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# Production and *in vivo* Nutritional Evaluation of Functional Soft Cheese Supplemented with Broccoli

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**Abstract:** Supplementation of soft cheese manufactured from UF–milk retentate with broccoli as a source of functional components was investigated. Cheese base UF– retentate was fortified during cheese manufacture with 10, 20, 30 and 40% of broccoli paste (T1, T2, T3 and T4 cheese treatments, respectively). Resultant cheese from different treatments was analyzed for chemical, physical, microbiological and sensory properties when fresh and during 4 wk of storage at 5± 2°C. The results showed that, addition of broccoli paste to milk retentate lowered the values of total solids, total protein, fat, salt and ash contents in the resultant UF-soft cheese. On the other hand, fortified retentate with broccoli paste resulted in higher pH values and soluble nitrogen (SN) content of UF-soft cheese. During storage, SN increased and pH values decreased in all treatments including control. Incorporating broccoli paste into milk retentate increased fiber and flavenoids contents, as well as water holding capacity (WHC) values while the firmness was decreased compared to the control. Adding broccoli paste to milk retentate was accompanied with high level of Potassium, Iron and Zinc and increased the folic and nicotinic acids contents of the resultant functional cheese. Treatments T3 and T4 had higher total bacterial count and mould & yeast followed by the control then the treatments T1 and T2, while coliforms was not detected in all treatments with broccoli or control along the storage period. The rats receiving broccoli enriched diet had the lowest level of serum LDL- cholesterol at the end of feeding period. Incorporation of soft cheese supplemented with broccoli paste in diet of albino rats lowered the serum values of ALT and AST. This means that there were improvements in liver functions which resulted in lower liver enzymes value. It could be concluded from the obtained results that, functional UF–soft cheese can be produced without any significant difference than that of control when supplemented with broccoli paste up to 20% in cheese base.

**Key words:** Cheese · Broccoli · Minerals · Vitamins · Nutritional · *In vivo* · Functional properties

## INTRODUCTION

Functional foods have recently emerged as a novel sector of health –enhancing products. The target function of functional foods is largely dependent on the used ingredients. The concept of functional foods has evolved as the role of food in the maintenance of health. These foods are now officially recognized as foods for specified health use [1]. Functional foods has became a very popular and preferred for consumer all over the world. Dairy foods can play a key role as functional products to enhance consumers health at levels not usually obtainable from normal foods. Cheese is one of the oldest dairy products and it has a high nutritive value particularly when introduced in special diets and many consumers, at different ages like it. Ultrafiltration (UF) as a technique for cheese manufacture was introduced in the early 1970 and has been proven successful in the production of soft cheeses. It has the potential to increase cheese yield through the retention of whey proteins in the curd. Ultrafiltration has also the potential to reduce production costs and develop cheeses with novel functional characteristics. On the other hand, Broccoli is a plant of the cabbage family, whose flower head is used as a vegetable. Broccoli has a large flower heads usually green in colour, arranged in a tree like fashion on branches sprouting from a thick, edible stalk. Broccoli is rich in vitamin C, as well as dietary fiber and also contains

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multiple nutrients with potential anti –cancer properties such as diindolylmethane. Broccoli is also an excellent source of folic acid [2], dietary fiber [3] and indole-3-cabinol, a chemical which boosts DNA repair in cells and appears to block the growth of the risk of aggressive prostate cancer [4]. Broccoli consumption has been also shown to be beneficial in the prevention of heart disease [5]. During the last decade consumption of broccoli has been highly recommended based on the presence of secondary plant metabolites with health protective effects. A part from these compounds, broccoli might rapport high levels of minerals, which however, are likely to be affected by cultivar, environment and type of inflorescence. Bioavailability of calcium in broccoli is compared to milk, reinforcing the importance [6]. Broccoli is usually prepared by several methods such as boiling, steaming and stir frying. Boiling method of Broccoli reduces the levels of suspected anti –cancer compounds with losses about 77% after thirty minutes of boiling. However, other preparation methods such as steaming, microwaving and stir frying had no significant effect on such compounds. Steaming broccoli for 3-4 minutes is recommended to maximize potential anti –cancer compounds, such as sulforaphane.

The objective of the present study was to evaluate the physical, chemical, microbiological and sensory quality attributes of UF soft cheese as affected by different levels of added broccoli paste. Nutritional aspects of resultant UF-soft cheese were also *in vivo* evaluated.

