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Utilization of Egyptian mulberry fruits to improvement the physicochemical and nutritional properties of ice milk

Ghanem, S. M.
Food Science and Technology Department, Faculty of Agriculture, AL-Azhar University, Cairo, Egypt.

M. M. Salama
Food Science and Technology Department, Faculty of Agriculture, AL-Azhar University, Cairo, Egypt.

A.N. Zaghlool
Food Science and Technology Department, Faculty of Agriculture, AL-Azhar University, Cairo, Egypt.

M. M. Kadry
Food Science and Technology Department, Faculty of Agriculture, AL-Azhar University, Cairo, Egypt.

A.M. Hassanin
Dairy Department, Faculty of Agriculture, AL-Azhar University, Cairo, Egypt.

Muhammad I. Haggag
Botany and Microbiology Department, Faculty of Science, Al-Azhar University, Nasr City, Cairo, Egypt
Email: Muhammad_aly@azhar.edu.eg

***Abstract*---**Ice milk is one of the most important popular dairy products, as it is consumed by all age groups and is especially preferred by children, especially in the summer. This research aims to produce functional ice milk using one of the lovable fruits that have a high nutritional and health value, which is the mulberry. The mulberry pulp is a good source of nutrients such as crude fiber, ash, and carbohydrates and biologically active biomolecules such as phenols, alkaloids, terpenoids, amino sugars, antioxidants, etc. Two species of mulberry fruits namely white mulberry (*Morus alba* L.) and black mulberry (*Morus nigra* L.) planted in Egypt were used in this study. The objective of this research was to study the effect of mulberry pulp addition by ascending levels (3, 6, and 9%) of both

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white mulberry pulp (WMP) and black mulberry pulp (BMP) severally, with mixed between them at level 6% on the nutritional value, physicochemical properties and organoleptic evaluation for produced ice milk. The present results showed that the incorporation of WMP or BMP into ice milk formula led to increasing the contents of crude fiber, ash, and carbohydrates as compared with the control sample. Also, the mineral contents for Ca, K, Mg, P, Zn, and Fe were significantly increased as the addition levels increased of (WMP or BMP) in ice milk samples as compared with the control sample. As for the physiochemical and rheological properties, the results showed that the addition of WMP or BMP into ice milk caused improvement in most physiochemical properties such as freezing point, viscosity, overrun, first drip time, and complete melting times. The ice milk produced by the addition of mulberry pulp exhibited good sensory properties when compared with the control sample, especially with the incorporation of 3 and 6% of both black and white mulberry pulp severally in formula samples. From the above mention, it could be concluded that the addition of mulberry pulp to dairy products such as ice milk could improve the physicochemical properties and nutritional properties of produced ice milk, and therefore it is recommended to utilize it in dairy products. The developed ice milk enriched with mulberry pulp could meet consumer expectations for healthy and functional food.

***Keywords*---**ice milk, white mulberry, black mulberry, nutritional value, mineral content, physiochemical properties, sensory evaluation.

Introduction

The nutritional content of dairy products, which provide the nutrients that people require, is linked to positive health impacts. Recently, functional nutrients have been added to milk and other dairy products to create a source of functional dietary elements. (Elkot *et al.* 2017). Additionally, customers today want meals enriched with beneficial substances like antioxidants, phenols, phytosterols, vitamins, and minerals, thus producers added these functional components to food items to appeal to consumers who are interested in maintaining a healthy lifestyle. (Shaviklo *et al.,* 2011).

The manufacture of dairy products with reduced fat contents and high nutraceutical and functional value is on the rise in dairy factories nowadays. Customers want to consume these foods; thus, they need to be affordable, with an acceptable "taste and look." Many varieties of simple ice cream, low-fat ice cream, and ice milk are currently offered in the marketplaces among these goods. Therefore, the objective of numerous research published in the literature was to replace or add functional food components with health benefits instead of conventional ingredients in ice cream formulations without changing flavour, mouthfeel, or other sensory qualities. (Bisla *et al.,* 2012, Karaman and Kayacier 2012, Sun-waterhous *et al.,* 2013, Ahanian *et al.,* 2014 and Umelo *et al.,* 2014).

Ice milk is a frozen beverage that has at least 2% fat, 7% fat, and at least 11% total milk solids. (Bikheet *et al.,* 2018). In the USA, a conventional frozen treat with a fat level between 2 and 8% is referred to as "ice milk." (Tharp and Young, 2013). The threshold for ice milk's fat content under Egyptian law is that it must be less than 3%. (Soad *et al.,* 2014); Additionally, ice milk has little nutritional fibres and natural antioxidants despite having a high-calorie content. One of the most common methods used today to produce goods with components that promote health advantages, such as functional foods, is food fortification. (Ficco *et al.,* 2018).

As a result, the goal of this study was to develop functional ice milk by boosting it with natural sources that have great nutritional and health Val Plants have piqued the interest of medical practitioners and pharmaceutical companies all over the world as natural sources of biologically active chemicals. Natural compounds obtained from specific plants have been utilized to prevent and cure common human ailments. Mulberry was noted among these plants for its bioactive biomolecules such as phenols, alkaloids, terpenoids, amino sugars, and so on. (Rohela *et al.,* 2020).

The mulberry fruit is a member of the Moraceae family and belongs to the genus Morus. Berries are consumed fresh or dried and are utilized in the production of several items such as jam, cold beverages, and wine. Furthermore, red and black berries have lately acquired prominence in the food business due to the presence of anthocyanin, which is an antioxidant molecule with free radical scavenging action. Abd EL-Malak *et al.* (2010).

Mulberry fibre has been shown to lower cholesterol levels in the liver and boost the activation of low-density lipoprotein (LDL) receptors. Berries can therefore be recommended to hypercholesterolemia patients to help them lose fat. (Venkatesan *et al.,* 2003 and Sirikanchanarod *et al.,* 2016). Due to its high polyphenol content, which includes flavonols, isoflavanols, stilbene, lignin, tannins, anthocyanin, and antioxidants, mulberry is also used to treat brain disorders like Alzheimer's and lower the risk of atherosclerosis, cardiovascular disease, cancers, neurodegeneration, and stomach cancer. Additionally associated to the prevention of stomach cancer are mulberry fruit extracts. (Huang *et al.,* 2011; Choi *et al.,* 2012 and Del Rio *et al.,*2013).

Mulberry fruit is also widely recognized for being a strong source of anthocyanin, an antioxidant with several biological benefits. Even though they come from the same species, mulberry fruits come in a variety of hues. Compared to the extracts from the other colours of mulberry fruit, the purple extract has the largest concentrations of anthocyanin and the maximum antioxidant activity. The mulberry fruit extract's total anthocyanin and ascorbic acid content degraded after being exposed to light or heat, which decreased its antioxidant activity. (Aramwit *et al.,* 2010). Additionally, mulberries are a great source of several vital nutrients, namely calcium, phosphorus, potassium, magnesium, and salt. However, different phenotypes have different mineral contents. (Gungor and Sengul, 2008).

Therefore, the goal of this study was to ascertain the impact of mulberry fruit pulp addition on the nutritional value, physicochemical characteristics, and sensory quality attributes of the enriched ice milk at varying levels (3, 6, and 9%) of both white and black mulberry separately and mixing them at level 6% with a ratio of 1:1.

Materials and Methods

Plant material:

In this study, Egyptian-grown black and white mulberries (Morus nigra and Morus alba) were employed. The source of the mulberries was Al-Hamoul near Kafr El-Sheikh, Egypt. In April 2022, the fruits (berries) were harvested. All of the harvested mulberry fruit samples were placed in plastic bags before being sent to the lab.

Chemicals:

All of the chemicals, reagents, and solvents employed in the current study's analytical procedures were of analytical quality. El-Gamhouria Trading Chemicals and Drugs Company in Cairo, Egypt provided all the chemicals utilized in this investigation.

Ingredients:

Fresh raw buffalo milk was purchased from the dairy production facility of Cairo University's Faculty of Agriculture in Giza, Egypt. Skim milk powder (34% protein, 1.23% fat, and 4% moisture) and whole milk powder (13.33% Total Solids, 2.42% fat, 4.20% Crude Protein, and 5.52% Lactose) were bought from the Nile Commercial CO. in Cairo, Egypt. Granulated sugar cane of commercial grade is available from Sugar and Integrated Industries CO. in Giza, Egypt. The Nile Commercial CO., Cairo, Egypt, was contacted for the procurement of stabilizers (vegetarian white gelatin). On October 6, in Egypt, Tag El-melouk provided vanillin extract for the food industry.

