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Nutritive Value of Ice Milk Prepared by Chia Seeds

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Abstract: Supplementation of dairy products with various dietary additives is necessary to enhance health condition. There is increasing demand for such functional dairy product for public health. Chia seeds have high nutritive value and several health benefits. The present study was planned to evaluate the nutritive value of ice milk sample which prepared with chia seeds as a stabilizer. Our previous studies revealed that 6% (w/w) chia seeds gave acceptable and palatable organoleptic properties beside the favorite physical properties of the resultant ice milk. So this ratio was a guide in the present study. Two treatments were achieved; the first was prepared by using 0.5% Carboxy methyl cellulose as commercial stabilizer and labeled (C) while the second sample was prepared by using 6% chia seeds powder and named (T). Free amino acids, free fatty acids, vitamins, minerals content and antioxidant activity were determined in the two samples. The dietary fibers were mathematically calculated. The obtained data indicated that the level of Glutamic, Glycine, Histidine. Arginine, Proline, Tyrosine, Valine, Methionine, Cysteine, Isoleucine, Leucine, Phenylalanine, Lysine acids were higher in fortified sample rather than control one. Fatty acids profile indicated that fortified sample was rich in ALA and poly-unsaturated fatty acids. It could be noticed also that the fortified sample was rich in vitamin A as well as vitamin D_3 when it is compared with control sample. Large variations were observed in the content of vitamin B_{12} between the two samples. For minerals content, it was clear that chia-ice milk sample had the higher level of Ca, Fe, P, Mg and Zn. Antioxidant activity was more pronounced (45.6%) in fortified sample rather in control one (8.1%). Obtained results revealed that 6% (w/w) chia seeds when used as stabilizer, enhanced the nutritive value of ice milk sample.

Key words: Ice Milk · Chia Seeds · Amino Acids · Fatty Acids · Minerals · Vitamins and Antioxidants

INTRODUCTION

Fortification of dairy products with different food additives to produce functional and healthy products is a global trend. These additives are largely variable according to the aim of their uses either for health enhancement or technology improvement. Fortunately, Chia seeds gain the two advantages. Chia's botanical name is *Salvia hispanica* L.

Chia seeds have 90-93% dry matter, composed of protein (15-25%), fats (30- 33%), carbohydrates (26-41%), dietary fiber (18-30%), ash (4-5%), minerals and vitamins It also contains high amount of antioxidants [1]. Chia seeds are considered as one of the most important rich sources in essential oils (PUFA) specially ALA (75%) which considered the parent omega-3 fatty acid. It is used for the preparation of omega-3 capsules and used for producing functional foods as gluten-free products [2]. Other study reported that chia seed contains 25 to 40% oil with 60% of it comprising (Omega) -3 -linolenic desirable acid and 20% of (Omega) -6 linoleic acid [3].

Concerning protein, Chia has high- quality- protein which contains 18 amino acids, including all essential amino acids [4]. Chia seeds are also considered a rich source of antioxidants, which is presented as ß- carotene, vitamin A, total phenols and total flavonoids specially

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quercetin and kaempferol. Chia flour is rich in fibers, minerals and vitamins [5]. The clinical benefits were generally briefed in the weight loss and body composition; exercise performance; type 2-diabetes; cardiovascular risk factors; postprandial glycemia & satietycc and plasma lipids [6]. Chia oil improved heart left ventricular dimensions, contractility, volume and stiffness as well as hypertension, glucose tolerance and insulin sensitivity [7].

Chia seed is used as stabilizer in yoghurt, soft cheese and ice milk [2, 3, 8]. Zaky *et al.* [9] prepared ice milk product using three ratios of chia seeds powder and studied the chemical, physical and organoleptic properties of the final products. They reported that 6% (w/w) chia seeds gave acceptable organoleptic properties beside the favorite physical properties. So, the present work was planned to evaluate the nutritional value of ice milk prepared with 6% chia seeds (as natural stabilizer) compared with that prepared by using CMC (as common stabilizer).

MATERIALS & METHODS

- Fresh buffalo milk and sweet cream were obtained from the Dairy Production Unit, Animal Production Res. Inst. Agric. Res. Center, Giza, Egypt.
- Skim milk powder, commercial sugar and cacao powder were purchased from the local market.
- Chia seeds powder was obtained from Bob's Red Mill Natural Foods Inc. Milwaukie, OR97222 U.S.A. Their total solid were 96.60 %; fat content was 33.16%; Protein level was 21.34%; ash ratio was 04.60 % while dietary fiber content was 24.50%.
- Carboxy methyl cellulose (CMC); as common stabilizer; was obtained from the Pharmaceutical Chemicals Nasr. Co, Egypt.

