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Characteristics of Nutraceutical Yoghurt Mousse Fortified with Chia Seeds

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***Abstract*— *Fortification yoghurt mousse with Chia seeds as a novel neutraceutical dairy product was studied. Chia seeds were added with the ratios (1,2and 3% to yoghurt mousse and compared with yoghurt mousse with 1.25% gelatin as control. The physicochemical and functional properties for Yoghurt mousse were evaluated. Fortification of 3% chia seed can be recommended for production novel dairy products with high neutraceutical properties and high acceptable sensory properties. Evaluation the preventive role of chia on lipids in normal and isoproterenol (ISO)-induced myocardial infarction was studied in rats. Chia at two doses (3% as one serving and 6% as double serving concentrated ratio in yoghurt mousse) was orally administered to rats for a period of 28 days. Isoproterenol (5 mg/kg) was injected intrapreitoneal to male wistar rats at last 7 days. ISO-treated rats also showed a significant increase ($p < 0.001$) in the levels of triglycerides, and very low-density lipoprotein cholesterol (VLDL-C) level in plasma with subsequent decrease ($P<0.01$) in the level of HDL as compared to yogurt-administered rats. Pretreatment with (43mg/kg BW) chia to ISO-treated rats showed a significant decrease ($p < 0.05$) in the levels of triglycerides, and very low-density lipoprotein cholesterol (VLDL-C) level in plasma as compared to ISO-induced rats. While Pretreatment with (86 mg/kgB.W) chia showed a significant increase ($p < 0.01$) in High -density lipoprotein cholesterol (HDL-C) level. The results of the present study indicated that the overall cardioprotective effect of chia seeds is probably related to its ability to inhibit lipid accumulation by its hypolipidaemic property.*

***Keywords*— Chia- Nutraceutical – lipid profile- Yoghurt Mousse - Physicochemical and Functional properties.- Cardio protective effect.**

I. INTRODUCTION

The concept of "nutraceutical" was introduced by Stephen DeFelice in 1989, by combining the terms "nutrition" and "pharmaceutical". The term refers to raw foods, fortified foods or dietary supplements containing biologically active molecules, also known as bioactive molecules Palthur et al., (2010). That provide health benefits beyond basic nutrition Liu (2003). These bioactive compounds include certain polysaccharides, peptides, phytochemicals, vitamins, and fatty acids that are naturally present in foods. Since fermented milk products are among highly-consumed food in the world, they have been used to deliver nutritional components into human diet. Furthermore, fortification of these products such as yogurt, is a good way to improve nutrient intake in daily food products Preedy et al., (2013). Seeds from Salvia hispanica L. or more commonly known as chia is a traditional food in central and southern America.

Currently, it is widely consumed for various health benefits especially in maintaining healthy serum lipid level. This effect is contributed by the presence of phenolic acid and omega 3/6 oil in the chia seed. Chia seeds, contain the richest botanical oil source of ALA (Alfa Linolinic Acid) and high amounts of fiber and minerals. Poudyal *et al.,* (2013) have recently shown that the administration of chia oil improved heart left ventricular dimensions, contractility, volume and stiffness as well as hypertension, glucose tolerance and insulin sensitivity in rats fed a high fat-high fructose diet. Therefore, Chia is considered an important nutraceutical product and one of the most efficient polyunsaturated fatty acid (PUFA) sources for enriching foods and producing functional foods and gluten-free products, such as bread and baked products. Ayerza and Coates (2001), Martnez and Paredes (2014).

Hydrocolloids or food gums are widely used in different applications in the food industry due to their ability to retain water. Chia seeds are strongly hydrophilc, capable of absorbing several times their weight in liquids such as water Vazquez *et al.,* (2009), this hydration capability is due to the structure of the outer seed coat. Chia seed can be utilized as a functional coating with improved functional properties Munoz *et al., (2012).* The approval of chia seed as a Novel Food by the European Parliament has led to high degree of usage of chia seed in a wide range of foods. It is already well established that chia does not have anti-allergic, anti-nutritional and toxic effect on human health. Biscuits, pasta, cereal bars, snacks and yoghurt and cake are usually supplemented with chia seed. Borneo et al. 2010). Chia is consider as one of the few medicinal plants that produce essential oil in a great concentration, which is used for the preparation of omega-3 capsules.

Probiotic dairy products such as dahi, yoghurt, ice cream, cheese, and kefir are appropriate vehicles to deliver beneficial bacteria to human host in addition to the available medical health supplements either in the form of pills or capsules Prajapati and Nair (2003); Shah and Prajapati (2013). The probiotics market has been one of the prime beneficiaries in the recent fad for functional foods. The global probiotic products market was estimated at $26 125.9 million in 2012. According to one survey probiotic market have risen up to worth $1732.8 million by 2019, incorporating probiotics in different kinds of food products (functional foods, dietary supplements, specialty nutrients, animal feed); in medicinal relevance regular, therapeutic, preventive health care; or by any other convenient mode of application. Anonymous (2014).

It is revealed from studies that chia seeds beside their neutracutical effect, These seeds had possess many important functional properties(water-holding capacity, oil holding capacity, solubility, viscosity, emulsion stability and foaming stability) which prove its potential to be used as a thickening agent, gel forming agent, chelator, foam enhancer, emulsifying agent, clarifying agent, rehydrating agent and as suspension formers in the formulation of food products at both home and commercial level. All these properties make chia a promising functional food for the future. Chia seeds offers a great future perspective for feed, food, medical, pharmaceutical and neutraceutical sectors. From this point of view the objectives of this study were to develop Yogurt mousse as a novel, high added-value dairy product fortified with chia seed *(Salvia hispanica L)* and study the changes in the physiochemical composition, microbiological, and functional properties as cardioprotective effect and its ability to inhibit lipid accumulation by its hypolipidaemic property.