Methods:

Experimental treatments:
Preparation of mulberry pulp:

The process outlined by Ozgen et al (2009). was followed in the manufacture of mulberry pulp. Mulberry fruits were cleaned, rinsed, processed, and homogenized by ultra-Truax for 5 min to create a homogeneous mass after being isolated from extraneous objects. Finally, 200 mL sterilized glass cans were filled with the fruit pulp that had been collected, which were then kept frozen at (-18 2 °C) awaiting analysis and further purposes.

Preparation of ice milk blends

The ice milk mixture, which was used as a control, had 3% fat, 12% SNF, 15% sugar, 0.2% gelatin, and 0.06% vanillin extract. To compare the mulberry-containing ice milk samples to the control sample, pulp from both white and black mulberries was added in separate amounts with rising levels (3, 6 and 9%) and blended at level 6% with a ratio of 1: 1.

Manufacture of ice milk samples

The dairy production facility of the school of agriculture at Al-Azhar University in Cairo, Egypt, produced ice milk mixtures. According to Marshall and Arbuckle, artificial ice milk samples were produced (1996). Ingredients were combined, boiled to 700 C and homogenized by an ultra truxx for 5 minutes. They were then pasteurized at 830 C for 15 seconds, cooled to 50 C, and aged at 50 C overnight. The cold mixtures included fruit pulp and vanilla essence. An ice cream maker is used to freeze the mixtures. Finally, 80 cm3 plastic cups with the produced ice milk were filled, covered, and allowed to solidify for 24 hours at (-30°C) before analysis. From each treatment, three duplicates were created this is according to Goff and Hartel (2013).

Analytical methods

Chemical analysis of mulberry pulp and produced ice milk samples

The following raw materials (white and black mulberry pulp) were evaluated for moisture, total solids, crude protein, ether extract, ash, and crude fiber. All samples of ice milk were also analyzed. were determined using the methods described in the A.O.A.C. (2016). At 25 °C, total soluble solids were calculated using a refractometer. Differences in all examined samples were used to determine the total carbs as follows: % crude protein + % ether extract + % ash + % crude fibre = 100% of carbs. Anthocyanins in total were determined according to the method described by Selim *et al.* (2008). The findings of the chemical analysis reflected the mean of the data for the examined parameter in three samples. ***Theoretical calculation of energy:***
White, black mulberry pulp and ice milk samples have their energy values (calories kcal per 100 g) theoretically determined using the technique outlined by Dougherty *et al.* (1988) as follows**:**

Energy value (kcal per 100 g) = (quantity of protein (g) ×4+ quantity of carbohydrate (g) ×4+ quantity of lipids (g) × 9).

Determination of minerals content:

The following elements were measured in triplicates in white, black mulberry pulp, and ice milk samples: calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), zinc (Zn), manganese (Mn), and iron (Fe), according to the method described in A. O. A. C. (2016). By using spectrophotometry, phosphorus was identified. according to the method of Rangana (1979**)**

Analysis of organic acids:

White and black mulberry pulp's succinic, citric, malic, fumaric, and tartaric acid content was examined using a modified version (Bevilacqua& Califano, 1989).

Analysis of ascorbic acid (Vitamin C):
Ascorbic acid content was estimated according to the method suggested by Cemeroglu (2007).

Determination of Trolox Equivalent Antioxidant Capacity (TEAC):
Analysis of the Trolox equivalent antioxidant capacity (TEAC) was done using ABTS that was made using potassium persulphate and a buffer. (Ozgen *et al.*, 2006).

Phytochemical screening:
Phytochemical analysis, which includes phytochemical screening and the separation of aromatic oils (Balbaa et al., 1981), Testing for aglycon compounds and/or glycosides, resins (Hostettmann, et al., 1991), saponins (Haggag & Elhaw, 2022), tannins Geissmann, T.A. (1962), flavonoids Trease, G.E. (1966), phytosterols, terpenes and alkaloids (Haggag & Elhaw, 2022) is recommended.

Analysis of phenolic compounds:
The modified technique of analysis was used to examine gallic acid, catechin, chlorogenic acid, caffeic acid, coumaric acid, ferulic acid, vanillic acid, rutin, and quercetin. Rodriguez-delgado *et al.* (2001).

Physiochemical characteristics of produced ice milk:
After 24 hours of storage, ice milk samples were examined for physicochemical parameters. The acidity and pH levels were assessed using the methods of A.O.A.C. (2016). The freezing point was determined using a low-temperature thermometer.

Rheological properties of produced ice milk:
The viscosity of the mixtures was determined at 20°C using a Brookfield viscometer (Model RVDVII, Brookfield Engineering Laboratories, INC., MA, USA) by the manufacturer's instructions. Hegedusic *et al.* (1995). At 20 rpm, the viscometer was turned on (spindle number 4).
Using a typical 100 ml cup, the overrun of ice milk samples was determined by (Marshall &Arbuckle, 1996) with the help of the following equation:
% Overrun = [(Net wt of cup of mix - Net wt of cup of ice milk)/ Net wt of cup of ice milk] × 100.
samples' initial drip and total melting times were measured in accordance with (Guven & Karaca ,2002). The melting resistance was tested using the technique of Elkot *et al.* (2017).

Sensory evaluation of tested samples:
Samples of ice milk were evaluated organoleptically by a 20-member panel from the personnel of the Dairy Department and the Food Science and Technology Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt, after one day of storage at - 30°C. Each participant was asked to rate the evaluated ice milk samples on many criteria, including flavour (30), body and texture (30), melting quality (20), appearance (20), and overall acceptability (100), using the procedure outlined by (Marshall and Arbuckle, 1996).

Statistical analysis:

At a minimum, three duplicates of each experiment were performed. The Statistical Package for Social Science (SPSS) computer program software, version 20.0, developed by IBM Software, Inc. Chicago, United States, 2018, was used to statistically analyze the data Gomez and Gomez (1984). One-way analysis of variance (ANOVA) at the 5% level of significance was used for the statistical analysis, and Duncan's multiple range tests were run (p 0.05).

Results and Discussion

Chemical composition and caloric value of both white and black mulberry pulp:

Table (1) contains the findings about the caloric value and chemical makeup of both white and black mulberry pulp.The information found in Table (1) showed that the moisture content of black and white mulberry pulps was 80.71% and 78.32%, respectively. These outcomes concur with those mentioned by Owon *et al.* (2016) They discovered that the white mulberry has 79.34% moisture. Additionally, these outcomes are quite similar to those that Ercisli and Orhan (2007), Imran *et al.* (2007), Abd EL-Malak *et al.* (2010) and Imran *et al.* (2010).

It was evident from the data shown in the same Table that the protein content of both the WMP and the BMP fell within the same range of around (1.21-1.36%). On a wet weight basis, the ether extract, ash, crude fibre, and carbohydrate contents of black mulberry pulp were 1.11, 1.09, 1.42, and 14.31%, while they were 1.67, 1.27, 2.07, and 15.46%, respectively, for white mulberry pulp. As a result, the white and black mulberry is regarded as an excellent source of nutrients including carbs and crude fibre. Therefore, it should be used to fortify meals. These results are almost in line with those that were Ercisli and Orhan (2007), Koca *et al.* (2008), and Imran *et al.* (2010).

On the other hand, Table (1) shows the combined anthocyanin content of both white and black mulberries. The results indicated that total anthocyanins were 0.27 and 66.74 mg/100g in white and black mulberries pulp; accordingly. The black mulberry had the highest anthocyanin concentration, according to the results, whereas the white mulberry had the lowest. These results are almost in line with those that were Naderi *et al.* (2004); Veberic *et al.* (2015) and Lee *et al.* (2017) They claimed that white mulberries have a greater anthocyanin concentration than black mulberries. Berries and red fruits' anthocyanin content may provide health advantages such a lower risk of coronary heart disease, stroke, some forms of cancer, and aging. (Prior, 2003 and Zafra-Stone *et al.* 2007). White mulberries, which are abundant in flavonoids, are also well-known as a crucial food source for immune system defense. (Butt *et al.,* 2008).

In terms of the caloric value as shown by the findings, it can be said that there are appreciable variations between the caloric value (kcal/100g) of either (WMP or BMP). However, as compared to a black mulberry pulp (BMP), which had a caloric value, of 72.67 Kcal/100g, the white mulberry pulp (WMP) had a greater caloric value of 81.71 Kcal/100g. According to earlier findings, both white and black mulberry pulp's approximate compositions are rich sources of nutrients such as crude fibre, ash, and carbs (as well as anthocyanin in a black mulberry pulp). Due to the addition of new substances and natural items whose makeup has preventive effects against certain diseases, it has a high nutritional value, and offers extra health advantages.