Ice Milk Processing: Ice milk mixes were prepared according to Marshall *et al*. [10] and the formula was adjusted as Control mix (C) containing 4% fat, 11% SNF, 16% sucrose and 0.5% CMC as mentioned before [9]. The preferable proportion of whole chia seeds (6 % w/w) were blended in the mixture of ice milk as stabilizer and labeled (T). All powder materials such as sugar, stabilizer, skim milk powder and cacao (2%) were mixed with fresh skim milk for 2 min., then the cream was blended. The components were added slowly and dissolved by using a mixer (Heidolph No. 111, Type RZR1; Germany) to reach a complete hydration. All other steps were done to obtain ice milk samples.

Fat content in control and treated ice milk samples were 4.2 & 4.0% while protein contents were 4.58 & 4.81% and ash contents were 0.84 & 0.92 % respectively [9].

Dietary Fiber Content: Dietary fiber content in ice milk sample was mathematically calculated from its original level in the seed (24.5%) as mentioned at package-label.

Free Amino Acids Profile: The amino acids composition of experimental samples were determined using HPLC-Pico-Tag method [11].

Free Fatty Acids Pattern

Preparation of Fatty Acids Methyl Ester: Fatty acid methyl esters were prepared according to the method of Wirasnita *et al.* [12].

Determination of Fatty Acids Content by GC- MS Apparatus: Fatty acids profile [13] was assessed using gas chromatography] coupled with a mass spectrometer (Shimadzu GC-MS QP 2120, Shimadzu; Kyoto; Japan

Minerals Content: A dry ashing method was used for the destruction of organic matter as described by Abou-Arab *et al*. [14]. The concentration of K, Mg, Ca, Fe and Zn were measured using an Atomic Absorption Spectrometer (SensAA Spectrometer)

Vitamins Level: Vitamins content were estimated in the ice milk samples using HPLC apparatus for vitamins soluble in fat or in water. HPLC analysis was carried out using an Agilent 1260 series according to Santos *et al*. [15].

Antioxidant Activity: Radical Scavenging Activity (RSA %) assay of ice milk samples was estimated using DPPH (2, 2-diphenyl-1picrylhydrazil)according the method of Locatelli *et al*. [16]. It was expressed as percentage inhibition of the DPPH radical and was calculated by the following equation;

$$RSA = \frac{Abs_{control} - Abs_{sample}}{Abs_{control}} \times 100$$

RESULTS AND DISCUSSION

Total Dietary Fiber (TDF): Dietary fiber was 1.47 % in treated sample as mathematically calculated from the original level of the seeds (24.5%). Other studies reported that TDF content in chia seed was 37.50% and 30-34 %

respectively [5, 17] which is markedly higher than wheat flours and whole grain cereals as previously recorded [18]. Chia seeds dietary fiber, of have insoluble fraction (IDF) accounts for approximately 85-93%, composed primarily of lignin, cellulose and hemicellulose while soluble dietary fiber (SDF) was approximately 7-15% and the mucilage was the main type of soluble fiber of the seed [5, 19, 20].

Dietary fiber has an important role in intestinal health and has crucial role in lower risk of developing coronary heart disease, hypertension, diabetes and obesity [21].

Amino Acids Profile: Results confirmed that chia seed is a potential source of biologically active peptides (Table 1) and it can be incorporated into human diets to produce more balanced and high quality protein source as previously reported by Segura-Campos *et al*. [22].

Results revealed that amino acids contents were high in treated sample of ice milk compared to control in Glutamic acid, Glycine, Histidine, Arginine, Proline, Tyrosine, Valine, Methionine, Cysteine, Isoleucine, Leucine, Phenylalanine and Lysine acids While Aspartic, Serine and Alanine acids content were high in control sample. Threonine level was nearly the same in the two samples. Tyrosine level was the highest in ice milk sample where its content was 1.04 g/100g followed by Lysine (0.91mg/100g). So, it could be concluded that treated samples which fortified by 6% chia seeds had the higher level of amino acids especially the essential ones. These results are in accordance to the previously reported that chia-seed is considered a high- quality- protein source where it contains 18 amino acids, including all essential amino acids [21]. Also, chia seed protein contains no gluten, that makes it ideal for sensitive persons to gluten present in other types of grain like wheat, rye, oat and barley [4].