## MATERIALS AND METHODS

**Materials:** UF milk concentrate (retentate) was obtained from dairy processing unit, Animal Production Research Institute, Agriculture Research center, Ministry of Agriculture, Egypt. Broccoli vegetable was obtained from the local market in Cairo, Egypt. Rennet powder (Hanelase) was obtained from Chr. Hansen's Lab., Denmark. Fine cooking salt produced by EL-Naser Saline's Company was obtained from the local market.

**Preparation of Broccoli Paste:** Broccoli paste was prepared by soaking the cleaned small pieces of broccoli in water (1 kg /200 ml water) and boiled for 10min., then minced and blended to get very fine paste which kept frozen until used. The gross chemical composition of UF milk retentate and broccoli paste is shown in Table 1.

Table 1: The gross chemical composition of UF milk retentate and broccoli paste

| Character assessed | Milk retenate | Broccoli paste |
|---|---|---|
| Moisture% | 72.07 | 89.32 |
| Protein% | 12.90 | 2.82 |
| Fat% | 11.00 | 0.37 |
| Ash% | 1.43 | 0.80 |
| Fiber% | - | 2.69 |
| Carbohydrate*% | 2.60 | 4.00 |
| pH value | 6.20 | 7.20 |

*Calculated by difference

**Production of Functional UF- soft Cheese:** Fresh UF milk retenate was heat treated to 72°C for 20 sec. and then cooled to 40°C. Cooked broccoli paste was added to warm retenate at levels of nil (control), 10, 20, 30 and 40% (g/100g retentate) T1, T2, T3 and T4, respectively. The UF- retentate was salted to 2% NaCl and renneted by adding rennet powder (Hanelase) at the ratio 3g /100kg. The pre-cheese was immediately filled into plastic containers, (0.25kg precheese) and incubated at the same temperature (40°C) to complete coagulation within 30 min. At this point the containers were removed from the incubator and kept at refrigerator temperature (5°C) for 4 weeks [7]. Three replicates were carried out for each treatment.

***In vivo* Experimental Study:** Albino rats (21) of uniform weight (80-100g) were obtained from the Experimental Animal House, Eyes Research Center, Giza, Egypt. Rats were fed for one week before starting the experiment on basal diet then divided randomly into three groups each of 7 animals. The basal diet consisted of 15% protein as casein, 10% cellulose as fiber, 10% fat as corn oil, 5% mixture of vitamins and salts and 60% carbohydrate as starch according to During *et al*. [8]. The first group was fed for another week on basal diet (negative control), while the 2nd and 3th groups were fed on basal diet supplemented with 20% of cheese, without broccoli (positive control) and cheese treatment supplemented with 30% broccoli, respectively. The diet given to the three groups continued for 4 weeks. All biological examinations were carried out in the initial and periodically to follow up the health parameters of experimental animals mentioned thereafter.

**Methods of Analysis:** Chemical Analysis: Moisture, fat, ash, total nitrogen (T.N), salt, titratable acidity, water soluble nitrogen (WSN) and crude fiber contents of the resultant cheese were determined according to A.O.A.C. [9]. Carbohydrate content was calculated by difference as

described by Ceirwyn [10]. Mineral contents were determined as described by Hankinson [11] using atomic absorption spectrophotometer No.3300 (Perkin Elmer, US instrument Division Norwalk, CT, USA). The levels of thiamin, riboflavin, niacin, folic acid, pyridoxine and cobalamin were determined as a B-Vitamin group by HPLC according to the method of Batifoulier *et al*. [12]. Total flavonoid contents were determined as described by Jia *et al*. [13].

**Physicochemical Properties:** Values of pH were measured using a digital pH meter (HANNA instruments, USA). Firmness values of resultant cheese were measured using a penetrometer (Kochler Co. Inc., USA) as mentioned by El-Shabrawy *et al*. [14]. Penetration depth was recorded in units of 0.1mm since penetrometer readings are inversely related to the firmness of cheese. Syneresis was determined according to the method of Dannenberg and Kessler [15], with slight modification. Hundred grams of cheese in plastic cup was cut into four sections and transferred into a funnel fitted with 120 mesh metal screen. The whey was drained into graduated cylinder. The amount of whey drained off was measured after 120 min at room temperature of cheese.