Table (1): Chemical composition and caloric value of both white and black mulberry pulp

Chemical composition (%)	White mulberry	Black mulberry
Moisture	78.32^{b}	80.71^{a}
Total solids	21.68^{a}	19.29^{b}
Total soluble solids	17.90^{a}	14.22^{b}
Protein	1.21^{a}	1.36^{a}
Ether extract	1.67^{a}	1.11^{b}
Ash	1.27^{a}	1.09^{b}
Crude fiber	2.07^{a}	1.42^{b}
Carbohydrates	15.46^{a}	14.31^{b}
Anthocyanin (mg/100 g)	0.27^{b}	66.74^{a}
Caloric value (kcal/100 g)	81.71^{a}	72.67^{b}

^{a,b,c} Mean values in the same row having different letter are significantly different ($P \leq 0.05$).

Mineral content (mg/100 g) on a fresh weight basis of both white and black mulberry pulp:

Minerals are crucial components of a healthy diet and are necessary for the body tissues' regular metabolic processes. Both white mulberry (WMP) and black mulberry pulp were tested for the presence of various macro and micro elements (bio-elements), including calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P), sodium (Na), zinc (Zn), manganese (Mg), and iron (Fe) (BMP). A comparison of the mineral composition of the WMP and BMP samples is shown in Table 2.

Table (2): Minerals content of both white and black mulberry pulp:

Mineral elements (mg/100 g fw)	White mulberry	Black mulberry	RDA* (mg / day)	
			Children	Adults
Calcium (Ca)	149.7^{a}	137.5^{b}	500 - 800	800 - 1200
Potassium (K)	931.9^{b}	1057.01^{a}	3000	3800
Phosphorus (P)	156.1^{a}	151.9^{b}	460 - 500	700 – 1250
Magnesium (Mg)	104.8^{b}	107.1^{a}	80 – 170	350 – 420
Sodium (Na)	61.6^{a}	56.5^{b}	1000	1500
Zinc (Zn)	2.8^{b}	3.2^{a}	3 – 5	8 – 12
Manganese (Mn)	3.5^{b}	3.9^{a}	1.0 – 3.0	2.0 – 2.3
Iron (Fe)	4.1^{a}	4.3^{a}	7 – 10	10 – 15

[a,b,c] Mean values in the same row having different letters are significantly different ($P \leq 0.05$). ***RDA**: Recommended Dietary Allowances (1989)

As can be seen from the data (Table 2), potassium, which made up roughly 1057.01 mg/100g of the black mulberry pulp, was the main macro-element. The same earlier data (Table 2), however, also showed that white mulberry pulp had higher concentrations of phosphorus, calcium, and sodium, which were measured to be 156.1, 149.7, and 61.6 mg/100g, respectively, in comparison to a black mulberry pulp, which was represented by approximately 151.9, 137.5, and 56.5 mg/100g, respectively. In comparison to a white mulberry pulp, BMP also had more Fe (4.3 mg/100g), Mn (3.9 mg/100g), and Zn (3.2 mg/100g). These results are consistent with those of Ercisli and Orhan (2007) and Koca *et al.* (2008).
According to the discussion above, it can be seen that the tested WMP and BMP are generally known for their richness in terms of the most tested macro and micro aspects. While the mulberry pulp is distinguished by its abundance in K, P, Ca, Mg, and Fe. As a result, all WMP and BMP samples that were evaluated were deemed to be reliable sources of both macro and microelements and should be used in food fortification.

Organic acids of both white and black mulberry pulp:

One of the key determinants of fruit flavour and crucial to human health is the presence of organic acids in fruits. Numerous studies have emphasized the significance of organic acids like tartaric, citric, and malic acids in the prevention and removal of kidney stones. (Penniston *et al.*, 2007). Malic acid offers several positive health effects, such as boosting immunity, protecting dental health, reducing the risk of poisoning from the buildup of toxic metals, promoting smoother, firmer skin, and reducing fibromyalgia symptoms. (Abraham and Flechas, 1992).

As can be seen in Table 3, malic acid predominated among the organic acids in the study's mulberries. Citric acid, succinic acid, tartaric acid, and fumaric acid came next, in that order. Fruits ranged in malic acid content from 1.152 (white mulberry) to 3.125 g/100 g. (black mulberry). Compared to white mulberries, black mulberries showed a greater concentration of citric acid (0.472 g/100 g). These findings are in agreement with the results of Ozgen *et al.* (2009), Gundogdu *et al.* (2011) and Sanchez *et al.* (2014) They claimed that the two primary organic acids present in mulberry fruits were malic and citric. The findings showed that all black and white mulberries have fumaric acid identified at the lowest levels. These outcomes are consistent with those attained by Koyuncu (2004) and Mikulic-petkovsek *et al.* (2012) They discovered that among the organic acids present in black mulberry fruits, fumaric acid had the lowest concentration.

Table (3): Organic acids (g/100 g FW) content of black and white mulberries

Sample	Citric acid	Tartaric acid	Malic acid	Succinic acid	Fumaric acid
Black mulberry	1.120[a]	0.302[b]	3.125[a]	0.131[b]	0.120[b]
White mulberry	0.472[b]	0.443[a]	1.152[b]	0.448[a]	0.138[a]

[a,b,c] Means with a different letter in the same column were statistically significant ($p<0.05$).

Vitamin C content and antioxidant capacity of both white and black mulberry pulp:

Table (4) shows the findings of the antioxidant capacity and vitamin C concentration of both white and black mulberry pulp. As shown in the results in the same Table (4), the vitamin C levels for the tested varieties of white and black mulberry were 12.900 and 15.305 mg/100 g, respectively. According to Ercisli and Orhan (2008), the vitamin C content of black mulberries ranged from 14.9 to 18.8 mg/100 mL. These findings support their findings. In the same context, Ercisli *et al.* (2010) reported the average vitamin C content in black and purple mulberries as 20.79 and 18.87 mg per 100 mL, respectively. Also, Lale and Ozcagiran (1996) reported that vitamin C content in black and purple mulberries was 16.6 and 11.9 mg/100 mL.

The antioxidant activity (TEAC test) of variance revealed that the species is of major significance in characterizing TEAC (P0.05) that fluctuated between 9.320 and 14.270 mol TE/g FW, and black mulberries had greater than white mulberries. This information was also available from the same Table. Black mulberry, as opposed to white mulberry, statistically enabled the greater concentrations of TEAC. These findings are in agreement with the results of Gundogdu *et al.* (2011) They claimed that compared to white mulberries, black mulberries showed higher TEAC levels.

Table (4): Vitamin C content (mg/100 g FW) and antioxidant capacity (µmol TE/g FW) of black and white mulberries

Sample	Vitamin C	TEAC
Black mulberry	15.305[a]	14.270[a]
White mulberry	12.900[b]	9.320[b]

[a,b,c] Mean values in the same column having different letter are significantly different ($P\leq0.05$).

Phytochemicals contents of both white and black mulberry pulp: -

The phytochemical analysis of the pulp from both white and black mulberries was the most successful, except of alkaloids.

Table (5): Phytochemicals contents in the mulberry pulp

Bioactive constituents		Glycosides and/or carbohydrates	Alkaloids	Flavonoids	Saponins	Tannins	Sterols and/or terpenes	Coumarins	Anthraquinones	Volatile oils	Cardiac glycosides	Phenolics
Observation	Black mulberry	+	-	+	+	+	+	+	+	+	+	+
	White mulberry	+	-	+	+	+	+	+	+	+	+	+

+: presence –: absence

Phenolic compounds of both white and black mulberry pulp:

In our research, the fruits of black and white mulberries had varying amounts of gallic acid, catechin, chlorogenic acid, caffeic acid, coumaric acid, ferulic acid, vanillic acid, rutin, and quercetin.

Table (6): Phenolic compounds (mg/100 g FW) of black and white mulberries

Phenolic compounds	Black mulberry	White mulberry
Catechin	8.30^{a}	6.80^{b}
Rutin	136.00^{a}	87.90^{b}
Quercetin	13.90^{a}	11.20^{b}
Chlorogenic Acid	223.80^{a}	92.00^{b}
Ferulic acid	6.50^{b}	10.30^{a}
Coumaric acid	11.40^{a}	6.80^{b}
Caffeic acid	16.00^{a}	13.60^{b}
Vanillic acid	6.50^{b}	7.70^{a}
Gallic acid	41.50^{a}	21.90^{b}

^{a,b,c} Mean values in the same row having different letter are significantly different ($P \leq 0.05$).