Other studies reported that Leucine presented the highest content in essential amino acids of chia. In addition to glutamic, arginine and aspartic acids, which presented more than 60% of non-essential amino acids [23]. In conclusion Chia seed is reported as a good source of plant protein which contained all essential amino acids.

Fatty Acids Pattern: Table (2) shows variations in fatty acids content of both control and fortified samples of ice milk. Chia fortified sample seemed to have more ALA (2.91%) vs. control (0.16%). The contents of poly unsaturated fatty acids were more pronounced in treated sample.

Table 1: Amino acids content of ice milk sample fortified with chia seeds

	Amount g/100g sample	
Amino Acid	Control	Treatment
Aspartic acid	0.45	0.51
Glutamic acid	0.55	0.74
Serine	0.30	0.24
Glycine	0.09	0.13
Histidine	0.10	0.15
Arginine	0.34	0.55
Threonine	0.33	0.34
Alanine	0.39	0.36
Proline	0.08	0.17
Tyrosine	0.58	1.04
Valine	0.17	0.21
Methionine	0.19	0.32
Cysteine	0.01	0.11
Isoleuoine	0.16	0.25
Leucine	0.19	0.32
Phenylalanine	0.31	0.34
Lysine	0.46	0.91

Table 2: Fatty acids profile (%) of ice milk sample fortified with chia seeds

Fatty acids	Control	Treatment
C6:0 (Caproic)	14.5	39.9
C8:0 (Caprylic)	3.8	4.6
C10:0 (Capric)	1.02	0.56
C12:0 (Lauric)	1.9	0.82
C14:0 (myristic)	9.5	4.41
C16:0 (Palmtic)	28.53	44.62
C16:1 *cis*9	1.8	4.83
C16:1 *cis* 14	0.47	0.96
C18:0 (Stearic)	12.21	25.94
C18:1 *cis* 11 (Oleic)	0.77	3.10
C18:1 *iso* 13	2.34	5.99
C18:1 *cis* 9	17.50	32.61
C18:2 *cis* 9, 12 (Linoleic)	0.69	5.97
C18:3 *cis* 9, 12, 15 (Linolenic)	0.16	3.91
C20:0 (Arachedonic)	0.23	4.12
Omega 3	20.77	45.61
Omega 6	0.69	5.97

Craig [24] found that chia oil contains mainly linoleic, oleic, palmetic and stearic acids, with a predominant amount of α-linolenic acid (62.8%). However, it was reported that the seed contains 25 - 40% oil; out of which 60% comprised (omega) ω-3 alpha-linolenic acid and 20% of (omega) ω-6 linoleic acid. Both essential fatty acids are required by the human body for good health and they cannot be artificially synthesized Mohd *et al*. [25] Other studies recorded α-linolenic acid (ALA) as the highest followed by linoleic, oleic acid and stearic acid in concentration. Meanwhile, the amount of unsaturated fatty acids was almost eight times than that of saturated fatty acids where the ratio of u-3 fatty acids and u-6 fatty acids was 2.65 [17, 23].

Table 3: Minerals content (%) of ice milk sample fortified with chia seeds

Item	Control	Treatment
Fe^{++}	0.040	0.053
P^{+++}	0.19	1.15
K^{+}	0.22	0.80
Mg^{++}	0.03	1.18
Ca^{++}	0.15	1.77
$Zinc^{+}$	0.022	0.029

According to USDA [4], chia seeds can lower serum triglyceride and elevates high-density lipoprotein contents in rats. This benefit has been attributed to ALA contents in chia seeds. The high ALA content (56.98 g/ 100 g oil) and a good ratio of u-3 and u-6 fatty acids (2.65) in chia should be good for the cardiovascular system in humans. Other study reported that chia seed is better source of omega-3 fatty acids than flaxseed and has approximately three to ten times the oil concentrations of most grains. These oils; which rich in unsaturated fatty acids; are the essential oils for our body needs to emulsify and absorb the fat soluble vitamins, A, D, E and K [21].

Minerals Content: Table (3) reflected the minerals content of ice milk samples. It could be notice that the level of iron was 0.053% for treatment vs.0.040 % for control while zinc was 0.022 and 0.029 for control and treatment respectively. The concentration of Ca; Mg, P and K were more pronounced in fortified samples rather than control as shown in Table (3) Andrew weill [26] reported that the chia seed is a rich source of calcium as it contains the important mineral boron. He added that chia seeds are contain five times-the calcium of milk, plus boron which is a trace mineral that helps transfer calcium into bones. He added that chia contains two times the amount of potassium as bananas and three times more iron than spinach.

