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Chemical, Rheological and Sensory Evaluation of Yoghurt Supplemented with Turmeric

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Abstract: Curcumin is the major active principle in turmeric, known by its antioxidative and anti-inflammatory properties and as a cancer chemopreventive agent. Set yoghurt was prepared from buffalos milk supplemented with turmeric powder of 0.0, 0.1, 0.25, 0.50, 0.75 and 1.0% (w/v). The changes in the chemical, rheological and sensory properties of yoghurt from different treatments were followed during cold storage at 5±2°C for 12 days. Increasing turmeric concentrations decreased WSN/TN (%) significantly, but the pH values were not significantly changed. Prolonged storage for 12 days changed both parameters significantly. Firmness and viscosity of yoghurt were changed significantly by increasing turmeric concentrations. Sensory evaluation showed that turmeric in different concentrations had significant effect on the acceptability of fresh and stored yoghurt.

Key words: Yoghurt, functional dairy products, turmeric, curcumin, sensory rheological properties

INTRODUCTION

Yoghurt is a popular, flavorful and healthful dairy product. Its production and consumption is growing continuously due to its therapeutic properties and high nutritive value (He *et al*., 2005). The health promoting properties of live lactic acid bacteria in yoghurt include protection against gastrointestinal upsets, enhancing digestion of lactose by maldigesters, decreasing risk of cancer, lowering blood cholesterol (Doornbos *et al*., 2005) and improving immune response and helping the body to assimilate protein, calcium and iron (Marona and Pedrigon, 2004). On the other hand, turmeric is a spice prepared from rhizome of the plant *Curcuma longa*. It is used in diet and cosmetics as skin cleansing, facemask. Also, it is used to promote wound healing, to treat liver disorders, diabetes and inflammatory conditions such as rheumatism, arthritis, sinusitis (Joe *et al*., 2004) and Alzheimers disease (Park and Kim, 2002). Curcumin (diferuoyl methane), is a yellow pigment, identified as the major active principle in turmeric. Since its content in turmeric ranges from 1 to 5%, individuals may consume from 3 mg to 190 mg of the compound daily through diet (Joe *et al*., 2004). For the past two decades, curcumin has attracted the interest of scientists as a cancer chemopreventive agent (Leu and Maa, 2002; Balcerek and Matlawska, 2005; Chakraborty *et al*., 2006), especially for tumors of the skin and digestive tract. Also, it is considered an antioxidant agent (Osawa and Kato, 2005) and its chemical structure allows to scavenge nitric oxide radial (Sreejayan and Rao, 1997). Turmeric is not particularly well absorbed when taken orally and has been shown that cooking (fried or boiled) does not alter the activity of turmeric. In India, it is not only used in cooking, taken for medicine and reduces pain, but is also used topically as a household remedy (Chan *et al*., 2005). Many new supplements added to yoghurt such as dwarf golden apple (Ann Bartoo and Badrie, 2005), algae oil emulsion (Chee *et al*., 2005) and honey (Varga, 2006), also, pigments from maize grains were used as new colorants (Salinas *et al*., 2005). No information found about supplementing yoghurt with herbs or spices. So, the objective of this work was to produce set yoghurt supplemented with turmeric powder and evaluate its chemical, rheological and sensory properties.

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MATERIALS AND METHODS

Materials

Fresh buffalo's milk was obtained from the farm of Agriculture Faculty, Cairo University. Skim milk powder (low heat), imported from Poland and turmeric powder was purchased from Cairo market. Freeze dried culture of *Lactobacillus delbrueckii* sp. *Bulgarius* and *Streptococcus salivarius* sp. *thermophilus* (1:1) was obtained from Chr. Hansen's Laboritorum. A/S, Copenhagen, Denmark. Bulk starter was propagated in sterilized reconstituted skim milk (11% TS).

