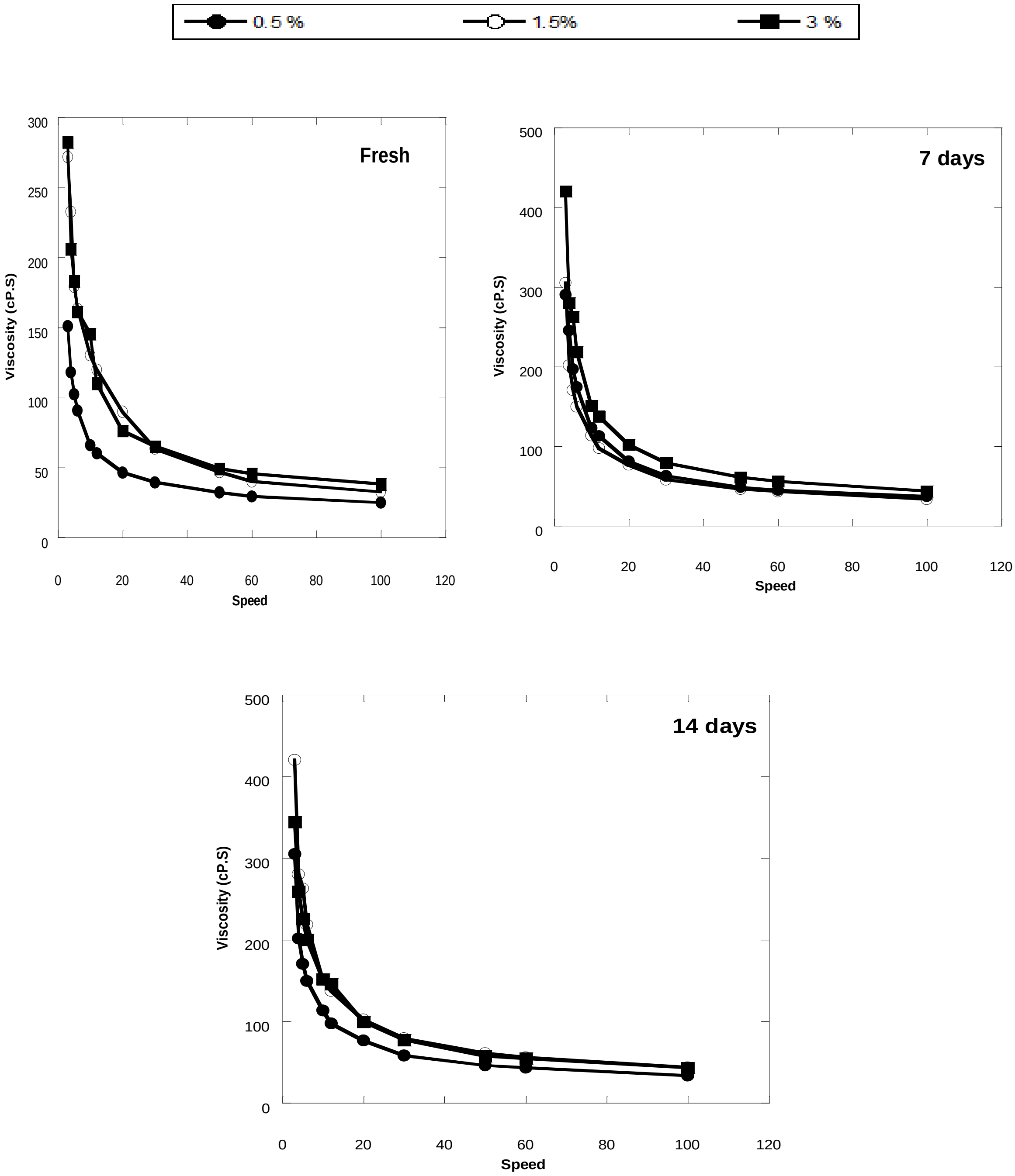

Figure 2: Viscosity of flavored milk beverage fresh and after storage for two weeks.