Chia seeds are an excellent source of minerals such as calcium and magnesium, needed for strong bones and a healthy nervous system beside iron, zinc and copper which are contained in a balanced ratio [20, 27, 28]. Anunciacao *et al*. [29], reported that the Brazilian chia seed was a highlight due to its concentration of iron, zinc, calcium, manganese, potassium and phosphorus. They added that the concentration of calcium in chia seed was observed to be six times higher than that of milk, whereas the iron concentration was observed to be 2.4-6 times higher than meat. Yi-Ding *et al* [23], recorded also that the major minerals of chia were Mg, Ca and K; Fe, Zn, Mn, Co and Se.

Table 4: Some vitamins contents (µg/ml) and antioxidant activity (%) of ice milk sample fortified by chia seeds

Vitamin (µg/ml)	Control	Treatment
A	30.25	56.36
D_3	0.51	0.85
E	0.38	0.26
C	40.20	93.58
B_{12}	0.94	44.46
B_2	1.40	1.53
RSA%	8.1	45.6

RSA: Radical Scavenging Activity

Vitamins Content: The vitamin contents either soluble in fat or soluble in water were determined in ice milk samples as shown in Table (4). It was clear that the sample fortified with chia seeds (T) were rich in vitamin A (56.36 µg/ml) when it compared with control sample which contained 30.25 µg/ml (about two folds) as well as vitamin D_3 where T sample was contented 0.85 µg/ml against 0.51*ug/ml* for control sample. Vitamin E was 0.38 µg/ml for control sample vs. 0.26 µg/ml for treatment. Large variations were observed in the contents of vitamin B_{12} between the two samples. Control gained 0.94 µg/ml while treated sample possessed 44.46 µg/ml (expressed about forty folds). For vitamin B_2, no clear differences were observed between control and treated samples where their values were 1.04 and 1.53 µg/ml respectively. Likely observation, was the high level of Vitamin C in treated samples (93.58 µg/ml) compared to control one (40.20 µg/ml). Muñoz *et al*.[19] reported that chia seed is rich in riboflavin, niacin and thiamine at levels above those of other seeds. .Andrew Weil, [26] showed that chia oil absorb the fat soluble vitamins (A, D, E and K) as well known that, all grains are rich source of vitamin B especially full grains or whole seeds. Also, [33] Melo-Ruiz *et al.* [27] reported that chia was a good source of vitamin A, E and C. In addition, Kulezy *et al*. [17] indicated that studies confirmed the presence of some vitamins, mainly vitamin B1 , B2 and niacin in chia seeds.

Antioxidant Activity: Table (4) also presents the antioxidant activity of ice milk samples expressed as RSA %. wide variation between the two samples was clear. Control sample gained 8.1 % while treatment had 44.6% which represented about 6 fold higher than control. This observation reflected the high antioxidant activity of chia seeds [5]. Reyes-Caudillo *et al*. [5] related the great antioxidant activity of chia to ß-carotene, vitamin A, total phenols and total flavonoids which have potential health benefit. Martínez-Cruz & Paredes-López [30] recorded that chia seeds have high concentration of antioxidant compounds, mainly phenolic acids and

flavonoids. It is known that rosmarinic acid is the phenolic compound present in the greatest amount (0.927 mg/g), followed by protocatechuic acid (0.747 mg/g), caffeic acid (0.027 mg/g) and gallic acid (0.012 mg/g). Yi Ding *et al*. [23] illustrated that the flavonoid content occupied 80.85% in the polyphenols of chia where both rutin and hesperidin are major components. While, Bartosz *et al*. [31] indicated also that chia seeds contained particularly polyphenols: gallic, caeic, chlorogenic, cinnamic and ferulic acids, quercetin, kaempferol, epicatechin, rutin, apigenin and p-coumaric acid. Isoflavones, such as daidzein, glycitein, genistein and genistin, are found in small amounts. Moreover, it was found that chia seeds also contain tocopherols:alfa-tocopherol (8 mg/kg lipids), gama-tocopherol (422 mg/kg lipids) and delta-tocopherol (15 mg/kg lipids).

CONCLUSION

It could be concluded that chia seeds successes in enhancing the nutritive value and improving the health benefit of ice milk sample through increasing the antioxidant activity and fiber content. It provided samples with essential amino acids , unsaturated fatty acids , vitamins and minerals.

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