**Microbiological Examination:** Total bacterial count was enumerated after incubation at 32°C/2 days by using plat count agar while coliform bacteria count was enumerated by incubation at 37°C/2 days according to Marshall [16] using Maconky agar. Samples of cheese were also examined for yeasts & moulds load at 28°C/5 days as mentioned by Koburger [17] using yeast extract and tryptone medium.

**Biological Examination:** The changes in body weight of albino rats were recorded weekly. Weight gain which is average of final weight_ average of initial weight, Feed Consumption which is total food consumed during the period of experimental for each group and Feed Conversion which is Feed Consumption/Weight gain. Blood samples were also obtained weekly from orbitial plexus of the eyes from all rats. Plasma was obtained from blood samples by centrifugation at 1500 rpm for 15 min at ambient temperature. Total cholesterol (TC) as enzymaticly determined according to the method of Allain [18]. Fully enzymatic determination of total triglycerides (TG) in plasma was measured calorimetrically at 546 nm according to Fossati and Principe [19]. Low density lipoprotein (LDL) was determined by enzymatic method of Wieland and Scidel [20], while, high density lipoprotein (HDL) was determined according to the method of Lopez-Virella *et al*. [21]. The activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were determined according to the method adopted by Reitman and Frankel [22], using special Biodiagnostic Kits. Hemoglobin ratio was determined according to the method adopted by Drabkin and Austin [23]. Red blood cells, white blood cells and platelets were counted according to Dacie and Lewis [24]. Antioxidant was determined according to the method of Koracevic and Koracevic [25].

**Sensory Evaluation:** All resultant UF-cheese samples were organoleptically assessed by 10 panelists at Food Science Department, Faculty of Agriculture, Ain Shams University and Dairy Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt according to the scheme of Nelson and Trout [26]. Cheese sample were assessed for flavour (out of 50 points), body & texture (out of 35 points) and outer appearance (out of 15 points). All data were analyzed by the General Linear Models procedure of SAS [27]. Least significant difference test was performed to determine differences in means at $P \leq 0.05$.

## RESULTS AND DISCUSSION

The chemical composition of UF–soft cheese supplemented with broccoli paste (Table 2) showed that, there were differences in moisture contents among all treatments including control. Control treatment possessed the lowest significant moisture with highest contents of fat, protein, ash and salt. The moisture content increased

Table 2: Gross chemical composition of fresh functional UF-soft cheese supplemented with broccoli paste

| | Treatments | | | | |
|---|---|---|---|---|---|
| Character assessed | Control | T1 | T2 | T3 | T4 |
| Moisture (%) | 70.07$^{c}$ | 73.03$^{b}$ | 74.51$^{ab}$ | 75.16$^{a}$ | 76.29$^{a}$ |
| Fat (%) | 11.00$^{a}$ | 9.00$^{b}$ | 9.00$^{b}$ | 8.50$^{bc}$ | 8.00$^{c}$ |
| Protein (%) | 12.10$^{a}$ | 11.63$^{a}$ | 11.05$^{ab}$ | 10.58$^{b}$ | 9.43$^{c}$ |
| Ash (%) | 3.31$^{a}$ | 3.22$^{a}$ | 2.97$^{a}$ | 2.84$^{ab}$ | 2.62$^{b}$ |
| Salt (%) | 2.10$^{a}$ | 2.01$^{a}$ | 2.00$^{a}$ | 2.10$^{a}$ | 2.00$^{a}$ |
| *Carbohydrate (%) | 3.52 | 3.12 | 2.47 | 2.92 | 3.66 |
| Flavenoids (%) | 0.031$^{b}$ | 0.039$^{b}$ | 0.057$^{b}$ | 0. 202$^{a}$ | 0.266$^{a}$ |
| Fiber (%) | 0.00$^{c}$ | 0.24$^{b}$ | 0.49$^{ab}$ | 0.76$^{a}$ | 1.01$^{a}$ |

*Calculated by difference

Control: UF-soft cheese without addition. $T_1$, $T_2$, $T_3$ and$T_4$: UF-soft cheese supplemented with 10, 20, 30 and 40% (w /w) broccoli pastes, respectively. a b c : Means with the same letter among treatments are not significantly different Acidity, soluble nitrogen and pH values:

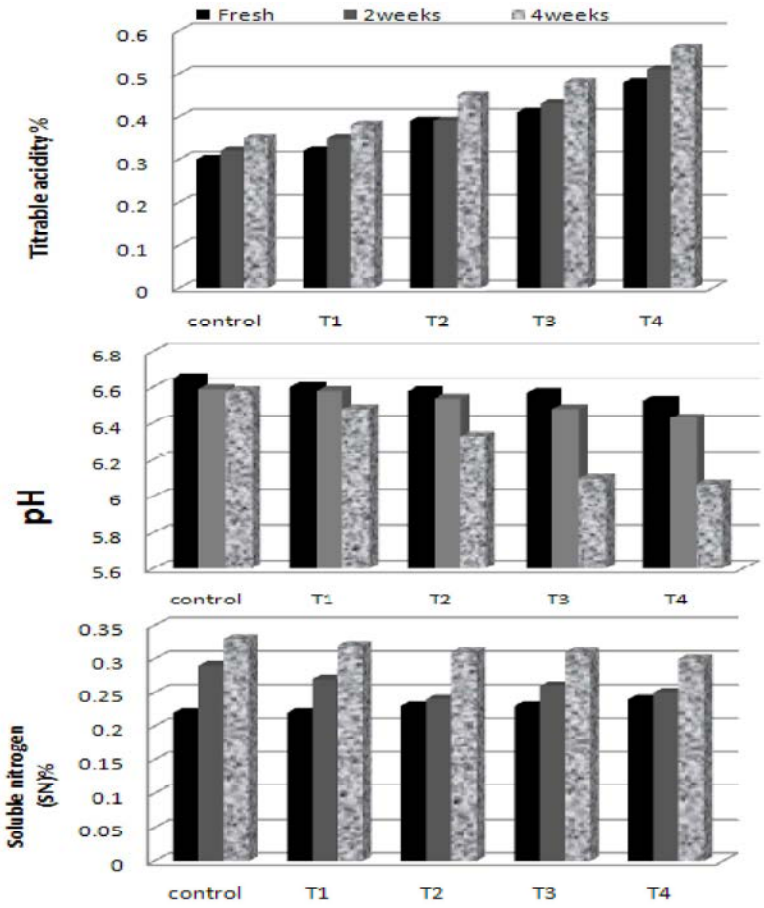


Fig. 1: Changes in the acidity, pH and soluble nitrogen of UF-soft cheese supplemented with broccoli paste during cold storage at 5±2°C.

while fat, protein, ash and salt content decreased in resultant UF-soft cheese with adding broccoli paste. The lowest contents of fat, protein, ash and salt in UF–soft cheese with broccoli are mainly due to the lower ratios of these components in broccoli paste compared to milk retentate (Table 1). These results are in agreement with those obtained by Awad [28] and Awad *et al*. [29], who outlined that addition of materials other than cheese such as fruits and vegetables with low protein content in the base blend decreased TN, ash and salt contents in processed cheese spreads. From the data presented in Table 2, soft cheese without broccoli (control) exhibited low flavonoids compared to treatments supplemented with broccoli paste. Incorporation of broccoli paste into UF-soft cheese base increased total flavonoids values. Broccoli can be considered as a rich natural material of flavenoids [30]. The increase in flavonoid value was more pronounced as the level of broccoli paste increased. As can be seen from the data in Table 2, the total flavonoids increased from 0.031% of treatment without broccoli paste (control) up to 0.226% in T4 with added 40% broccoli paste. Incorporating broccoli paste into milk retentate caused also an increase in fiber content of cheese (Table 2). This could be related to the higher fiber content in broccoli. These results are in agreement with the finding of Couto *et al*. [3], who found that the cream soups with broccoli contained higher dietary fiber. From the previous obtained data, adding broccoli into cheese base could be considered as a health promoting source since it increased the functional components such as flavonoid and fiber contents in final cheese product.