Preparation of Turmeric Yoghurt

Fresh skim milk was standardized to ~ 15.0 milk solids and ~ 3.2% fat using skim milk powder and fresh cream. Standardized milk was divided into six equal portions (six treatments) turmeric powder was added at the rate of 0.1, 0.25, 0.5, 0.75 or 1.0%, in addition to plain yoghurt without turmeric as control. Each treatment was stirred well, heated at 90°C for 5 min, cooled to 42°C, then inoculated with 3% of starter culture, dispensed into plastic cups (100 mL) and incubated at 42°C until a uniform coagulam was formed. The obtained yoghurt were stored in refrigerator at 5±2°C for 12 days. Samples were taken for chemical, rheological analysis and sensory evaluation, fresh (after 1 day of manufacture), 4, 8 and 12 days of storage. Three replicates were prepared from each treatment.

Chemical Analysis of Turmeric Yoghurt

Yoghurt samples were examined for pH value using a laboratory pH meter (HANNA, Instrument, Italy) with combined electrode. Water Soluble Nitrogen (WSN) was obtained as described by Coskun and Tuncturk (2000) as follows: 10 g of yogurt sample were homogenized with 50 mL (40°C) distilled water and held for 1 h at the same temperature, centrifuged at 3000 x g for 30 min., the extract was filtered after cooling to 4°C and used to determine the nitrogen content by Kjeldahl method. Chemical analysis were replicated three times for each sample.

Rheological Analysis of Turmeric Yoghurt

The quantity of whey which has separated from yoghurt samples after 2 h at 5°C (syneresis) of control and turmeric yoghurt was determined according to Dannenberg and Kessler, 1988).

The firmness of turmeric yoghurt samples was measured as described by Kammerlehner and Kessler (1980), using Koehler K 19500, Penetrometer, Syamore AVE, USA. The depth to penetrate into the yoghurt curd is measured after 5 sec at 15°C using cone and a standardized rod; total weight 82.5 g. The depth of penetration (0.1 mm = Penetrometer Unit, PF) is a function of the firmness of yoghurt curd.

Shear stress of control and turmeric yoghurt was measured using rotary viscometer (Rheotest II, 50 Hz Germany) as described by Toledo (1980). The measurements were taken in cold water bath (5°C) using spindle (H), samples were subjected to shear rates ranging from 0.3 to 27 (S^{-1}) for upward curve. Rheological measurements were replicated three times for each sample.

Sensory Evaluation

Sensory evaluation consists of descriptive and hedonic studies as follows:

Descriptive Sensory Analysis

Fifteen assessors (7 female, 8 male, aged between 25 and 45 years) who had experience with yoghurt descriptive vocabulary for appearance, body and texture and flavor were participated. Yoghurt was sensory evaluated fresh and during cold storage period (12 days) according to Keating and White (1990), using a scheme of 10 points for appearance, 40 points for body and texture and 50 points for flavor. Panel members also instructed to report any defects or unpleasant flavor.

Consumer Assessment

Two consumers groups were participated in the preference test (fresh sample only was used). Group-1, included 50 consumers from local area, group-2, included 50 consumers were chosen randomly from different areas in Cairo. Each consumer was asked to express his preference on a nine point hedonic scale. Consumers were provided water at room temperature and asked to rinse thoroughly after testing each yoghurt sample to clean their palate. Also, consumers reaction of the idea of adding medicinal herbs such as turmeric powder to yoghurt was investigated using a five point hedonic scale.

Statistical Analysis

Statistical analyses were performed using the GLM procedure with SAS (1994) software. Duncan's multiple comparison procedure was used to compare the means. A probability to $p \leq 0.5$ was used to establish the statistical significance.

RESULTS AND DISCUSSION

Chemical Changes

As shown in Table 1 addition of turmeric powder with different concentrations decreased the pH values of fresh yoghurt samples, no significant reduction observed. These results are agreement with those obtained by Conner (1993) who reported that turmeric had little antimicrobial activity. While during cold storage period, pH values decreased significantly ($p \leq 0.05$). These results attributed to the continuation of metabolic activity of starter culture.