Sedimentation and serum separation of flavored milk beverage

Table (4) shows the Sedimentation and serum separation of flavored milk beverage stored for two weeks. Significant differences were found in the sedimentation ratio of fresh beverage made with 0.5 % sesame oil and that from other treatments the beverage containing 0.5 % sesame oil showed the highest sedimentation ratio of 6.75%, while treatment made with 1.5 % sesame oil and treatment made with 3.0 % sesame oil showed the lowest sedimentation ratio of 3.45 and 2.32 respectively. This indicates that recorded sedimentations were about 50% of the total sample weight in treatment made with 1.5 % sesame oil and 66% in treatment made with 3.0 % sesame oil. This may due to the increase in the added sesame oil. Also, during storage there was a significant decrease in the sedimentation between treatments at the end of 2nd week. Which may due to the action of kiwi constituents on proteins in skim milk. The present results are agreement with previous report [6]. Kiwi was reported to contain a proteolytic enzyme with activity similar to papain [36]. This enzyme may induced gellation, of milk proteins which nearly in an increase in sedimentation. These enzymes may play an important role in food digestion.

Table 4: Sedimentation and serum separation (%) of flavored milk beverage stored for two weeks.

	Storage period (days)	0.5%	1.5%	3%
Sedimentation %	1	6.75^{Aa}	3.45^{Ab}	2.32^{Ac}
	7	2.52^{Cb}	2.60^{Ba}	1.24^{Bc}
	14	2.69^{Ba}	1.67^{Cb}	0.29^{Cc}
Serum separation%	1	8.00^{Ba}	0.00^{Cb}	0.00^{Bb}
	7	10.00^{Aa}	8.00^{Bb}	0.00^{Bc}
	14	10.00^{Aa}	9.00^{Ab}	4.00^{Ac}

A, B, C: Means with the same letter during storage period are not significantly different ($p \leq 0.05$)
a, b, c: Means with the same letter among treatments are not significantly different ($p \leq 0.05$)

The mix beverage containing 0.5% sesame oil separate serum after 1 day of storage while no serum separation was recorded with other two treatments. There is no serum separation after one day of storage and after 7 days in the treatment containing 3% sesame oil. After 14 days of storage, the lower separation was recorded with treatment containing 3% sesame oil. Statistical analysis showed the sesame oil percentage had a significant effect on the serum separation. This can be explained on the basis that the sesame oil improved soft texture in the prepared beverage and also serum separation.

Sensory evaluation of flavored milk beverage

The data in **Table (5)** reffers to the sensory evaluation of flavored milk beverage during storage. The results showed that the milk beverage containing 1.5% sesame oil recorded the highest preferance than the other two treatment. Sensory score decreased by storage for all beverage treatments exept flavor scores which increased with increase of storage time. The body and texture of all flavored milk beverage containing different concentration from sesame oil charachtarized by heavy and sick texture. The present results are in aggrement with that reported by Alimoradi et al [30] Also, Ahanian et al [15] found that addition of sesame extract to ice cream made from different combinations soy milk and skim milk masked completely the beany taste of soy milk, and the sample had quite appropriate and smooth texture and has had desirable overall acceptance.