As shown in Table (6), the amount of catechin, rutinm, quercetinm, chlorogenic acid, ferulic acid, coumaric acid, caffeic acid, vanillic acid, and gallic acid in mulberry fruits were 8.30, 136.00, 13.90, 223.80, 6.50, 11.40, 16.00, 6.50 and 41.50 mg/100g for black mulberries, and 6.80, 87.90, 11.20, 92.00, 10.30, 6.80, 13.60, 7.70 and 21.90 mg/100g for white mulberries, respectively for mulberry fruits, chlorogenic acid was the predominant phenolic substance. Our data support the conclusions of Gundogdu *et al.* (2011) They claimed that the black and white mulberries had the most chlorogenic acid.

Effect of addition mulberry pulp (white or black) on quality criteria of ice milk samples:

Chemical composition of ice milk samples produced:

Table (7) contains the chemical composition findings of ice milk and blends made by adding various amounts of both white and black mulberry pulp (3, 6, and 9%). The acquired findings are in the same Table. show how the total solids and fat contents of all ice milk fell within the parameters of the guidelines set out by the Egyptian Standards (2005).

Table (7): Chemical composition and caloric value of ice milk prepared by addition of white and black mulberry pulp

Chemical composition (%)	Control Sample	Ice milk + WMP			Ice milk + BMP			Mix 6%
		3%	6%	9%	3%	6%	9%	
Moisture	71.04^{e}	73.33^{d}	75.64^{b}	77.80^{a}	73.48^{d}	75.88^{b}	78.23^{a}	74.75^{c}
Total solids	28.96^{a}	26.67^{b}	24.36^{d}	22.20^{e}	26.52^{b}	24.12^{d}	21.77^{e}	25.25^{c}
Total soluble solids	22.96^{c}	23.47^{b}	24.02^{a}	24.49^{a}	23.39^{b}	23.83^{ab}	24.25^{a}	23.82^{ab}
Protein	4.91^{a}	4.94^{a}	4.97^{a}	4.99^{a}	4.95^{a}	4.98^{a}	5.01^{a}	4.99^{a}
Ether extract	3.41^{a}	3.46^{a}	3.50^{a}	3.55^{a}	3.44^{a}	3.47^{a}	3.50^{a}	3.49^{a}
Ash	0.82^{a}	0.85^{a}	0.87^{a}	0.90^{a}	0.84^{a}	0.85^{a}	0.87^{a}	0.87^{a}
Total carbohydrates	19.82^{a}	17.42^{b}	15.02^{d}	12.76^{e}	17.29^{b}	14.82^{d}	12.39^{e}	15.90^{c}
Anthocyanin (mg/100 g)	0.00^{d}	0.00^{d}	0.02^{d}	0.03^{d}	2.01^{c}	3.99^{b}	6.04^{a}	2.02^{c}
Caloric value (kcal/100 g)	129.61^{a}	120.58^{b}	111.96^{d}	102.65^{e}	119.92^{b}	110.43^{d}	101.10^{e}	114.97^{c}

^{a,b,c} Mean values in the same row having different letter are significantly different ($P \leq 0.05$). **WMP:** white mulberry pulp, **BMP:** black mulberry pulp,

According to Table (7), the proximal composition of the formulations containing both white and black mulberry pulp from 3 to 9% showed a significantly higher (p0.05) content of moisture, total soluble solids, and anthocyanin (mg/100g), as well as a decrease in total solids and carbohydrate content compared, to the control sample. As was to be predicted, the control formulation had the most carbs and the least amount of total soluble solids (T.S.S), protein, ether extract, and other nutrients. While the control sample had the lowest concentration of crude protein (4.91%), the frozen milk samples that contained either white or black mulberry pulp exhibited increases in crude protein from 4.94 to 5.01% by increasing the addition levels from 3 to 9%. These outcomes are consistent with Ozgen *et al.* (2009) and Gundogdu *et al.* (2011).

On the other hand, total soluble solids are crucial in regulating the quality of frozen milk. As the level of WMP or BMP was raised, the total soluble solids content rose. The nature of WMP or BMP and the dosages utilized made these outcomes foreseeable. As a result, ice milk blends with a high total solids concentration have a more appealing body feel. (Marshall *et al.,* 2003). These results were consistent with Bajwa *et al.* (2003) for strawberry pulp and Murtaza *et al.* (2004) for fig paste ice cream.

As shown in the data obtained in the same Table, it was possible to observe that the lipid content of the ice milk samples had slightly increased in comparison to the control sample. Table 7 also revealed that adding various amounts of black mulberry pulp caused the anthocyanin content of the generated ice milk to significantly increase (p 0.05) in comparison to the control sample. As opposed to the control sample (0.0%), it rose from 0.02% to 6.04% in the tested samples with both white and black mulberry pulp when the addition amount was increased from 6.0 to 9.0%, respectively. However, compared to the other analyzed samples, the frozen milk samples that included 9% black mulberry pulp (BMP) had the greatest anthocyanin concentrations. These findings are in agreement with the results of Liu, (2004) and Eyduran *et al.* (2015) They said that because of the berries' (mulberry fruits') high anthocyanin content and antioxidant properties linked to phytochemicals, they are highly well-liked and are therefore a part of the human diet. As indicated in Table (7), the number of carbs in the frozen milk samples with black mulberry pulp (BMP) gradually decreased, reaching 17.29, 14.82, and 12.39 in the samples with 3, 6, and 9%, respectively, as opposed to 19.82% in the control sample. In the same text, when the addition level rose from 3.0 to 9.0% in comparison to the control sample, the ice milk samples containing white mulberry pulp (WMP) recorded the lowest concentration of carbs. The results are by Ercisli and Orhan (2008), Ozgen *et al.* (2009) and Gundogdu *et al.* (2011).

As shown in the previous Table, it is clear that there are significant differences (P 0.05) between the caloric value (Kcal/100g) of the tested samples containing mulberry pulp (white or black) and the control sample. This is especially true for the samples containing 9% of either black or white mulberry pulp, which results in a decrease (P 0.05) in caloric value as the addition level increases.

As shown in Table (7), ice milk samples with mulberry pulp (white or black) at all addition levels (3, 6 and 9%) had the highest values of nutrients like protein, ether extract, ash, and anthocyanin contents and the lowest value of calories. In contrast, control samples had the lowest levels of protein, ether extract, ash, and anthocyanin contents and recorded the highest value of calories. These results are in agreement with those reported by Ozgen *et al.* (2009) who reported that black mulberry was rich in anthocyanin.

A good amount of nutrients like protein, ether extract, and anthocyanin content may be found in mulberry pulp, whether it is white or black, according to prior findings on its approximate composition. White or black mulberry pulp has a high nutritional content and offers extra health advantages by including new substances and natural products whose composition has anti-infective properties. Berries and red fruits' anthocyanin content may provide health advantages such as a decreased risk of coronary heart disease, stroke, and some forms of cancer. (Prior, 2003 and Zafra-Stone *et al.* 2007).

Minerals contents of ice milk are produced by adding different levels of both white and black mulberry pulp:

The mineral contents of the control sample and tested samples containing mulberry pulp (white or black) at levels of 3, 6, and 9 % were determined and recorded in Table (8).