II. MATERIALS AND METHODS

1. Materials:

Chia seeds *(Salvia hispanica L.)* in the form of packed whole seed was obtained from Bob's Red Mill Natural Foods Inc. Milwaukie, OR97222U.S.A. Commercial lyophilized mixed yoghurt starter culture (YCX11) was obtained from Chr. Hansen's laboratories, Copenhagen, Denmark. Buffaloes' milk was used for manufacture of yoghurt Mousse. The milk was obtained from Animal Production Research Institute, Ministry of Agriculture. Cream 30% fat were prepared. Gelatin Dr.Oetker (UK) Ltd., Sugar and vanilla were obtained from local market. All common chemicals used for experimental animals were purchased from one of the following suppliers Sigma Co. (St. Loius, MO, USA).All other reagents were of the highest grade commercially available. (All chemicals used in the study were of analytical grade).

2. Preparation of Yoghurt Mousse:

Yoghurt Mousse was prepared according to Menendez et al., (2006). 75 gram buffaloe' milk 3% fat and 15 gram Cream milk (30% fat content) were pasteurized and inoculated with 3% w/w of yogurt culture at 42ºC then incubated to 4 h . The mixture was cooled to 6o C and left to stand for 12h. It was then whipped with 10 gm of sugar in the presence of 1.25g (1.1% w/w) of powdered gelatin previously prepared in 15ml of water at 80º C. The product was finally packed in yoghurt cartons and stored at 6ºC.

The same assay was repeated adding 1, 2 and 3% g from chia seeds instead of gelatin. Four treatments of yoghurt mousse were as follows:

1- Yoghurt mousse with 1.25 % gelatin. (control)
2- Yoghurt mousse with 1% Chia seeds
3- Yoghurt mousse with 2% % Chia seeds
4- Yoghurt mousse with 3% % Chia seeds

3. Analytical Methods for Yoghurt Mousse

3.1. Methods of chemical analysis

Chia seeds were determined by AOAC (2005) contents, total standard methods for total solid, fiber, fat, protein, and ash. Carbohydrate contents were calculated by difference. The iron, zinc, Phosphorus and calcium contents of Chia seeds by the atomic absorption method by the HPLC method (AOAC 2012). The Yoghurt Mousse Chia Seeds fortified formulations were analyzed for total solids (TS), fat, crude protein and carbohydrates were calculated by difference (AOAC 2012). The pH values of the fermented products from the different treatments were measured using a digital pH meter (Model HI9321) (Hanna, Germany). Fatty acids composition were determined according to AOAC (2012).

3.2. Rheological and syneresis analysis

Water-holding capacity of yoghurt was determined using a procedure by Guzmane *et al.*, (1999). 20g of yoghurt (Y) was centrifugated for 30 min at 1250×g at 20°C. (h = 4.8 cm). The whey expelled (WE) was removed and weighed. The water-holding capacity (WHC) was determined as:

$$WHC = \frac{100\times(Y\ WE)}{Y}$$

- The viscosity was measured using a Brookfield DV digital viscometer (Brookfield Engineering, Middleborough, MA, USA) with spindle No 92 at 50 rpm.
- Assessment syneresis, the whole yoghurt samples (50g) were transferred to a stainless steel sieve, 120

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mesh and left in a 4º C to drain in graduated cylinder. The total whey drained after 2 hrs, was measured Williams, *et al.*, (2004).

The following formula was used to calculate syneresis.

$$\text{Synersis} = \frac{\% \ V1 \times 100}{V2}$$

Where: V1 = volume of whey after draining

V2= volume of yoghurt sample

3.3. Microbiological analysis

Total bacterial count, Lactic acid bacteria ,Total coliform count, yeast and molds, Spore form, *Staphylococcus aureus* and *Bacillus cerues* were determine according Marshall (1993).

3.4. Sensory analysis

Yoghurt Mousse sample were evaluated by experienced members of the staff of the dairy department, APRI Egypt after 1,4and 8 days of cold storage at 6ºC. The samples were scored as 60, 30 and 10 for flavor, body& Texture and Colors & appearance.

Experimental Animals

Adult male Wistar rats, weighing (150±20) g. They were kept under observation for about 15 days before the onset of the experiment to exclude any intercurrent infection. The chosen animals were housed in plastic cages with good aerated covers at 25°C ± 0.5°C as well as 12 h light/dark cycles. Animals were allowed free access to water and were supplied daily with a standard diet.

Experimental design

Forty two male Wistar rats weighing (140–160) g were randomly allocated into seven groups having **sex in each as follows:**

- Group I (Control): Rats received only distilled water for 28 days.
- Group II (ISO + low dose chia): Rats received yogurt by oral gavage for 28 days.
- Group III (low dose chia): Rats received chia seeds (3%) by oral gavage for 28 days.
- Group IV (high dose chia): Rats received chia seeds (6%) by oral gavage for 28 days.
- Group VI (ISO): Rats received daily ISO (5 mg/kg, ip) for the last 7 days.
- Group VII (ISO + low dose chia): Rats received chia (3%) by oral gavage for 28 days and ISO (5 mg/kg BW, ip) for the last 7 days.
- Group VIII (ISO + high dose chia): Rats received chia (6%) by oral gavage for 28 days and ISO (5 mg/kg BW, ip) for the last 7 days. At the end of the experiment, animals were sacrificed and blood samples were collected and centrifuged to separate plasma. Plasma were then kept at -80°C for subsequent biochemical assays.