Supplementing retentate with broccoli paste resulted in higher pH values of UF-soft cheese (Fig. 1). Control treatment had the lowest pH while treatment with 40% broccoli paste showed the highest one. This could be due to the high pH of broccoli paste used in manufacture of cheese (7.2) compared to the pH of retentate (6.2) (Table 1). During storage, the pH values decreased with extending the storage period. These could be attributed to a limited growth and activity of resistant microflora and

enzymes in the product which cause a hydrolysis of some lactose to organic acids. The changes in pH values of all treatments had an opposite trend to that of acidity. This agrees with that reported by Awad [28]. Soluble nitrogen content (SN) of UF-soft cheese was affected by adding broccoli paste in UF milk retentate (Fig. 1). Among fresh UF- soft cheese treatments, control one possessed the lowest SN content. Adding broccoli paste into retentate increased the SN content being highest with 40% of broccoli paste. Soluble nitrogen increased during storage in all treatments including the control. This could be the result of enzymatic activity of resistant proteinases present in the product. It could be also due to the hydrolysis in UF-soft cheese with broccoli paste.

**Water Holding Capacity (WHC) and Firmness:** It is well known that whey syneresis from cheese curd are inversely related to the water holding capacity in the curd. Whey syneresis values of UF-Soft cheese with broccoli paste are presented in Table 3. All treatments showed higher WHC values than that of the control without broccoli paste. The value of exudates significantly decreased with increasing the ratio added of broccoli paste in the retentate. The increase in WHC values of treatments with broccoli paste could be due to the higher content of fiber in broccoli-which may bind more water in the resultant cheese. The firmness expressed as depth of penetration decreased with increasing the broccoli paste ratio in the cheese base. The lowest penetration depth was recorded in control treatment and the values increased in all treatments with broccoli paste being more pronounced in sample with 40% broccoli paste (T4). These changes could be due to the differences occurred in water binding capacity and fiber content of final product.

**Mineral and Vitamins Contents:** UF-soft cheese treatments made with broccoli paste showed different mineral contents compared to the control (Table 4). Adding broccoli paste to milk retentate was accompanied by high level of magnesium, manganese, potassium, iron and zinc in the resultant cheese except for calcium which was higher in control. From the results in Table 4, it could be noticed that the iron content of fortified soft cheese with broccoli varied between 0.27-0.45 mg/100g compared to 0.15 mg/100g in control treatment. These results are in agreement with that reported by Ohba and Iio [31] who stated that beverage prepared using broccoli had the same calcium content as milk, with high level of iron

Table 3: Curd syneresis and penetration values of fresh UF-soft cheese made with broccoli paste

| Treatments* | Syneresis (ml) | Penetration depth (mm) |
|---|---|---|
| Control | 39.5$^{a}$ | 18.5$^{c}$ |
| $T_1$ | 36.7$^{ab}$ | 20.5$^{b}$ |
| $T_2$ | 31.1$^{bc}$ | 22.1$^{a}$ |
| $T_3$ | 28.5$^{c}$ | 22.8$^{a}$ |
| $T_4$ | 17.2$^{d}$ | 23.0$^{a}$ |

*See Table 2 for details. a, b, c: Means with the same letter among treatments are not significantly different ($P \leq 05$)

Table 4: Mineral and vitamin contents of UF-soft cheese made with broccoli paste

| Character assessed | Treatments* | | | | |
|---|---|---|---|---|---|
| | Control | T1 | T2 | T3 | T4 |
| | Minerals (mg/100g) | | | | |
| Ca | 51.92 | 45.56 | 40.55 | 36.28 | 32.73 |
| Na | 246.32 | 254.16 | 289.23 | 315.92 | 329.79 |
| K | 35.62 | 37.32 | 41.23 | 46.40 | 51.73 |
| Mg | 9.22 | 9.64 | 10.89 | 12.93 | 15.17 |
| Mn | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| Fe | 0.15 | 0.28 | 0.27 | 0.36 | 0.45 |
| Zn | 0.22 | 0.24 | 0.32 | 0.38 | 0.44 |
| | Vitamins (ppm) | | | | |
| Vit.(B1) | 20.15 | 28.59 | 34.97 | 41.61 | 42.97 |
| Vit.(B2) | 51.27 | 67.80 | 98.40 | 140.87 | 159.23 |
| Vit.(B6) | 4.21 | 6.96 | 8.25 | 10.83 | 12.86 |
| Folic acid | 9.73 | 19.71 | 31.58 | 39.01 | 41.37 |
| Nicotinic acid | 45.82 | 68.99 | 150.84 | 182.09 | 213.38 |
| Vit.(B12) | 35.15 | 49.72 | 54.55 | 84.34 | 95.68 |