Table (8): Minerals content of ice milk prepared by addition of both white and black mulberry pulp

Mineral (mg/100 g fw)	Control Sample	Ice milk+ WMP			Ice milk +BMP			Mixed ice milk (WMP&BMP)
		3%	6%	9%	3%	6%	9%	6%
Ca	157.22[d]	162.13[c]	165.81[b]	170.30[a]	161.12[c]	165.24[b]	169.08[a]	166.55[b]
K	189.10[h]	216.12[g]	243.71[d]	269.24[b]	221.68[f]	253.00[c]	283.80[a]	237.76[e]
P	85.85[d]	90.33[c]	93.91[b]	97.40[a]	90.25[c]	93.61[b]	96.93[a]	94.00[b]
Mg	12.90[d]	15.88[c]	18.92[b]	21.87[a]	15.86[c]	18.91[b]	21.89[a]	18.95[b]
Na	54.83[d]	56.62[c]	58.44[b]	60.00[a]	56.55[c]	58.28[b]	59.94[a]	58.36[b]
Zn	1.07[b]	1.14[ab]	1.20[a]	1.27[a]	1.15[ab]	1.22[a]	1.30[a]	1.22[a]
Mn	0.15[d]	0.26[c]	0.35[b]	0.47[a]	0.27[c]	0.35[b]	0.50[a]	0.38[b]
Fe	0.13[d]	0.25[c]	0.37[b]	0.47[a]	0.25[c]	0.38[b]	0.49[a]	0.35[b]

[a,b,c] Mean values in the same row having different letter are significantly different (P≤0.05). **WMP:** white mulberry pulp, **BMP:** black mulberry pulp,

When mulberry pulp (white or black) incorporation levels were raised relative to the control sample, the tested sample's mineral content rose. As shown in the results in Table (8), it can be noted that the levels of addition of the tested raw materials (WMP or BMP) to the ice milk samples resulted in a significant increase (p 0.05) in the content of all minerals tested, particularly K, Ca, P, Mg, and Na, as compared to the control sample, which had the lowest content of minerals. Due to the high mineral concentration of the fruit pulp, ice milk with WMP or BMP has high mineral content. The majority of the components' daily needs must thus be supplemented. On the other side, the amount of Zn, Mn, and Fe was moderately increased in the ice milk samples with (WMP or BMP) as compared with the control sample which was prepared without any addition. Therefore, composite ice milk can be considered richer in minerals. These findings are in agreement with the results of Ercisli and Orhan (2007), Koyuncu *et al.* (2014), Sanchez *et al.* (2014) and Sanchez-Salcedo *et al.* (2015).

From the aforementioned, it can be inferred that adding mulberry pulp (either white or black) to dairy products like ice milk may enhance its nutritional value and contribute to the provision of both children and adults who consume ice milk. As a result, it should be used in dairy products.

Physiochemical properties of ice milk enriched with mulberry fruit pulp:

On milk proteins, the ice cream's pH is quite important. The statistical analysis of the data, as shown in Table 9, reveals that, when compared to the control sample, the pH values of the tested samples fell as the quantities of both mulberry pulp (white and black) increased from 3% to 9%. The correlation between the rise in total acidity values and the decline in pH values suggests that fruit pulp's naturally slightly acidic properties may be to blame. These outcomes are consistent with those of Temiz and Yesilsu (2010) and Liang *et al.* (2012).

Table (9): Physicochemical and rheological properties of ice milk enriched with mulberry fruits pulp.

Treatments / Tests	Control Sample	Ice milk + WMP			Ice milk + BMP			Mixed ice milk (WMP&BMP)
		3%	6%	9%	3%	6%	9%	6%
pH	6.20^{a}	5.95^{ab}	5.73^{bc}	5.60^{c}	5.97^{ab}	5.86^{bc}	5.78^{bc}	5.71^{bc}
Acidity %	0.29^{c}	0.35^{bc}	0.40^{ab}	0.47^{a}	0.36^{bc}	0.42^{ab}	0.48^{a}	0.41^{ab}
Freezing point (°C)	-2.33^{b}	-2.38^{ab}	-2.45^{a}	-2.53^{a}	-2.37^{ab}	-2.50^{a}	-2.55^{a}	-2.47^{a}
Viscosity (cPs)	27.0^{e}	29.0^{cd}	31.0^{bc}	33.0^{ab}	30.0^{c}	32.0^{b}	34.0^{a}	32.0^{b}
Overrun (%)	50.0^{d}	55.0^{c}	57.0^{b}	62.0^{a}	54.0^{c}	58.0^{b}	61.0^{a}	58.0^{b}
First drip time (min)	6.05^{ab}	6.18^{a}	6.25^{a}	6.31^{a}	6.20^{a}	6.24^{a}	6.33^{a}	6.26^{a}
Melting time (min)	45.20^{e}	47.19^{d}	49.02^{bc}	51.45^{a}	47.09^{c}	50.02^{b}	51.89^{a}	49.78^{b}

^{a,b,c} Values with different small letters in the same row are significantly different (P≤0.05). **WMP:** white mulberry pulp, **BMP:** black mulberry pulp, **(Min)**: minutes, **%:** percentage, **Cps**.: Centipois, **(°C)**: Celsius

As can be shown in Table 9, ice milk samples containing both mulberry pulp (WMP and BMP) from 3% to 9% varied in titratable acidity from 0.35% to 0.48% as compared to the control sample (0.29%). The frozen milk sample with a 6% mix of white and black mulberries was reported (0.41%), meanwhile. Our findings are in accordance with those published by because the milk proteins, mineral salts, and dissolved carbon dioxide, which are organic acids present naturally, were responsible for the apparent acidity of frozen milk mixtures. Marshall *et al.*, (2003) and Lim *et al.*, (2010).

The mean size of the generated ice crystals and their innate thermodynamic instability are both influenced by the freezing point depression (FPD), which is a crucial factor in the manufacture of ice cream. (Hartel, 2001). Ice milk mixtures had the highest freezing point when compared to the control sample, as indicated in Table (9). Additionally, the FPD of the frozen milk samples increased considerably (P 0.05) with the addition of both mulberry pulp, which may have been caused by an increase in the number of soluble components and/or fibres. These results are in agreement with those reported by Soukoulis *et al.* (2009) they reported that the percentage of fiber used in ice cream making affected significantly the freezing point.

Rheological properties of produced ice milk enriched with mulberry fruit pulp:

Since it typically goes hand in hand with the desired body and texture, viscosity is one of the most crucial aspects of ice milk. A certain amount is needed to achieve the desired whipping ability and hold air bubbles in the ice cream. (Bahramparvar and Mazaheri, 2011). The viscosity values of the ice milk samples were considerably affected by the addition of both mulberry pulps (WMP and BMP) to the ice milk combinations, as shown in Table (9).

The data from Table 9 showed that, when the amount of mulberry pulp in ice milk mixes was increased from 3% to 9% compared to the control sample, the viscosity values ranged from 29 to 34 centipoise for samples containing both white and black mulberry pulp, while the ice milk sample contained a mix of them recorded viscosity values between those ranges (32.0 centipoise). Mulberry was added to the cold milk, which considerably raised the viscosity (P 0.05). The high starch and fibre content in mulberry fruits accounts for the treated ice milk mixtures' high viscosity. These results were consistent with those reported Luzardo-Ocampo *et al.* (2021). Additionally, certain proteins may aggregate and form fat globules at low temperatures, and tiny air cells can form in ice cream during storage, which can increase viscosity levels. (Innocente *et al.*, 2002 and Kavaz Yuksel, 2015).

Overrun is an important parameter for evaluating an ice milk product. This situation relates to a rising in the volume of ice milk during processing (Cruz *et al.,* 2009). It is related to yield and profit to the producer. According to the results shown in the same Table, the Overrun (%) of the ice milk samples increased when compared to the control sample, rising from 55.0% to 62.0% for the tested samples containing both white and black mulberry pulp when the addition level increased from 6.0 to 9.0% to 58.0% for the ice milk containing a 6% mixture of them. The overflow was considerably (P0.05) increased when the amount of both mulberry pulp (WMP and BMP) in the ice milk increased up to 9%. The results from the same Table (8) revealed that samples with 9% of both white and black mulberry pulp had the largest overrun. These outcomes Elkot *et al.,* (2017).

Ice milk's composition, the amount of air added, any additives, the type of ice crys tals present, and the network of fat globules it developed while freezing all have a n impact on how quickly it melts. (Koxholt *et al.,* 2001). The meltdown properties of ice cream contribute to the sensory properties of the product Temiz and Yeşilsu (2010).

Table (9) shows how the mulberry addition affects the first dripping time and ice milk melting rate. The results show that ice milk samples containing mulberry melted more slowly and were harder than the control under all circumstances. Mulberry pulp was added between 3% and 9%, greatly increasing the first dripping time (min) (P 0.05). These results confirm the findings of Goraya and Bajwa (2015).

The malting durations of the control sample, which was 45.20 minutes, and the enhanced ice milk with mulberry pulp, which ranged between 47.09 and 51.89 minutes with increase levels from 3.0 to 9%, were noticeably different (p 0.05), as can be shown in the same table. The enhanced ice milk with both mulberry pulp (WMP and BMP) had a longer melting time (51.45 and 51.89 min) in comparison to the control sample (45.20 min). Table 9 displays the melting rate, which is the weight loss of the examined samples during 60 minutes at room temperature (25 + 1 °C). A product of good quality would exhibit a comparatively strong resistance to melting. The control samples melted more quickly and softly than the ice. (Regand and Goff, 2003). With an increase in mulberry pulp content, ice milk treatments' melting resistance rose. These outcomes support the conclusions of Ali, (2012) who discovered that mulberry ice milk's melting rates decreased as its viscosity increased. Last but not least, adding the mulberry pulp to all treatments had a significant (P0.05) impact on the physicochemical and rheological parameters compared to the control. These findings are almost in accord with Du *et al.,* (2021) and Cheng *et al.,* (2021).