Blood Samples preparation

Blood was collected from sacrificed rat in vacuontainer and centrifuged 3000g for 10 min. Plasma samples were collected and stored at -80 until.

Determination of lipid profile and cardiovascular risk indices

Plasma total cholesterol, triglycerides, and high-density lipoprotein (HDL)-cholesterol were assayed using commercial diagnostic kits (spectrum diagnostics Egyptian company of biotechnology, Cairo, Egypt). Very low-density lipoprotein (VLDL)-cholesterol concentration was calculated according to the following formula:

VLDL-cholesterol = triglycerides/5.

Cardiovascular risk indices were calculated according to Ross (1992) as follows:

Cardiovascular risk index= total cholesterol/HDL-cholesterol.

Statistical analysis

Statistical evaluation was conducted with Instat Program GraphPad. Software, Inc, San Digeo, USA, version3. 6, Copyright©1992-2003 Results were expressed as mean ± S.E. The results were analyzed for statistical significance by one way ANOVA followed by Tukey-Kramer & Duncan’s multiple comparison post-test. Values of $p< 0.05$ were regarded as significant.

III. RESULTS AND DISCUSSION

The Chia seeds used in this study had the following nutrient composition as shown in Table (1) Dietary fiber recorded 24.60 g /100 g, which higher than previously reported by Tosco (2004). The fat content, protein and ash were 33.16 , 21.34 and ash 4.6 g/100 g respectively. These results are in accordance with that reported by Michele and Myriam (2014)

Chemical analysis of yoghurt mousse fortified with Chia seeds

Table (2) shows Chemical analysis of yoghurt mousse fortified with chia seeds at the ratio of (1, 2 and 3%). The total solids (TS) content increased with the increase in the percentage (w/w) of Chia seeds. Significantly increase could be observed in fat, protein and fiber due to the high content of these nutrient components in Chia seeds. These results are in accordance with those reported by Safaa (2017), who found the total solids were increased in soft cheese and its formula by the increasing of chia flour ratios. Protein content of chia seeds is greater than protein content of all the cereals. The absence of gluten in chia is another unique feature of chia that it can be digested by the patients suffering from celiac disease. Rahman *et al*.,(2015).

Chia seed contains between 34 and 40 g of dietary fiber per 100 g, equivalent to 100 % of the daily recommendations for the adult population Mohd *et al.*, (2012). Fortifying yogurt mousse with Chia seeds increase the fiber content as chia seeds ratio increased. Ratio of 3% recorded 1.26% fiber content in the end product which provide nearly 8.5 % from the fiber daily recommended for one serve . Dietary fiber is one of the important components of healthy diet. Intake of adequate amount of dietary fiber is associated with the prevention of cardiovascular diseases like stroke, myocardial infarction, vascular diseases, obesity, hypertension, hyperglycemia, and hyperlipidemia. Dietary fibers also cannot be digested and absorbed by the small intestine but get fermented in the large intestine. The total dietary fiber content of chia seeds ranges is much higher than that present in several grains, vegetables and fruits such as corns, carrot, spinach, banana, pear, apple, kiwi . Reyes *et al.*, (2008), Ovando *et al.*, (2009). The insoluble dietary fiber of chia is capable of retaining water several times of its weight during hydration and thus provides bulk and prolongs the gastro-intestinal transit time. Increased gastro-intestinal time is directly related to gradual increase in post-prandial blood glucose levels and decrease in insulin resistance over a period of time. Munoz *et al.*, (2012). Edwards and Garcia (2009) explained the health effects of food hydrocolloids which dependent on how they are incorporated into foods and in the diet. There are many hydrocolloid carbohydrates naturally present in plant foods as part of the cell wall, such as hemicelluloses and pectin, with all these features, chia seeds can be used as emulsifiers and stabilizers due to their high fiber content, and as an ingredient for products gluten-free, and with low carbohydrate.

Obtained results in Table (2) also indicate that there were significantly decrease in pH values for Yogurt mousse fortified with 1, 2and 3% chia seeds respectively than control treatment .This is agreement with Tamime and Robisons (2007) who mentioned that The concentration of lactic acid in milk during fermentation increases .

The minerals content of yoghurt mousse

The incorporation of chia seed in yoghurt mousse improved the nutritional value of the product. Chia is an excellent source of minerals, it contains 13 to 354 times more calcium, 2 to 12 times more phosphorus, and 1.6 to 9 times more potassium than 100 g of wheat, rice, oats and corn. The iron content of chia is also quite high compared to most other seeds: it has six times more iron than spinach, 1.8 times more than lentils, and 2.4 times more than liver. Bushway *et al.*, (1981); Beltrán-Orozco and Romero, (2003). As illustrated in Table (2) ,it could be observed that the three yoghurt mousses which fortified with chia seeds are richer in minerals with an increase by the ratio increase compared with the control yoghurt mousse.

All dairy products, contains very little iron. Therefore, dairy products are logical vehicles for iron fortification because they have high nutritive values, reach target population and are widely consumed. The quality of iron-fortification dairy products depends on the iron sources used, levels of iron and properties of dairy products utilized for iron fortification. Fortification with iron is technically more difficult than with other nutrients because iron reacts chemically with several food ingredients. For these reasons, the ideal iron compound for food fortification should be one that supplies highly bioavailability iron and in the meantime does not affect the nutritional value or sensory properties of the food and should be stable during food processing and of low cost. For all this consideration fortification yoghurt mousse with chia seeds reach to 3% can be a safety source of iron and it can provide 1.14mg/100g witch nearly 14% from the daily recommendation in one serve. Same trend with zinc content in chia seeds, ranging from 4.58 to 4.58 mg per 100g Sukhneet *et al*., (2016) which can consider as an excellent source for zinc .Added chia to yoghurt mousse Significantly increased zinc content reach to 0 .68 mg/100g which about (6% DRI) for one serve, this highest score recorded with the ratio of 3%. Zinc is important in order for the body to function effectively. Zinc controls the enzymes that operate and renew the cells in our bodies. The formation of DNA. Zinc deficiency is the fifth leading risk factor for disease in the developing world. In a recent survey by WHO .Bimola *et al*.,(2014).