*See Table 2 for details

(3- time than that of milk).All elements were increased with increasing broccoli paste content in milk retentate. Vitamin contents of UF-soft cheese made with broccoli paste are presented in Table 4. UF-soft cheese with broccoli paste had higher vitamin contents. Control cheese without broccoli showed the lowest vitamin contents in all examined vitamins among all treatments. Increasing the ratio of broccoli added led to higher values of vitamins being highest in T4 with 40% broccoli paste. Cheese treatment with 40% broccoli (T4) showed higher vitamin $B_2$, $B_6$ and $B_{12}$ contents by up to 3 folds of the control cheese. Folic acid content in all treatments was also higher than the control (up to 4-times) which could be due to the high content of folic in broccoli paste [32]. Milk products are considered as poor sources for folic acid. So, UF- soft cheese made with broccoli can be recommended as a good source of folic acid.

**Microbiological Examination:** Data presented in Table 5 illustrates the microbiological examinations of UF- Soft cheese made with different levels of broccoli when fresh

Table 5: Total bacterial count, yeasts & moulds and coliform bacterial counts (log cfu/g sample) of UF-soft cheese made with broccoli paste, fresh and during cold storage at 5±2°C

| Storage period (weeks) | Treatments* | | | | |
|---|---|---|---|---|---|
| | Control | T1 | T2 | T3 | T4 |
| | Total bacterial count | | | | |
| Fresh | 125 | 115 | 102 | 140 | 143 |
| 2 | 43 | 33 | 43 | 64 | 44 |
| 4 | 63 | 65 | 56 | 81 | 73 |
| | Yeasts & Moulds count | | | | |
| Fresh | 1 | 2 | 1 | 2 | 2 |
| 2 | 3 | 4 | 3 | 3 | 1 |
| 4 | 12 | 6 | 6 | 4 | 5 |
| | Coliform bacterial count | | | | |
| Fresh | 3 | 5 | 5 | 7 | 9 |
| 2 | N.D | N.D | N.D | N.D | N.D** |
| 4 | N.D | N.D | N.D | N.D | N.D |

*See Table 2 for details

**Not detected

Table 6: Feed consumption, weight gain and feed conversion ratio of albino rates as affected by feeding on UF-Soft Cheese made with 30% broccoli paste

| Rats groups | Positive group | Negative group | Treatment Group |
|---|---|---|---|
| Feed Consumption (g) | 1290 | 1331 | 1420 |
| Weight Gain (g) | 98 | 102 | 118 |
| Feed Conversion ratio (F.C.R) | 13.16 | 13.04 | 12.03 |

and periodically during cold storage. Generally, it could be noticed that treatments T3 and T4 showed higher total bacterial count and yeast & mould followed by the control then treatments T1 and T2. These counts followed similar trend for all cheese treatments being decreased during the first 2 weeks of storage and then increased at the end of storage. The data in Table 5 also indicated that among all treatments, control cheese had the lower coliform counts. The highest coliform bacterial count in cheese treatments made with broccoli could be due to the incorporation of broccoli paste in the cheese blends. Coliform bacteria were not detected in all treatments including control with prolonging the storage period up to 2 weeks or thereafter.

***In vivo* Biological Examinations of UF Cheese:** Table 6 presents the feed consumption, weight gain and feed conversion ratio of albino rates as affected by feeding on diet containing UF-Soft Cheese containing broccoli paste. The data cleared that the treated group consumed higher level of diet through the treating period. This could be a reflection of better health of rats treatment group than that in positive as negative groups. Therefore, the weight gain in treatment group fed on UF-Soft cheese made with broccoli paste was higher than that of positive or negative groups. Feed conversion ratio (FCR) which is the ratio between the feed consumption to the weight gain through the experimental period was lower in rats group fed on cheese than that of positive or negative groups. This means that the diet containing cheese fortified with broccoli paste increased the weight gained from the unit of feed. Therefore, including broccoli in the diet of rate resulted in better health with higher efficiency to convert the consumed diet to weight gain in experimental animals.