Table 2 shows that increasing turmeric concentrations increased the WSN/TN (%) significantly ($p \leq 0.05$) compared with control sample or yoghurt with low turmeric concentration (0.1%). Also, during cold storage the WSN/TN ratios significantly changed. This may suggest that turmeric powder had no inhibitory effect on proteolytic organisms. The proteinase activity of *L. bulgaricus* hydrolyses the casein to yield polypeptides and broken down by the peptidases of *S. thermopilus* with liberation of amino acids (Tamime and Robinson, 1985).

Correlation analysis revealed negative correlation (-0.308) between pH values and WSN/TN ratio. This could be due to the level of librated amino acids in the products were associated with the proteinase activity of *L. bulgaricus* which became the predominant organism in such acidic environment (Tamime and Robinson, 1985).

Table 1: The changes in pH values of control and turmeric yoghurt during cold storage

	Treatments					
Storage period (days)	Control	T_1	T_2	T_3	T_4	T_5
Fresh	4.67±0.11^a	4.65±0.13^a	4.65±0.02^a	4.64±0.05^a	4.62±0.05^a	4.56±0.12^a
4	4.39±0.09^b	4.45±0.09^b	4.44±0.13^b	4.47±0.11^b	4.49±0.10^b	4.46±0.14^b
8	4.20±0.06^c	4.29±0.08^c	4.24±0.01^c	4.25±0.02^c	4.24±0.03^c	4.27±0.04^c
12	4.11±0.01^d	4.09±0.03^d	4.19±0.02^d	4.19±0.03^d	4.15±0.02^d	4.25±0.01^d

Means with different superscripts are significantly ($p<0.05$) difference; SE = Mean±Standard Error

Table 2: Effect of turmeric concentration on Water Soluble Nitrogen/Total Nitrogen (%) of yoghurt during cold storage

	Treatments					
Storage period (days)	Control	T_1	T_2	T_3	T_4	T_5
Fresh	8.90±0.74^d	9.83±0.57^d	10.22±0.36^c	10.26±0.14^c	10.27±0.44^c	10.29±0.33^c
4	10.31±0.88^c	9.65±0.56^c	10.36±0.59^c	10.69±0.51^c	10.92±0.49^c	10.39±0.47^c
8	12.65±2.27^b	12.75±1.42^b	11.06±1.95^c	12.03±1.36^b	11.13±2.02^c	10.59±1.27^c
12	13.16±1.52^a	13.13±2.30^a	13.52±1.25^a	13.58±1.09^a	13.40±2.31^a	13.27±1.43^a

Means with different superscripts are significantly ($p<0.05$) difference; SE = Mean±Standard Error

Rheological Properties

Syneresis of Yoghurt

The rate of syneresis gradually decreased with increasing turmeric concentrations from 0.1 to 1.0%. These results could be due to water retention by swollen the turmeric particles, beside the bonds between the network of milk gel became greater and stronger (Fig. 1). Also, could be attributed to the association of (β-LG) with casein which led to form filamentous appendages on the surface of the micelles. This complex protects the micelles from excessive fusion and have less susceptibility to serum separation (Kalab *et al*., 1983). Correlation analysis revealed negative correlation (-0.39) between WSN/TN ratios and syneresis. Prolonging the cold period of storage for 12 days decreased the syneresis of yoghurt compared with fresh samples. This may be attributed to the immobilization of the liquid phase in a three dimensional matrix composed of casein micelles linked together depends on total solids, Ca^{2+}, pH, preheating treatment of milk and others (Walstra *et al*., 1999). High significant correlation was found between pH values and syneresis.