Physicochemical analysis of yoghurt mousse fortified with Chia seeds during storage.

-Viscosity

Viscosity is defined as the resistance of the fluid to flow caused by internal friction Malcolm (2002). Fortification yoghurt mousse with (3%) chia seeds resulted a significant ($P<0.05$) increase in viscosity, followed by yoghurt mousse with (2%) chia seeds and yoghurt mousse with gelatin as control respectively. The lowest record was obtained by yoghurt mousse with 1% chia seed .Table (3) .These results could be due to the low concentrations of chia and the week jelly nature formed by chia in low concentration. Viscosity of yoghurt mousse gradually increase during storage periods in all treatments. markedly increase could be observed with added of chia seeds especially in the ratios 2% and 3% , it could be attributed to the chia mucilage properties which can change the size and shape of the chia, and give yoghurt mousse smooth and stable texture. Campos (2015) suggested that chia mucilage can be used as an emulsifier and stabilizer in an ice cream. He also mentioned that extracted mucilage of chia has been used to improve and maintain the quality of ice cream during storage.

-Syneresis

Synersis is the shrinkage of the gel, which lead to whey separation. Table (3) shows that the syneresis of yoghurt mousse decreased in parallel with viscosity the. Also it could be observed that less syneresis has also been reported for yoghurt mousse with gelatin as control than (yoghurt mousse fortified with 1% chia seeds. Significant syneresis decreased ($P<0.05$) recorded by advancing storage .These effects of Chia seeds on syneresis could be attributed to the presence of fiber retaining more aqueous phase. Chia seeds contain 5-6% mucilage, which can be used as dietary fiber. Reyes *et al.,* (2008). Muñoz et al. (2012) studied the hydration of chia mucilage, finding that a 100 mg sample of mucilage absorbs 2.7 g of water, which is 27 times its own weight.

-Water holding capacity (WHC)

Water holding capacity WHC is the amount of water absorbed and held by the hydrated sample after an external force is applied. A principal feature of chia seeds is that when placed in an aqueous medium, it secretes a mucilaginous polysaccharide that surrounds the seed. It has been reported that consumption of this mucilage aids digestion and that, together with the seed, constitutes a nutritious food source .Salgado-Cruz *et al.,* (2005). As shown in Table (3) there were significant differences between the water holding capacity (WHC) of yoghurt mousse fortified with chia seeds and control. The highest WHC when fresh was obtained for yogurt mousse samples made using (3% chia) it was recorded 65.25 % which was 61.4 % higher than that of control yogurt mousse (40.41 %). Same trend can be observed during storage period. These results is in agreement with Ranil *et al.,* (2014) who found that chia seed gel had the highest WHC when compared against commercial guar gum and gelatin, which are 2 commercial food ingredients used to improve WHC. According to Galla and Dubasi (2010), WHC depends on a number of factors including ingredient and water interactions, number of hydration positions, protein configuration and fat. High WHC of Chia seeds can be explained by its higher protein and fiber contents as these components could bind water as stated by Ragab et al., (2004). Fortified yoghurt mousse with different concentration of Chia seed enhanced water holding capacity when fresh and during storage period the high levels of dietary fiber in chia mucilage help maintain the moisture in the product, and avoid the loss of moisture during storage because of the numerous free hydroxyl groups in fiber which can form hydrogen bonds with water.Oakenfull (2001), Wang and Cui, (2005)

Microbiological Characteristics

Data in Table (4) showed microbiological analysis of yoghurt mousse fortified with chia seeds. It could be observed that yoghurt mousse fortified with chia seeds (3%) recorded the lowest total bacterial count .From the same table it could also be noticed that total bacterial counts were decreased with increasing of chia percentage. These results could be due to phytochemical caused inhibition of microbial growth Safaa (2017). On the other hand lactic acid bacteria in yoghurt mousse with 3% chia seeds showed increasing than the control sample when supplement with chia seed. This increasing were also in parallel with the increasing of chia concentration .Same trend were found by Carmen *et al.*,(2015) who reported that yogurt supplementation with 1,4 % chia seeds and 7, 6 % cranberries significantly improves the stability of lactic acid bacteria . High fiber contents in chia seeds lead to increase the population of LAB and the fecal water content and reduce microbial harmful enzyme (β-glucosidase, β-glucuronidase and tryptophanase) activities. Lee *et al.,(*2011). From the same table it could be also observed that spore form count recorded highest number in yoghurt mousse with 1% chia seeds, followed by the control treatment, while yoghurt mousse with 2% and 3% recorded the lowest spore counts. Same trend were noted during storage period. This is could be due to the reducing on the pH by fermenting the lactose to lactic acid; adding acids or other approved preservatives; adding sugar or salt to reduce the water activity (aw); removing water Loralyn *et al.,* (2009). Mould and yeast are not detected in yoghurt mousse fortified with Chia seeds when fresh and during storage (8 days/6^{o} C).