Serum blood lipids and liver functions of albino rats as affected by feeding on UF- soft cheese fortified with 30% broccoli paste are shown in Table 7. Data indicated that the levels of serum triglycerides and cholesterol of rats were affected by feeding on a diet enriched with broccoli paste. The serum cholesterol and triglycerides level in positive control group was significantly higher than that of experimental group during the feeding period. At the end of feeding period, the treatment group which fed on broccoli supplemented diet had the lowest levels of serum cholesterol and triglycerides. The parallel reduction in triglycerides might be a direct result of cholesterol which plays a major role in the transport of triglycerides [33]. Also, it could be noticed that LDL– cholesterol levels of treatments group were significantly lower than those of positive and negative control groups throughout the feeding period. The rats received broccoli supplemented diet had the lowest level of serum LDL- cholesterol at the end of feeding period. The results are in agreement with those obtained by El-Sokary [34] and El-sayed *et al*. [35].

From data in Table 7, it could be also noticed that an increase of HDL- cholesterol in all rats groups. Rats fed on cheese with broccoli paste diet showed the highest level of serum HDL-cholesterol compared with the positive and negative control groups. The rate of increase was proportion to the feeding period. HDL-cholesterol may control the lipid metabolism by removing free cholesterol from the peripheral cell by etherifying it into neutral lipid or by increasing the role of triglycerides catabolism. Tietz [36] reported that HDL may inhibit the uptake and degradation of LDL by compositing the LDL receptor mediated pathway. Antioxidant level increased in all animal groups during the feeding period showing higher value in treatment group fed on cheese fortified with broccoli paste. The high ratio of antioxidant indicates more healthy rats since it can work against the free radical and promote power against cancer disease.

Table 7: Serum blood lipids profile and liver functions of albino rats as affected by feeding on UF-soft cheese made with 30% broccoli paste during feeding period of 4 weeks

| | Negative group | | | Positive group | | | Treatment group | | |
|---|---|---|---|---|---|---|---|---|---|
| Lipids profile | Zero | 2wk | 4wk | Zero | 2wk | 4wk | Zero | 2wk | 4wk |
| Cholesterol(mg/dl) | 87 | 82 | 78 | 86 | 73 | 69 | 84 | 71 | 65 |
| Triglycerides(mg/dl) | 89 | 77 | 74 | 85 | 75 | 71 | 83 | 65 | 57 |
| HDL(mg/dl) | 14 | 16 | 22 | 9 | 12 | 20 | 7 | 11 | 19 |
| LDL(mg/dl) | 52.8 | 48.3 | 45.6 | 50.0 | 47.1 | 41.5 | 44.7 | 38.2 | 29.6 |
| Antioxidant(mM/l) | 1.08 | 1.87 | 3.17 | 1.49 | 2.91 | 3.50 | 2.04 | 4.20 | 7.08 |
| ALT (U/ml) | 15.9 | 22.73 | 42.21 | 14.05 | 25.15 | 31.44 | 26.65 | 21.52 | 13.48 |
| AST (U/ml) | 28.52 | 30.70 | 41.59 | 31.90 | 41.45 | 44.92 | 31.68 | 29.08 | 16.64 |

HDL: high density lipoprotein

LDL: Low density lipoprotein

ALT: alanine aminotransferase

AST: aspartate aminotransferase

Table 8: Blood profile of albino rats as affect by feeding on UF-Soft Cheese made with 30% broccoli paste

| | Negative group | | Positive group | | Treatment group | |
|---|---|---|---|---|---|---|
| Blood profile | Zero | 4wk | Zero | 4wk | Zero | 4wk |
| Hemoglobin(Hb, g/dl) | 13.09 | 14.80 | 13.30 | 15.60 | 12.21 | 16.80 |
| Red blood cells (RBCs, million/µl) | 4.56 | 5.13 | 4.63 | 5.40 | 4.27 | 5.80 |
| White blood cells (WBCs /µl x$10^2$) | 79 | 83 | 73 | 103 | 76 | 145 |
| Platelets (PLT/c mm x$10^{4)}$ | 96 | 98 | 88 | 102 | 86 | 122 |

**Effect of Broccoli Paste on Liver Enzymes of Rats:** The ratios of ALT and AST as an indication of liver functions are shown also in Table 7. Incorporation of soft cheese made with broccoli paste in diet of albino rats lowered the serum values of ALT and AST. This means that there were improvements in liver functions which resulted in lower liver enzymes value. Liver functions improvements of treated rats groups are mainly due to the functional components in broccoli paste. Serum ALT and AST values of treatment group increased with extending feeding period. It could be noticed that administration of soft cheese containing broccoli paste induced a significant decrease in the activity of serum ALT and AST. The obtained results are in agreement with those of Nigm [37] and El-Sayed *et al*. [35]. Ahn *et al*. [38] stated that broccoli sprout can effectively inhibit the lipid oxidation of microencapsulated high oleic sunflower oil.