Yoghurt Firmness

Yoghurt firmness as affected by different concentrations of turmeric powder, fresh or during cold storage (12 days) are presented in Fig. 2. Adding turmeric powder increased significantly yoghurt firmness compared with control sample. These results may be due to the rearrangement within the

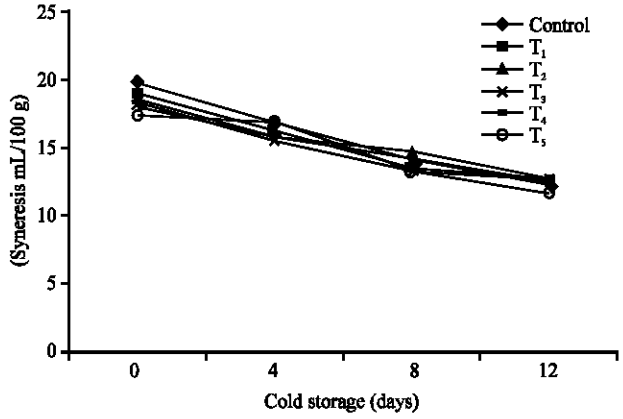

Fig. 1: Syneresis of yoghurt samples during cold storage as affected by turmeric powder

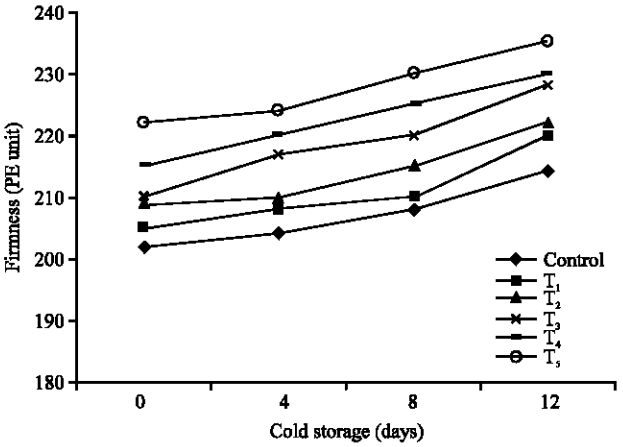

Fig. 2: Firmness of yoghurt samples during cold storage as affected by turmeric powder

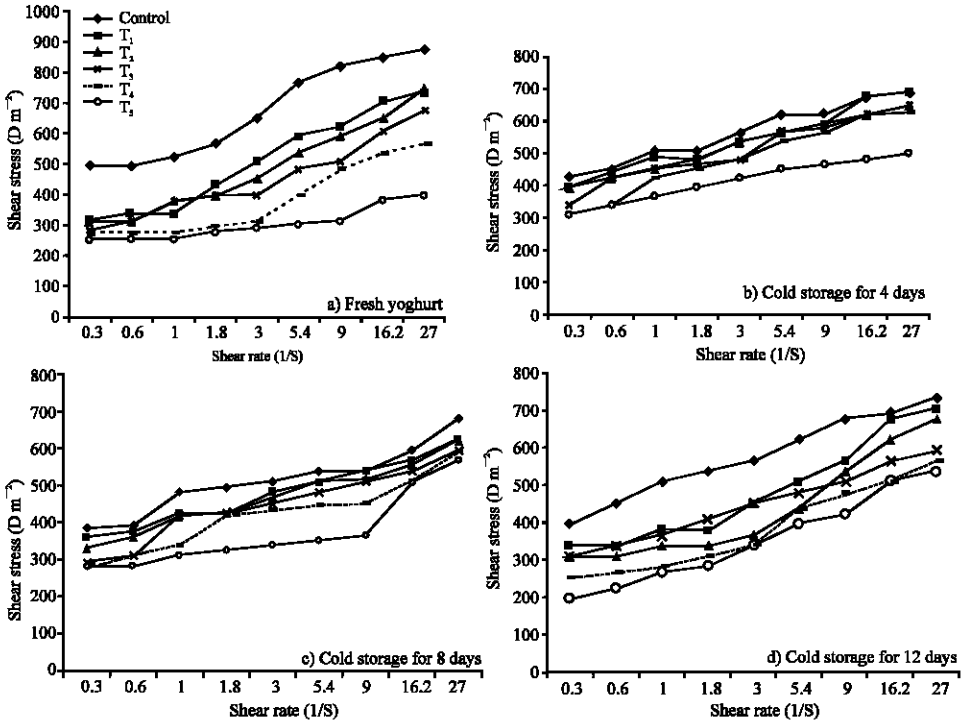

Fig. 3: Effect of turmeric powder on shear stress/shear rate of yoghurt during cold storage