Effect of both white and black mulberry pulp addition on sensory evaluation of ice milk samples:

An essential consideration when assessing the quality of food products is sensory assessment. The customer is a significant element in product choice as well, and the primary qualities associated to quality are surface color, odour, taste, and texture. (Pereira *et al.,* 2013).

The organoleptic quality properties (appearance, flavor, body and texture, and melting resistance) of ice milk containing different levels of both white and black mulberry pulp severally and with mixed between them as compared with the control sample were evaluated, and the obtained results are tabulated in Table (10).

Table (10): Sensory evaluation of produced ice milk enriched with different levels of mulberry pulp

Properties / Treatments		Appearance (20)	Flavor (30)	Body and texture (30)	Melting resistance (20)	Overall accept. (100)
Control sample		19.0^{a}	28.0^{a}	27.0^{a}	16.0^{a}	90.0^{a}
Ice milk+ WMP	3 %	18.0^{ab}	26.0^{b}	27.0^{a}	16.0^{a}	87.0^{b}
	6 %	18.0^{ab}	22.0^{d}	27.0^{a}	16.0^{a}	83.0^{c}
	9 %	17.0^{bc}	13.0^{f}	25.0^{b}	15.0^{b}	70.0^{f}
Ice milk +BMP	3 %	16.0^{c}	24.0^{c}	25.0^{b}	16.0^{a}	81.0^{d}
	6 %	16.0^{c}	23.0^{cd}	25.5^{b}	16.0^{a}	80.5^{d}
	9 %	15.0^{cd}	13.0^{f}	26.0^{ab}	15.0^{b}	69.0^{f}
Ice milk+ (WMP&BM)	6 %	16.0^{c}	20.0^{e}	25.0^{b}	15.0^{b}	76.0^{e}

WMP: white mulberry pulp, **BMP:** black mulberry pulp, Values with different small letters in the same column are significantly different ($p<0.05$).

As shown by the findings in Table 10, all samples had acceptable appearances, with the control sample scoring the highest (19.0), followed by the ice milk samples with white berries at levels 3% and 6%, which both recorded the same degree of appearance (18.0). The frozen milk sample with the black mulberry, however, obtained the lowest amount of appearance at 9%. (15.0). According to the flavour study findings, adding mulberry pulp at a level of 9% to ice milk had a negative impact by giving the drink's throat a strange flavour after consumption. In comparison to the 28.0 of the control sample, the samples of ice milk with 9% added berries registered about 13.0. According to one expert, the potassium element, which imparts a taste that combines bitterness and saltiness, maybe the cause of this peculiar flavour. Shallenberger (1993). Additionally, when the proportion of adding berries to the combinations increased, the percentage of sweetness increased as well, which resulted in a fall in the degrees of acceptability. The large proportion of carbs in the berries was seen in Table (1). The ice milk with white berries and a 3% addition rate was the sample that tasted the most similar to the control sample. The enhanced ice milk samples with mulberry pulp had a strong berry aroma, and the aroma was stronger in all treatments when compared to the control sample as the amount of addition rose. In addition, as the proportion of berries added to the combinations rose, the percentage of sweetness also rose, which resulted in a decline in acceptability levels as the percentage of addition rose. Table 1 showed that the berries included a significant amount of carbs. The 3% addition rate of ice milk with white berries was the sample that tasted the most similar to the control sample. In the enriched ice milk samples with mulberry pulp, the smell of berries was noticeable, and it got worse as the percentage of addition rose in all treatments as compared to the control sample. In contrast, there was no discernible difference in the properties of melting resistance between any of the treatments when compared to the control samples, with the exception of samples produced by the addition of white mulberries at a level of 9% or samples produced by the addition of black mulberries at a level of 9% and 6% mixed.

According to the acquired data, the sample with white berries added at a percentage of 3% was closest to the control sample in terms of general acceptability, followed by the sample with white berries added at a percentage of 6%. The sample of ice milk with white berries by 3% recorded 87.0 overall acceptance, the sample of ice milk with white berries by 6% recorded 83.0, and the control recorded 90.0 overall acceptability. The ice milk with 9% additional blackberries was the least acceptable sample overall, with a score of 69.0. These findings show that adding both white and black mulberry pulp at rates of 3% and 6% to ice milk gives it a distinct flavour; increasing these percentages results in off-tastes, thus using it at higher rates than that is not advised.

Conclusions

The findings above showed that mulberry was successfully added to dairy products (ice milk). When compared to the control sample, the ice milk samples with both mulberry pulp (white and black) at levels between 3 and 6% had an excellent sensory acceptance. Mulberry pulp addition significantly increased the number of nutrients including protein, dietary fibre, and minerals. Additionally, adding the mulberry pulp to dairy products may enhance the physicochemical and rheological characteristics of the ice milk that is generated. Mulberries may be added to ice milk mixtures as a useful complement to a diet that often lacks certain elements. These foods are regarded as functional foods since they have additional health advantages beyond the regular nutrients they provide. The current findings suggest that mulberries should be used to produce ice milk since they are good and accessible sources of numerous nutrients that are enhancing the nutritional content of this product. To investigate the use of these unique functional raw materials in other products, it is necessary to assess their features and organoleptic attributes that meet customer expectations.

References

A.O.A.C (2016). Association of Official Analytical Chemist. Official Methods of Analysis. 19th edition, Washington D.C., USA.

Abd EL-Malak, G. A., EL-Kasas, F. B. and Youssef, S. M. (2010). Evaluation of some mulberry species and their suitability for processing jams. J. Food and Dairy Sci., Mansoura University, 1(11): 697 -707.

Abraham, G. E. and Flechas, J. D. (1992). Management of fibromyalgia: rationale for the use of magnesium and malic acid. Journal of Nutritional Medicine, 3, 49-59.

Ahanian, B., Rezvan, P. and Fardin, M. (2014). Effect of substitut- ing soy milk instead of skim milk on physicochemical and sensory properties of sesame ice cream. Indian Journal Science & Research, 7(1): 1134 –1143.

Ali, M. S. A. (2012). Studies on some dairy products substitutes. M.Sc. Thesis, Faculty of Agric., Cairo University, Egypt.

Aramwit, P., Banga, N. and Srichanab, T. (2010). The properties and stability of anthocyanins in mulberry fruits Food Research International. 43, 4: 1093-1097.

Ayuanda, L. N., Wahidin, W., Raidanti, D., Minarti, M., & Ningsih, D. A. (2022). Online midwife's training on psychoeducation of perinatal mental health during COVID-19 Pandemic. International Journal of Social Sciences and Humanities, 6(1), 85–97. https://doi.org/10.53730/ijssh.v6n1.4741

Bahramparvar, M., and Mazaheri Tehrani, M. (2011). Application and functions of stabilizers in ice cream. Food reviews international, 27(4), 389-407.

Bajwa, U.A., Huma, N., Ehsan, B., Jabbar, K. and Khurrama, A. (2003). Effect of different concentration of strawberry pulp on the properties of ice cream. Int. J. Agric.Biol., (l5): 635–637.

Balbaa, S.I.; Hilal, S.H. and Zaki, A.Y. (1981): In "Medicinal Plants Phytochemicals." Third Ed. General Organization for University Books, Cairo, Egypt, 644 pp.

Bevilacqua, A. E. and Califano, A. N. (1989). Determination of organic acids in dairy products by high performance liquid chromatography. Journal of Food Science, 54, 1076-1076.

Bikheet, M. M.; Abdel-Aleem, W. M. and Khalil, O. S. F. (2018). Supplemented Ice Milk with Natural Bioactive Components from Roselle Calyces and Cinnamon Extracts. J. Food and Dairy Sci., Mansoura Univ., Vol. 9 (7): 229 – 235.

Bisla, G., Archana, Verma, P. and Sharma, S. (2012). Development of ice creams from soybean milk and watermelon seeds milk and evaluation of their acceptability and nourishing potential. Advances in Applied Science Research, 3(1):371 - 376.