Sensory properties of yoghurt mousse fortified with Chia seeds

Sensory analysis indicated in Table (4) that yoghurt mousse fortified with 3% chia seeds has got highest scores for all sensory parameters during whole storage period , followed by yoghurt mousse with 2%chia seeds and the control treatments .yoghurt mousse with 1% chia recorded the lowest total scores this is due to the low concentration of of chia seeds 1%. Treatment yoghurt mousse with gelatin 1.25% concentration recorded higher scores than yoghurt mousse with 1% chia. Panelists preferred yoghurt mousse with chia seeds regarding to its nutty flavor , crunchy texture and gelling properties which fits the mousse properties . Chia possesses many important physiochemical and functional properties which makes it more suitable in the food industry. Chia acts as a good thickener, gel former, chelator, foam enhancer, emulsifier, suspension formers, clarifying agent and as a rehydrating agent .These results is in agreement with Sukhneet Suri *et al.,* (2016).

Effect of incorporation chia seeds on the Microstructure of Yoghurt mousse

Based on the microscopic investigation Yoghurt mousse fortified with 3% chia seeds effect on microstructure and in appearance than Yoghurt mousse control. Bubbles play a key role in foamed food products, including confectionery mousses because they create fine texture with a light, smooth and creamy mouth feel. The quality of such products is directly impacted by the formulation and processing conditions. As can be seen in the micrographs, the microstructure of yoghurt mousse using 3 % chia seeds which gained the highest scores greatly differed than that using 1.25 % gelatin. No strands could be seen in the gel structure with 3% chia seeds , while for yoghurt mousse with 1.25% gelatin, the structure was much looser and the strands could be seen clearly (Fig 1. A) Some particles were observed with 1.25 % gelatin gels. This results could be due to the low concentration of gelatin and the low pH in yoghurt mousse .this is in agreement with Zhihua Pang *et al.,(*2014) ,Who mentioned that the hardness of gelatin gels increased at high gelatin concentration (5.0%),and the fracturability of the gels was greatly influenced by pH, which is minimum at its isoionic point (IP) because of the maximum molecular folding at that pH. Petrie and Becker (1970). It was reported that aggregation of gelatin increased and the gelatin gel turned from transparent to opaque as the pH was increased from 5.4 to 7.5 (Walkenstrom and Hermansson, 1997) .On the other hand chia seed gel had higher emulsion activity and stability than gelatin gel. The chia seed gel and chia flour gel could have higher OHC due to the concentrated gels sponge-like nature which could absorb. The gel would have greater space in it spongy structure to absorb and trap the oil. Such sponge-like structures are not formed by gelatin and guar gum which could explain the much lower oil holding capacity. Gelatin is a protein which allows its gel to set at lower temperature and it works best at low temperature. Chia seed is polysaccharide based and their gels generally do not set at low temperature similar to guar gum, which is a different gel behavior compared to gelatin. However, interestingly chia seed gel had a lower spread value (3.38 mm) compared to gelatin (7.17 mm) at 3 °C, indicating that chia seed has the potential to replace gelatin in chilled food formulation. Ranil *et al*., (2014).

Fatty Acids Composition

The major fatty acids in buffalo milk are the palmitic acid, the oleic acid, the stearic acid and the miristic acid. The content of essential C18:2 (omega 6), known for its atherogenic properties decreased slightly in the coagulation of milk, while C18:3 (omega 3) increased. These fatty acids are essential for growth and development and are beneficial in the maintenance of human health and prevention of chronic diseases and neurological disorders. Yashodhara *et al.,* (2009). Fatty acids are essential nutrients for many lactic acid bacteria, and supplementation of growth medium with fatty acids can influence the membrane composition and growth rate Johnsson *et al*., (1995) ; Muller *et al.,* (2011). In our studies it could be observed in Table (6) that Oleic acid (C18:1) was in the highest percentage (27.53, 28.35) among the unsaturated fatty acids in each control and fortified yoghurt mousse with 3% chia seeds. This is in agreement with Sheisa *et a*l.(2013) who reported that chia seeds showed the most significant amounts of oleic and linolenic acids, 197.76 and 174.73 mg/ g-1, respectively . Lopez (2010) mentioned that the incorporation of milks enriched with oleic acid into the diet has resulted in reductions in total cholesterol, LDL-cholesterol and triglyceride levels, the effects of which were observed among healthy individuals, those with increased risk for cardiovascular disease and individuals with CVD. From the same table it can also illustrated that the content of essential C18:2 (omega 6) and C18:3 (omega 3) in yoghurt mousse sample fortification with chia seeds at the ratio (3%) showed a higher records (7.54 and 4.80) compared to control samples which were (5.26 and 1.45) for C18:2 (omega 6) and C18:3 (omega 3) respectively.

The presence of higher concentration of polyunsaturated fatty acids in chia oil has increased its popularity and cultivationmany folds. Omega-3 fatty acids are comprised of three essential fatty acids; alpha-linolenic acid, eicosapentaenoic acid, and docosahexaenoic acid whereas omega-6 is comprised of linoleic acid and arachidonic acid . Pawlosky *et al*. (2003). Chia seed with appreciabl amounts ofω-3 alpha-linolenic acid (ALA) andω-6 linoleic acid. Of all the known food sources chia contains the highest concentration of these fatty acids. On an average it contains about 64 % ω-3 and 19 % ω-6 fatty acids. Ali *et al*.,(2012). The seed is appropriately known as power house of omega fatty acids. Eicosapentaenoic acid, an docosahexaenoic acid have cardio-protective effects Manzella and Paolisso (2005). Diets must be balanced in the omega-6 and omega-3 fatty acids to be consistent with the evolutionary understanding of the human diet. This balance can best be accomplished by decreasing the intake of oils rich in omega-6 fatty acids (corn oil, sunflower, safflower, cottonseed, and soybean) and increasing the intake of oils rich in omega-3s (canola, flaxseed, perilla, and chia). Artemis (2010). It can be take in consideration that the total ω-3 PUFAs available from milk is only 0.33 mg/100 mL, so in order to achieve 0.5

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g/d ω-3 PUFA which consider as recommended daily allowance of omega-3 the intake of at least 150 L of milk or 15 kg cheese or 5 kg butter is required, suggesting that unfortified milk and dairy products supply inadequate amounts of dietary PUFAs. Commercial dairy products such as liquid milk and yoghurt are currently fortified with ω-3 PUFAs obtained from flaxseed, fish oil, or marine microalgae. Balasubramanian Ganesan *et al*. (2014). But it can be taken in consideration that atypical organoleptic characteristics such as flavor and smell from marine sources were not found in chia .Ayerza (2002) This showed the superiority of chia seed against other nutritional sources rich with PUFAs.