**Effect of Broccoli Paste on Plasma Lipid Profile:** Blood profile of albino rats as affected by feeding a diet containing cheese made with 30% broccoli paste is presented in Table 8. The hemoglobin ratio improved in rat blood as a function of feeding with cheese containing broccoli paste as can be seen in treatment group. The increase in hemoglobin level of rats fed on balanced diet containing soft cheese enriched with broccoli may be due to the addition of broccoli paste which is rich in iron (Table 4).

It can be also seen from the data in Table 8 that the count of RBCs and WBCs increased in all rat groups under investigation after 4 week of feeding period showing higher values in group fed on diet containing cheese made with broccoli paste. The platelets count showed also higher number in treatment group especially at the end of feeding period. Higher values of RBCs, WBCs and PLT of albino rats fed on a diet containing cheese made with broccoli paste which indicates an improvement in blood picture could be directed to the effect of broccoli paste in the diet.

**Sensory Evaluation:** Sensory evaluation of UF-soft cheese made with broccoli paste is shown in Table 9. The flavour of resultant cheese enhanced and became more preferable to panelists with adding broccoli paste into retentate up to 20% compared to the control. At 30% the panels started to detect the flavour of broccoli paste in the product, but the cheese was still accepted at this ratio. The body and texture of resultant cheese were

Table 9: Sensory attributes of UF-soft cheese made with broccoli paste during cold storage at 5±2°C

| | | Treatments* | | | | |
|---|---|---|---|---|---|---|
| Storage period | Character assessed | Control | T1 | T2 | T3 | T4 |
| Fresh | Flavour (50) | 48 | 48 | 49 | 45 | 43 |
| | Body &texture(35) | 33 | 34 | 34 | 31 | 29 |
| | Appearance(15) | 14 | 14 | 13 | 12 | 11 |
| | Total(100) | 95[a] | 96[a] | 96[a] | 88[b] | 83[c] |
| 2 weeks | Flavour(50) | 46 | 46 | 47 | 43 | 40 |
| | Body &texture(35) | 31 | 32 | 33 | 29 | 26 |
| | Appearance(15) | 14 | 13 | 13 | 11 | 10 |
| | Total(100) | 91[a] | 91[a] | 93[a] | 83[b] | 76[c] |
| 4 weeks | Flavour(50) | 45 | 45 | 46 | 41 | 39 |
| | Body &texture(35) | 30 | 31 | 31 | 27 | 25 |
| | Appearance (15) | 13 | 13 | 13 | 11 | 10 |
| | Total(100) | 88[a] | 89[a] | 90[a] | 79[bc] | 74[c] |

*See Table 2 for details. a, b, c : Means with the same letter among treatments are not significantly different

improved and the cheese showed more ability to spread with adding broccoli paste into retentate. Treatments with up to 20% broccoli paste showed firm enough body and good texture with no defects, while with higher broccoli paste ratios, the body started to be more firm which was more obvious with 40% broccoli paste. Addition of broccoli paste into retentate led to slight green colour of resultant cheese and this become more obvious with increasing the ratio added. Generally, the appearance of final product was affected by the ingredients used in manufacture of cheese. Total scores of UF-soft cheese indicated that all resultant products were acceptable but addition broccoli paste into retentate up to 20% gave a better organoleptical quality compared to the control. Increasing the ratio of broccoli added up to 30% or more produced cheese with significantly lower quality attributes compared to other treatments. Storage of cheese up to one month slightly lowered the total quality attributes and this effect was more marked in cheese samples at the end of storage period. These findings are in agreement with those of Awad [28].

In conclusion, UF-soft cheese can be produced with adding broccoli paste up to 20% into retentate without any significant difference than that of control without addition. Impact of broccoli paste up to 20% into retentate produced highly acceptable soft cheese and much better flavour with even improved body and texture. Incorporation of broccoli paste into human diet like cheese exhibited several nutritional advantages as examined *in vivo* albino rats. The diet contained soft cheese with broccoli paste, resulted in lower level of cholesterol, triglycerides and LDL in blood serum. Antioxidant level was increased with significant improvement of liver functions (lower ALT &AST) and blood profile (hemoglobin, RBC, WBC and PLT).

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