Butt M.S., Nazir A., Sultan M.T. and Schroen K. (2008). *Morus alba* L. nature's functional tonic. Trends Food Sci. Technol., (19): 505-512.

Cemeroglu, B. (2007). Food Analysis. Publication of Food Technology Society, 168-171, No: 34, Ankara, Turkey.

Cheng, J., Tang, D., Yang, H., Wang, X., Zhu, M., & Liu, X. (2021). The dose-dependent effects of polyphenols and malondialdehyde on the emulsifying and gel properties of myofibrillar protein-mulberry polyphenol complex. Food Chemistry, 360, 130005.

Choi, D.Y., Lee, Y.J., Hong, J.T., Lee, H.J., 2012. Antioxidant properties of natural polyphenols and their therapeutic potentials for Alzheimer's disease. Brain Res. Bull. 2012, 144–153.

Cruz, A.G., Antunes, A.E.C., Sousa, A.L.O.P., Faria, J.A.F. and Saad, S.M.I. (2009). Ice cream as a probiotic food carrier. Food Res Int, 42, 1233-1239.

Del Rio, D., Rodriguez-Mateos, A., Spencer, J.P.E., Tognolini, M., Borges, G., Crozier, A., 2013. Dietary (poly)phenolics in human health: structures, bioavailability, and evidence of protective effects against chronic diseases. Antioxid. Redox Signal. 18, 1818−1892.

Dougherty, M., Sonbk, R., Lrive, J. and Rao, C. S. (1988). Oat fiber low caloric breads soft type cookies and pasta. Cer. Food World., 33, 424–427.

Du, H., Yang, H., Wang, X., Zhu, F., Tang, D., Cheng, J., and Liu, X. (2021). Effects of mulberry pomace on physicochemical and textural properties of stirred-type flavored yogurt. Journal of Dairy Science, 104(12), 12403-12414.

Egyptian standards 1185-1 (2005). Egyptian Organization for Sta-ndardization and Quality, ARE.

Elkot, W. F., Ismail, H. A. and Rayan, A. M. (2017). Enhancing The Functional Properties and Nutritional Quality of Ice Milk with Sebesten Fruits (*Cordia myxa* L.). *Egypt. J. Food Sci.* Vol.45, pp.125 – 134.

Elkot, W. F., Ismail, H. A., and Rayan, A. M. (2017). Enhancing The Functional Properties and Nutritional Quality of Ice Milk with Sebesten Fruits (Cordia myxa L.). 45(1), 125-134

Ercisli, S. and Orhan, E. (2007). Chemical composition of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry fruits. Food Chem.

Ercisli, S. and Orhan, E. (2008). Some physico-chemical characteristics of black mulberry (*Morus nigra* L.) genotypes from Northeast Anatolia region of Turkey. Scientia Horticulturae, 116, 41- 46.

Ercisli, S., Tosun, M., Duralija, B., Voća, S., Sengul, M. and Turan, M. (2010). Phytochemical Content of Some Black (*Morus nigra* L.) and Purple (*Morus rubra* L.) Mulberry Genotypes. Food Technology and Biotechnology, 48, 102- 106.

Eyduran, S.P., Ercisli, S., Akin, M., Beyhan, O., Gecer, M.K., Eyduran, E. and Erturk, Y.E. (2015). Organic acids, sugars, vitamin C, antioxidant capacity, and phenolic compounds in fruits of white (*Morus alba L.*) and black (*Morus nigra L.*) mulberry genotypes. J. App. Bot. Food Qual., (88): 134–138.

Ficco, D. B. M., Borrelli, G. M., Giovanniello, V., Platani, C. and De Vita, P. (2018). Production of anthocyanin-enriched flours of durum and soft pigmented wheats by air-classification, as a potential ingredient for functional bread. Journal of Cereal Science, 79, 118-126.

Geissmann, T.A. (1962): In "The Chemistry of Flavonoids Compounds." Pergamon Press, New York, 483pp.

Goel, K., Singh, R., Saini, V., & Sharma, M. (2022). Physicochemical evaluation of Solanum nigrum linn. and Tribulus terrestris linn. International Journal of Health Sciences, 6(S4), 10786–10795. https://doi.org/10.53730/ijhs.v6nS4.10898

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research 2nd ed. John Wiley and Sons, New York, USA.

Goraya, R. K., & Bajwa, U. (2015). Enhancing the functional properties and nutritional quality of ice cream with processed amla (Indian gooseberry). Journal of food science and technology, 52(12), 7861-7871.

Gundogdu M., Muradoglu F., Sensoy R.I.G. and Yilmaz H. (2011). Determination of fruit chemical properties of *Morus nigra* L., *Morus alba* L. and *Morus rubra* L. by HPLC. Sci. Hort., (132): 37-41.

Gungor, N. and Sengul, M. (2008). Antioxidant activity, total phenolic content and selected physicochemical properties of white mulberry (*Morus alba* L.) fruits. Int. J. Food Prop.

Güven, M., & Karaca, O. B. (2002). The effects of varying sugar content and fruit con- centration on the physical properties of vanilla and fruit ice-cream-type frozen yogurts. International Journal of Dairy Technology, 55, 27–31.

Haggag, M.I. & Elhaw, M.H. (2022): Estimation of some phytochemical materials and isolation of two flavonoids from pomegranate peel using different chromatographic techniques, Mater. Today: Proc., 57, 362–367.

Hartel, R. W. (2001). Crystallization in foods (1st ed.). Gaithersburg, Maryland: Aspen Publishers Inc.

Hegedusic, V., Lovric, T. and Parmac, A. (1995) Influence of phase transition (freezing and thawing) on thermophysical and rheological properties of apple puree – like products. Acta – Alimentaria, 22, 337–349.

Hostettmann, K.; Hostettmann, M. and Marston, O. (1991): In "Saponins, In "Methods in Plant Biochemistry." Vol. 7 (Dey, P.M. and Harborne, J.B., eds), Academic Press, New York, pp: 435-471.

Huang, H.P., Chang, Y.C., Wu, C.H., Hung, C.N., Wang, C.J., 2011. Anthocyanin-rich Mulberry extract inhibit the gastric cancer cell growth in vitro and xenograft mice by inducing signals of p38/p53 and c-jun. Food Chem. 129, 1703–1709.

Imran, M., Khan, H., Shah, M., Khan, R. and Khan, F. (2010). Chemical composition and antioxidant activity of certain Morus species. J Zhejiang Univ. Sci., B11 (12): 973-980.

Imran, M., Talpur, F. N., Jan, M. S., Khan, A. and Khan, I. (2007). Analysis of nutritional components of some wild edible plants. J. Chem. Soc. Pak., 29(5):500-508.

Innocente, N., Comparin, D., & Corradini, C. (2002). Proteose-peptonewhey fraction as emulsifier in ice-cream preparation. International Dairy Journal, 12(1), 6 9 – 7 4.

Karaman, S., and Kayacier, A. (2012). Rheology of ice cream mix flavored with Black Tea or Herbal Teas and effect of flavoring on the sensory properties of ice cream. Food & Bioprocess Technology, 5(8): 3159 – 3169.

Kavaz Yuksel, A. (2015). The effects of blackthorn (Prunus spinosa L.) ad-dition on certain quality characteristics of ice cream. Journal of Food Quality, 38(6), 413–421. https://doi.org/10.1111/jfq.12170.

Koca, I., Ustun, N.S., Koca, A.F., Karadeniz, B. (2008). Chemical composition, antioxidant activity and anthocyanin profiles of purple mulberry (*Morus rubra*) fruits Journal: Food, Agriculture & Environment, 6 (8): 39–42.

Koxholt, M. M., Eisenmann, B. and Hinrichs, J. (2001). Effect of the fat globule sizes on the meltdown of ice cream. Journal of Dairy Science, 84(1), 31-37.

Koyuncu F., Cetinbas M. and Ibrahim E. (2014). Nutritional constituents of wild-grown black mulberry (*Morus nigra* L.). J. Appl. Bot. Food Qual., (87): 93-96.

Koyuncu, F. (2004). Organic acid composition of native black mulberry fruit. Chemistry of natural compounds, 40, 367-369.