network produced by attractive forces between individual casein particles and turmeric powder leading to affect the yoghurt gel (Walstra *et al*., 1999). No significant effect observed by prolonging the cold storage period.

Shear Stress

The effect of turmeric powder concentrations on shear stress (Dyne m^2) of yoghurt at shear rate ranging from 0.3 to 27.0 (S^{-1}) of fresh samples or during cold storage are presented in Fig. 3a-d. It is clear that shear stress values decreased by increasing the turmeric concentrations from 0.1 to 1.0% compared with control samples in fresh yoghurt or during cold storage period (12 days). These results could be due to the effect of turmeric powder which decreased the volume fraction of gel fragments, then the fragments may lost a lot of interstitial solvent which lead to reduce intermolecular bonds (Walstra *et al*., 1999). Barrantes *et al*. (1994), reported that yoghurt with high milk viscosity tends to have high firmness.

Generally, the rheological properties reflected that turmeric powder may be more interactions with milk protein and/or water during heating temperature, during fermentation process and during cold storage.

Sensory Analysis

Descriptive Study

Mean scores for appearance decreased, but not significantly with increasing turmeric powder concentrations up to 0.5% and then decreased significantly with 0.75 or 1.0% powder (Table 3). These results could be due the condensed yellow color, which affected the preference of high concentrations

of turmeric yoghurt. Also, appearance mean scores decreased by prolonging the cold storage period with all turmeric concentrations. Body and Texture mean scores decreased significantly ($p<0.05$) by increasing turmeric concentrations, but, after 4 days, the mean scores decreased significantly ($p<0.01$). Firmness of turmeric yoghurt (Fig. 2) confirmed these results. High significant correlation was found between Body and Texture scores and firmness of turmeric yoghurt. Flavor mean scores decreased significantly ($p<0.01$) by increasing turmeric concentrations up to 0.25%. Prolonging cold storage period affected the flavor significantly, could be due to the strong taste which increased by increasing the acidity of yoghurt with higher turmeric concentrations. High significant correlation was found between flavor scores and pH values of turmeric yoghurt.

Consumer Acceptability

Consumers are not one homogenous group in terms of typical demographic criteria or in terms of their responses to products. For some products, it is not unusual to identify one or more population groups whose preference behavior is very different from that of the total population. So, two different preference groups were participated to judge the new yoghurt with different turmeric concentrations as shown in Table 4. It is obvious that lower concentration of turmeric (0.1%) got the highest preference mean score with the two groups, decreased significantly by increasing turmeric concentrations.

Table 5 shows the response of consumers to the idea of supplementing yoghurt with medicinal herbs such as turmeric. Ninety percent of the panelists ranked turmeric yoghurt as extremely good idea or an good idea. Only ten percent were neutral about the idea, no one ranked as bad idea.

Table 3: Effect of turmeric powder on appearance, body and texture and flavor of yoghurt during cold storage period