The ω-6/ ω-3 ratio was at level 3.63 and 1.57 for yoghurt mousse with gelatin as control and yoghurt mousse fortified with chia seeds with the ratio of 3% this ratio is commonly used to assess the nutritional value and healthiness of food lipid material for human consumption. Simopoulos(2008) recommended that ratio ω-6/ ω-3 from 4:1 reach to 1:1 as an ideal ratio in human diets to prevent the development of cardiovascular diseases and some chronic diseases including cancer. The incorporation of ingredients with high PUFA content into fermented dairy products like chia seeds provides numerous health benefits .

Effect of Chia on lipid profile and cardiovascular risk indices

Data represented in Figure (2) show the effect of chia on lipid profile and cardiovascular risk indices of normal and ISO-induced hypertrophic rats. Compared to the control group, rats supplemented with chia at both doses and ISO-induced rats exhibited insignificant change in all studied parameters. While rats supplemented with yogurt mousse alone showed a significant decrease (P<0.001) in levels of TG and VLDL-C [fig.2 a&b] associated with a significant increasein levels of TC and HDL-C [fig.2 c&d] (P<0.05, P<0.001, respectively).

In addition, Compared to yogurt mousse group, ISO-administered rats showed significant (P, 0.001) increase in TAG and VLDL-C compared with a significant decrease (P< 0.001) in HDL-cholesterol (Fig2a,b&c). On the other side, Pretreatment with chia to the ISO-induced rats showed a significant decrease (P<0.001)in the level of TAG and VLDL (Fig2 a&b) in low dose chia group with subsequent increase (P<0.01) in the level of HDL at high dose chia group in comparison to the ISO-treated group. (Fig 2d).The cardiovascular risk indices TC/HDL-cholesterol showed non significant (P<0.05) variation between all studied groups (Fig.2 e).

The variation in omega-3 fatty acid chemistry might cause a difference in important factors mediating effects on blood lipids like distribution to tissues, distribution among the various lipoproteins in blood and effects on regulators of lipid metabolism in the liver. The main finding in the study presented here was that the chia seeds rich altered the blood lipid profiles in dyslipidemic, ISO-treteated rat markedly and in a health-beneficial manner by reducing circulating triglycerides and VLDL-cholesterol total, while it increased HDL-cholesterol.

IV. CONCLUSION

According the results from this study it could be recommended to incorporate chia seed with the ratio 3% in the production of yoghurt mousse as a novel neutraceutical and desirable dairy product.. In addition, based on the current research findings, chia seed is a good choice of healthy to maintain a balanced serum lipid profile. Furthermore, details on the mechanisms of chia seed's hypolipidemic effects need to be studied with reference to its health content of the omega 3 and omega 6 fatty acids ratio.

Table.1: Composition of chia seeds

Nutrient Amount/ 100g	
Total solid	**96.60**
Dietary fiber	**24.50**
Fat	**33.16**
Protein	**21.34**
Ash	**4.60**
Other carbohydrate	**16.0**
Caloric value (Kcal/100 g)	**(545.8)**

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Table.2: Chemical composition of yoghurt mousse fortified with Chia seeds

Components	Yoghurt Mousse (1.25 gelatin)	Yoghurt Mousse (1% chia seeds)	Yoghurt Mousse (2% chia seeds)	Yoghurt Mousse (3% chia seeds)
Total solids	26.83^{b}	27.35^{ab}	27.86^{ab}	28.53^{a}
Fat	7.53^{b}	7.80^{b}	8.23^{a}	8.56^{a}
Protein	6.42^{b}	6.63^{ab}	6.95^{ab}	7.21^{a}
Fiber	-------	0.34^{c}	0.79^{b}	1.26^{a}
Ash	1.16^{a}	1.28^{a}	1.45^{a}	1.58^{a}
pH	4.80b	4.76ab	4.73a	4.69a
Calcium (mg/100g)	185.3^{ab}	193.6^{ab}	202.4^{a}	210.0^{a}
Phosphorus(mg/100g)	93.5^{b}	115.4^{ab}	126.0^{ab}	135.0^{a}
Irion (mg/100g)	0.53^{b}	0.65^{ab}	0.78^{a}	1.14^{a}
Zinc (mg/100g)	0.47^{b}	0.52^{ab}	0.61^{a}	0.68^{a}

Table.3: Physicochemical analysis of yoghurt mousse fortified with Chia seeds during storage.