Lale, H. and Ozcagiran, R. (1996). A study on pomological, phenologic and fruit quality characteristics of Mulberry (Morus sp.) species. Derim, 13, 177-182.
Lee, Y.M., Yoon, Y., Yoon, H., Park, H.M., Song, S. and Yeum, K.J. (2017). Dietary anthocyanins against obesity and inflammation. Nutrients 2017, 9.
Liang, L., Wu, X., Zhu, M., Zhao, W., Li, F., Zou, Y., & Yang, L. (2012). Chemical composition, nutritional value, and antioxidant activities of eight mulberry cultivars from China. Pharmacognosy magazine, 8(31), 215.
Lim, C. W.; Norziah, M. H., and Lu, H. F. S. (2010). Effect of flaxseed oil towards physicochemical and sensory characteristic of reduced fat ice creams and its stability in ice creams upon storage. International Food Research Journal, (17):393-403.
Liu, R.H. (2004). Potential synergy of phytochemicals in cancer prevention: mechanism of action. J. Nutr., 134 (12 Suppl): 3479−3485.
Luzardo-Ocampo, I., Ramírez-Jiménez, A. K., Yañez, J., Mojica, L., & Luna-Vital, D. A. (2021). Technological applications of natural colorants in food systems: A review. Foods, 10(3), 634.
Marshall RT, Arbuckle WS (1996) Ice cream. ITP International Thompson Publishing, New York, p 361.
Marshall, R.T., Goff, H.D. and Hartel, R.W. (2003). Ice cream. 6th ed. New York: Kluwer Acad/ Plenum Pub.
Mikulic-Petkovsek, M., Schmitzer, V., Slatnar, A., Stampar, F. and Veberic, R. (2012). Composition of sugars, organic acids, and total phenolics in 25 wild or cultivated berry species. Journal of food science, 77, 1064-1070.
Murtaza, M. A., Huma, G. N., Din, M. U., Shabbir, M. A. and Mahmood, S. D. (2004). Effect of fat replacement by fig addition on ice cream quality. Int. J. Agric. Biol., (l6): 68–70.
Naderi, G. A., Asgary, S., Sarraf-Zadegan, N., Oroojy, H. and Afshin-Nia, F. (2004). Antioxidant activity of three extracts of Morus nigra. Phytotherapy Research, 18 (5): 365–369.
Owon, M. A., Gafar, A. M., Saleh, S. M. and Marwa, M. S. (2016). Identification of bioactive compounds from egyptian mulberry fruits and their uses in improvement the quality of some foods. J. Agric. Res. Kafr El-Sheikh Univ., 42(4): 33-52.
Ozgen, M., Reese, R. N., Tulio, A. Z., Scheerens, J. C. and Miller, A. R. (2006). Modified 2, 2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) method to measure antioxidant capacity of selected small fruits and comparison to ferric reducing antioxidant power (FRAP) and 2, 2 ‘-diphenyl-1-picrylhydrazyl (DPPH) methods. Journal of Agricultural and Food Chemistry, 54, 1151-1157.
Özgen, M., Serçe, S. and Kaya, C. (2009). Phytochemical and antioxidant properties of anthocyanin-rich *Morus nigra* and *Morus rubra* fruits. Scientia horticulturae, 119, 275-279.
Penniston, K. L., Steele, T. H. and Nakada, S. Y. (2007). Lemonade therapy increases urinary citrate and urine volumes in patients with recurrent calcium oxalate stone formation. Urology, 70, 856-860.
Pereira, D., Correia, R. M. P. and Guine, F. P. R. (2013). Analysis of the physical-chemical and sensorial properties of Maria type cookies. Acta Chimica Slovaca, 6, 269-280.
Prior, R. L. (2003). Fruits and vegetables in the prevention of cellular oxidative damage. American Journal of Clinical Nutrition, (78): 570–578.

Rangana, S. (1979). Manual of analysis of fruit and vegetable products. Tata McGrow-Hill, New Delhi.

RDA. (1989). Recommended Dietary Allowances of Minerals, Subcommittee on the 10thEdition of the RDAs, Food and Nutrition Board Commission on Life Sciences National Research Council, National Academy Press, Washington, D.C.

Regand, A., and Goff, H. D. (2003). Structure and ice recrystallization in frozen stabilized ice cream model systems. *Food hydrocolloids*, *17*(1), 95-102.

Rodrıguez-Delgado, M. A., Malovana, S., Perez, J. P., Borges, T. and Montelongo, F. G. (2001). Separation of phenolic compounds by high-performance liquid chromatography with absorbance and fluorimetric detection. Journal of Chromatography A, 912, 249-257.

Rohela, G.K., Phanikanth, J., Mir, M.Y., Aftab, A.S., Pawan, S., Sadanandam, A., Kamili, A.N., 2020. Indirect regeneration and genetic fidelity analysis of acclimated
plantlets through SCoT and ISSR markers in *Morus* alba L. cv. Chinese white. Biotech. Rep. 25 (2020), 313–321.

Sanchez E.M., Calin-Sanchez A., CarbonellBarrachina A.A., Melgarejo P., Hernandez F. and Martinez-Nicolas J.J. (2014). Physicochemical characterization of eight Spanish mulberry clones: Processing and fresh market aptitudes. Int. J. Food Sci. Technol., (49): 477-483.

Sanchez-Salcedo E.M., Mena P., Garcia-Viguera C., Martinez J.J. and Hernandez F. (2015). Phytochemical evaluation of white (*Morus alba* L.) and black (*Morus nigra* L.) mulberry fruits, a starting point for the assessment of their beneficial properties. J. Funct. Foods, (12): 399-408.

Selim, K.; Khalil, K.E., Abdel-Bary, M.S. and Abdel-Azeim, N.A. (2008). Extraction, Encapsulation and Utilization of Red Pigments from Roselle (*Hibiscus sabdariffa* L.) as Natural Food Colourants. Alexandria Journal of Food Science and Technology, Article 2, 5(2): 7-20.

Shallenberger, R. S. (1993). Taste chemistry principles. In Taste chemistry (pp. 47-109). Springer, Boston, MA.

Shaviklo, G. R., Thorkelsson, G., Sveinsdottir, K. and Rafipour, F. (2011). Chemical properties and sensory quality of ice cream fortified with fish protein. *J. Sci. Food Agric.*, 91,1199–1204.

Sirikanchanarod, A., Bumrungpert, A., Kaewruang, W., Senawong, T., Pavadhgul, P., 2016. The effect of mulberry fruits consumption on lipid profiles in hypercholesterolemic subjects: a randomized controlled trial. J. Pharm. Nutr. Sci. 60, 7–14.

Soad, H. T., Mehriz, A. M. and Hanafy, M. A. (2014). Quality characteristics of ice milk prepared with combined stabilizers and emulsifiers blends. *Int. Food Res. J.*, 21,1609–1613.

Soukoulis, C., Lebesi, D. and Tzia, C. (2009). Enrichment of ice cream with dietary fiber: Effects on rheological properties, ice crystallisation and glass transition phenomena. Food Chemistry, 115(2): 665 – 671.

Sun-Waterhouse, D., Edmonds, L., Wadhwa, S. S. and Wibisono, R. (2013). Producing ice cream using a substantial amount of juice from Kiwifruit with green, gold or red flesh. Food Research International, 50(2): 647– 656.

Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. International Journal of Health Sciences, 6(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949

Temiz, H., & YeşilSu, A. F. (2010). Effect of pekmez addition on the physical, chemical, and sensory properties of ice cream. Czech journal of food sciences, 28(6), 538-546.

Tharp, B.W. and Young, L.S. (2013). *An encyclopedic guide to ice cream science and technology,* p. 183: DES tech Publications, Inc.

Trease, G.E. (1966): In "Text Book of Pharmacognosy". 8th Ed., Tyndall and Cassel, London, 596 pp.

Umelo, M.C., Uzoukwu, A. E. and Odimegwu, E N. (2014). Proximate, physicochemical and sensory evaluation of ice cream from blends of cow milk and tigernut (*Cyperus Esculentus)* milk. International Journal of Scientific Research & Innovative Technology,1(4): 63 –76.

Veberic, R., Slatnar, A., Bizjak, J., Stampar, F. and Mikulic-Petkovsek, M. (2015). Anthocyanin composition of different wild and cultivated berry species. LWT-Food Sci. Technol.

Venkatesan, N., Devaraj, S.N., Devaraj, H., 2003. Increased binding of LDL and VLDL to apo B, E receptors of hepatic plasma membrane of rats treated with Fibernat. Eur. J. Nutr. 42, 262–271.

Zafra-Stone S., Bagchi, M., Chatterjee, A., Vinson, J. A. and D.Bagchi. (2007). Berry anthocyanins as novel antioxidants in human health and disease prevention Molecular. Nutrition and Food Research, 51(6): 675–683.