Properties	Storage period (days)	Treatments T_1	T_2	T_3	T_4	T_5
Appearance	Fresh	8.8 ± 1.2^{Aa}	8.3 ± 1.2^{Aa}	7.6 ± 1.6^{Bb}	7.4 ± 1.4^{Ba}	7.7 ± 1.3^{Ba}
(10 points)	4	8.1 ± 1.8^{Aa}	8.2 ± 1.3^{Aa}	8.0 ± 1.3^{Aa}	7.4 ± 1.7^{Ba}	7.4 ± 2.0^{Ba}
	8	8.1 ± 1.2^{Aa}	7.4 ± 1.0^{Bb}	7.6 ± 1.6^{Cb}	7.2 ± 2.1^{Ca}	7.3 ± 2.0^{Cb}
	12	7.7 ± 1.0^{Ba}	7.8 ± 0.7^{Ba}	7.4 ± 1.1^{Ba}	7.2 ± 1.1^{Ba}	7.1 ± 1.2^{Ba}
Body and texture	Fresh	36.2 ± 2.0^{Aa}	36.1 ± 2.8^{Aa}	36.3 ± 3.2^{Aa}	36.3 ± 2.9^{Aa}	35.9 ± 3.6^{Ab}
(40 points)	4	35.4 ± 3.4^{Ab}	35.8 ± 3.4^{Ab}	34.2 ± 2.9^{Ba}	34.9 ± 3.9^{Ba}	34.6 ± 3.8^{Ba}
	8	33.9 ± 3.4^{Bb}	33.7 ± 4.4^{Bb}	34.5 ± 3.2^{Ba}	33.1 ± 2.2^{Bb}	33.2 ± 2.5^{Bb}
	12	33.5 ± 3.7^{Bb}	32.4 ± 2.9^{Bab}	34.8 ± 3.1^{Ba}	32.2 ± 2.8^{Bab}	32.1 ± 3.6^{Bab}
Flavor	Fresh	42.7 ± 3.8^{Aa}	42.0 ± 4.5^{Aa}	39.9 ± 3.6^{Ba}	37.5 ± 3.7^{Bab}	37.1 ± 3.0^{Bab}
(50 points)	4	40.7 ± 3.6^{Ab}	40.4 ± 4.9^{Ab}	38.0 ± 3.6^{Bb}	36.9 ± 2.1^{Bc}	36.8 ± 3.4^{Bc}
	8	39.5 ± 3.6^{Ba}	39.4 ± 3.9^{Ba}	37.2 ± 2.0^{Bab}	35.2 ± 3.3^{Bc}	35.0 ± 4.1^{Ca}
	12	38.2 ± 2.3^{Bb}	38.2 ± 4.6^{Bb}	36.3 ± 4.4^{Bc}	34.8 ± 3.9^{Ca}	34.0 ± 3.3^{Ca}

A, B, C means with different superscripts are significantly ($p<0.01$) difference; a, b, c means with different superscripts are Significantly ($p<0.05$) difference; SE = Mean±Standard Error

Table 4: Overall acceptance scores for yoghurt supplemented with different turmeric concentrations for two preference groups

Treatments	Mean score* Group 1	Group 2
T_1	7.4 ± 1.2^{Aa}	7.1 ± 1.3^{Aa}
T_2	7.1 ± 1.1^{Aa}	6.5 ± 1.4^{Ba}
T_3	7.0 ± 1.0^{Ab}	6.5 ± 1.0^{Ba}
T_4	6.7 ± 1.2^{Ba}	6.4 ± 1.3^{Ba}
T_5	6.2 ± 1.5^{Ba}	6.1 ± 1.9^{Bc}

* Based on 9-point hedonic scale; Group-1 = Responses based on 50 consumers from one local area; Group-2 = Responses based on 50 consumers from different areas A, B, C means with different superscripts are significantly ($p<0.01$) difference; a, b, c means with different superscripts are significantly ($p<0.05$) difference; SE = Mean±Standard Error

Table 5: Consumer reaction to turmeric yoghurt

It is an extremely good idea	66
It is a good idea	24
I am neutral about the idea	10
It is a bad idea	0
It is an extremely bad idea	0
Total	100

CONCLUSIONS

It could be concluded as follows:

- Introducing turmeric powder as medicinal plant to dairy products such as yoghurt was considered by 90% of Egyptian as a good idea.
- Less amount of turmeric was more acceptable and improved some of the rheological properties of set-yoghurt.

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