Treatments	Storage Days	Yoghurt Mousse (1.25 gelatin)	Yoghurt Mousse (1% chia seeds)	Yoghurt Mousse (2% chia seeds)	Yoghurt Mousse (3% chia seeds)
Viscosity (Cp)	**1**	**3552^{ab}**	**1040 ^{b}**	**3080^{ab}**	**5784^{a}**
	4	**3326^{ab}**	**1489^{b}**	**4882^{ab}**	**6164^{a}**
	8	**3210^{ab}**	**1730^{b}**	**6480^{a}**	**6568^{a}**
Synersis%	**1**	**0.88^{ab}**	**1.12^{a}**	**0.54^{b}**	**0.40^{b}**
	4	**1.21^{ab}**	**1.60^{ab}**	**0.72^{a}**	**0.53^{a}**
	8	**2.15^{ab}**	**2. 20^{ab}**	**0.80^{a}**	**0 .60 ^{a}**
WHC%	**1**	**40.41^{b}**	**46.32^{ab}**	**49.63^{ab}**	**65.25^{a}**
	4	**44.63^{ab}**	**50.14^{ab}**	**58.37^{ab}**	**67.47^{a}**
	8	**47.52 ^{b}**	**52.56 ^{b}**	**67.47^{ab}**	**70.32 ^{a}**

Table.4: Sensory properties of yoghurt mousse fortified with Chia seeds during storage period

Treatments	Storage Days	Yoghurt mousse (1.25%gelatin)	Yoghurt mousse (1% chia seeds)	Yoghurt mousse (2% chia seeds)	Yoghurt mousse (3% chia seeds)
Flavor (60)		**54^{a}**	**52^{b}**	**54^{a}**	**55^{a}**
Body&texture (30)	**1**	**23^{a}**	**21^{b}**	**23^{a}**	**25^{a}**
Colors&appearance (10)		**8^{a}**	**7^{ab}**	**8^{a}**	**8^{a}**
Total (100)		**85**	**80**	**85**	**88**
Flavor (60)		**52^{ab}**	**51^{ab}**	**55^{a}**	**56^{a}**
Body&texture (30)	**4**	**23^{a}**	**20^{b}**	**24^{a}**	**25^{a}**
Colors&appearance (10)		**8^{a}**	**7a^{b}**	**8^{a}**	**8^{a}**
Total (100)		**83**	**78**	**87**	**89**
Flavor (60)		**52^{ab}**	**50^{b}**	**56^{a}**	**57^{a}**
Body&texture (30)	**8**	**23^{ab}**	**20^{b}**	**24^{a}**	**26^{a}**
Colors&appearance (10)		**7^{a}**	**6^{b}**	**8^{a}**	**8^{a}**
Total (100)		**82**	**76**	**88**	**91**

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Table.5:Microbiological analysis of yoghurt mousse during storage period

Treatments	Storage Days	T.B.C Log CFU/10^{-3}	L.A.B log CFU/10^{-6}	Spore form log CFU/10^{-1}	T.C.C	Yeast and Mould
Yoghurt Mousse (1.25 % gelatin)	**1**	**80**	**49**	**1.3**	**ND**	**ND**
	4	**52**	**76**	**1.7**	**ND**	**ND**
	8	**36**	**123**	**2.6**	**ND**	**ND**
Yoghurt Mousse (1% chia seeds)	**1**	**77**	**65**	**1.4**	**ND**	**ND**
	4	**63**	**93**	**1.9**	**ND**	**ND**
	8	**32**	**156**	**3.2**	**ND**	**ND**
Yoghurt Mousse (2% chia seeds)	**1**	**62**	**75**	**1.2**	**ND**	**ND**
	4	**44**	**125**	**1.5**	**ND**	**ND**
	8	**28**	**175**	**1.8**	**ND**	**ND**
Yoghurt Mousse (3% chia seeds)	**1**	**58**	**89**	**1.1**	**ND**	**ND**
	4	**46**	**167**	**1.5**	**ND**	**ND**
	8	**20**	**183**	**1.7**	**ND**	**ND**

T.B.C: Total bacterial count.L.A.B.: Lactic acid bacteria.T.C.C. : Total coliform count

Table.6: Fatty Acids Composition of control yoghurt mousse and yoghurt mousse fortified by Chia seeds.

Fatty acids %	Yoghurt Mousse with gelatin	Yoghurt Mousse 3% Chia
Caproic Acid, C6:0	**1.83**	**1.78**
Caprilic Acid, C8:0	**1.65**	**1.37**
Capric Acid, C10:0	**4.82**	**3.58**
Lauric Acid, C12:0	**2.65**	**2.37**
Myristic acid (C14:0)	**7.30**	**6.82**
Pentadecanoic acid (C15:0)	**1.86**	**1.36**
Pentadecenóico acid (C15:1)	**0.83**	**0.71**
Palmitic Acid, C16:0	**25.70**	**22.43**
Palmitoleic acid (C16:1	**0.67**	**0.60**
Margaric acid (C17:0)	**3.20**	**2.85**
Stearic acid (C18:0)	**14.67**	**14.26**
Oleic acid (C18:1 – ω-9)	**27.53**	**28.35**
Linoleic acid(C18:2 – ω-6)	**5.26**	**7.54**
Linolenic acid (C18:3 – ω-3)	**1.45**	**4.80**
ΣSaturated acids	**65.18**	**58.13**
ΣUnsaturated acids	**34.24**	**40.69**
Σ PUFA ω-6/Σ PUFA ω-3	**3.63**	**1.57**