Table 5: Sensory evaluation of flavored milk beverage stored for two weeks

Treatment	Storage Period (days)								
	1			7			14		
	Color (20)	Flavor (40)	Appearance (40)	Color (20)	Flavor (40)	Appearance (40)	Color (20)	Flavor (40)	Appearance (40)
0.5%	18.11^{Ba}	28.11^{Bc}	34.56^{Ba}	17.75^{Bb}	30.75^{Bb}	33.38^{Bb}	16.43^{Cc}	31.33^{Ba}	32.12^{Bc}
1.5%	18.67^{Aa}	32.89^{Aa}	35.67^{Aa}	18.5^{Ab}	33.00^{Aa}	34.75^{Ab}	17.81^{Ac}	33.47^{Aa}	33.71^{Ac}
3.0%	17.33^{Ca}	24.44^{Cc}	33.56^{Ca}	17.13^{Cb}	31.88^{ABa}	32.13^{Cb}	16.76^{Bc}	30.17^{Cb}	31.54^{Cc}

A,B,C: Means with the same letter among treatments are not significantly different ($p \leq 0.05$)
a,b,c: Means with the same letter during storage period are not significantly different ($p \leq 0.05$)

Minerals and vitamins content in flavored milk beverage

Vitamins and minerals are considered key officials of health and function including work performance. As shown in **Table (6)** data indicated that minerals content (phosphorus, calcium, magnesium, iron, zinc) in milk kiwi beverage 1.5 % sesame oil was 37.84, 43.65, 35.75, 2.7 and 3.6 mg / 100g respectively.

Table 6: Mineral (mg/100g) and vitamins (µg/100g) content of flavored milk beverage containing 1.5 % sesame oil

Minerals (mg/100g) and vitamins (µg/100g)	
P	37.84
Ca	43.65
Mg	35.75
Fe	2.70
Zn	3.60
Vitamin C	21333.00
Vitamin B1	71.34
Vitamin B2	883.52
Vitamin B6	46.63
Vitamin E	34.22

The present result indicated that this beverage consider amusing source of minerals especially calcium and phosphorus and the intake of this nutrients from beverage improving health. Calcium and phosphorus is an important for bone health, Furthermore low calcium intake has been associated with higher risk of colorectal cancer [37]. Iron is a trace element that is required for the delivery of oxygen to tissues, iron deficiency, damages muscle function and limits work capacity [38]. Magnesium is required in a wide variety of essential cellular actions that support varied physiologic systems [39]. Zinc is required for nucleic acid and protein synthesis, cellular differentiation and replication, and glucose use and insulin secretion [40]. Vitamin C is the major water-soluble antioxidant, and α-tocopherol or vitamin E is the major lipid-soluble membrane-localized antioxidant in humans. Vitamins C and E, have a high antioxidant capacity which protection against harmful free radicals, which reduced the risk of chronic diseases, cancer, diabetes and Alzheimer's disease [41]. This beverage is a great source of vitamin C 21333 µg/100g and this owing to the presence of kiwifruit in this beverage, Jung et al [42] reported that Kiwifruit have a high content of vitamin C. The sesame oil is extensively known to be a rich source of vitamin E. It has been reported that the component sesamin in oil improves the bioavailability of vitamin E by inhibiting the α-tocopherol degrading enzymes [43]. The beverage content 34.22 µg/100g of vitamin E as shown in **Table (6)**. The B group vitamins are water-soluble vitamins required as cofactors for enzymes essential in cell function and energy production. This beverage have a rich source of thiamin 71.34 µg/100g, riboflavin 883.52 µg/100g and pyridoxine 46.63 µg/100g and this owed to the presence of skim milk and kiwi fruit on this beverage. The deficiency of water-soluble vitamins causes disorders of the nervous system and of rapidly dividing tissues [44].

CONCLUSION

The main objective of this study is to develop a functional milk beverage fortified with kiwi pulp and sesame oil to elevate its nutritional value and health properties. The Storage of beverage significantly resulted in increasing the viscosity while the pH, sedimentation and serum separation decreased with the increase of added sesame oil. Scores for the different sensory refer that beverage 1.5% sesame oil recorded the highest acceptability then other treatments. Results exposed a new functional beverage with high content of phenolic compounds and high antioxidant capacity increased with increasing sesame oil addition. Furthermore, this beverage is a rich source of many vitamins, minerals, and high level of PUFAs therefore was characterized by high nutritional value and potential health properties.

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