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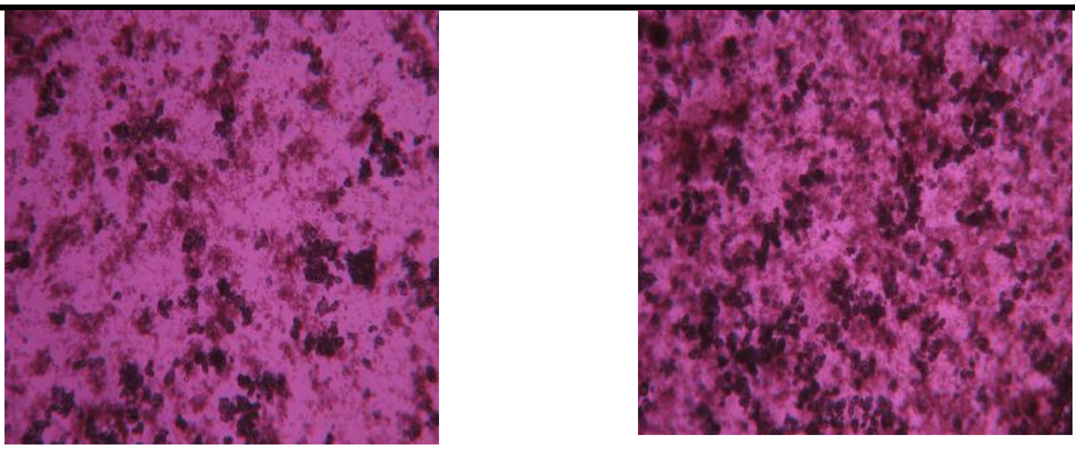

Yoghurt mousse (1.25%gelatin) **Yoghurt mousse (3% chia seeds)**

Fig.1: Microstructure of Yoghurt mousse fortified with chia seeds.

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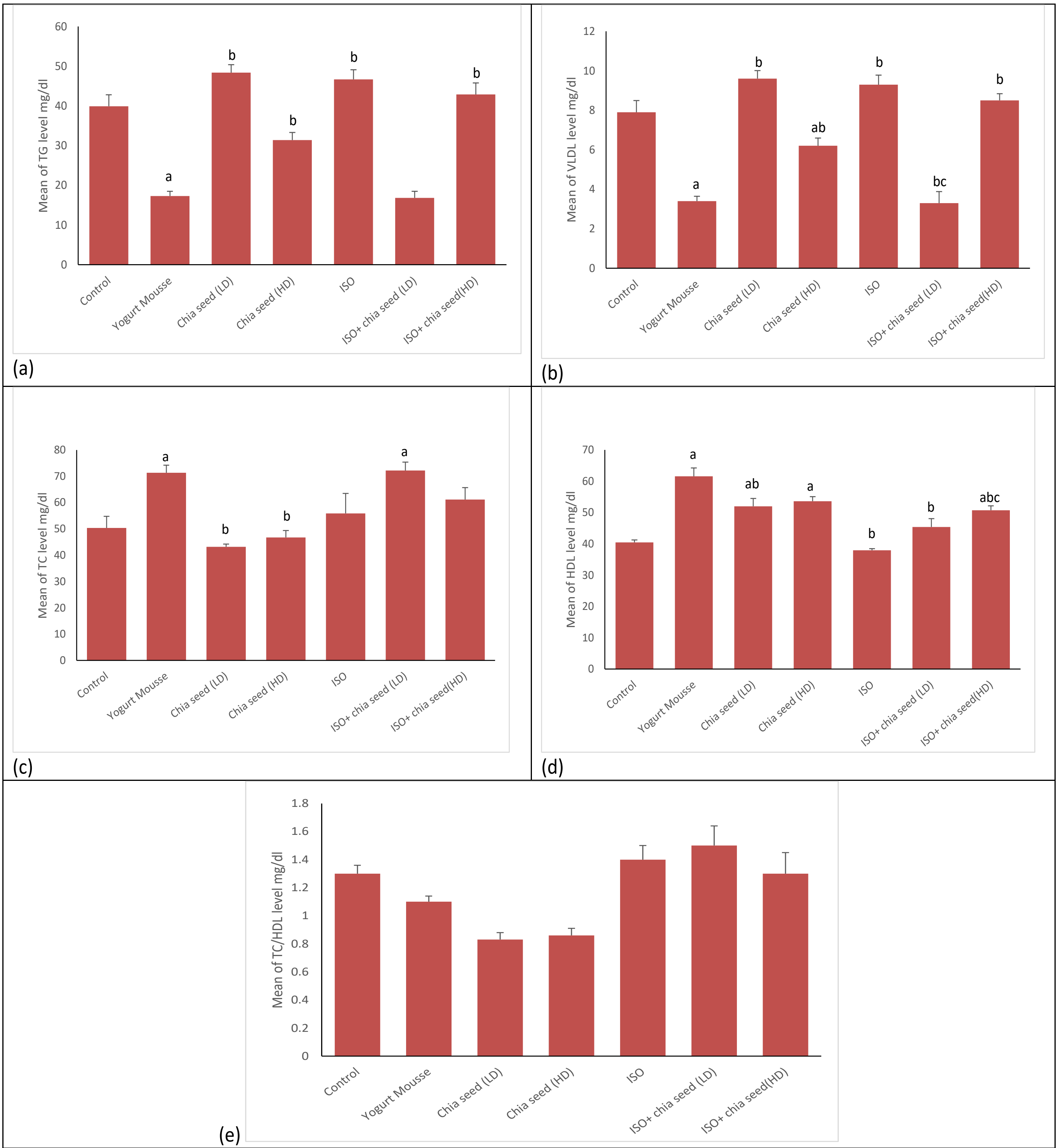

Fig.2 Effect of chia seeds on serum TAG (a), VLDL-C (b), TC (c), HDL-C (d) and TC/HDL-C (e) in ISO-induced rats. The data represent the means ± SEM.[a]: Significant difference vs. proper control. [b]: Significant difference vs. yogurt control. [c]: Significant difference vs. ISO-group values. $P < 0.05$ is regarded as significant. SE M, standard error of the mean; ISO, isoproterenol;TG: triglycerides; vLDL, very-low-density lipoprotein; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; LD, low dose; HD, high dose; vs, versus.

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