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Sensory and textural properties of functional yoghurt Enriched with Spirulina and natural honey

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Abstract
The present study was aimed to develop protein-enriched functional yoghurt using *spirulina* as a source of protein and replacement of cane sugar with natural honey and to assess the sensory and textural properties of the developed functional yoghurt. Different levels of *spirulina* (0.2%, 0.4%, 0.6% and 0.8%) were added to the yoghurt to assess the optimum level of inclusion based on the sensory evaluation. Seven different treatments of protein-enriched and honey fortified yoghurt samples were prepared for this study. The treatments were denoted as T1 (*Spirulina* 0.6% without replacement of cane sugar), T2 (*Spirulina* 0.6% and 1% replacement of cane sugar with honey), T3 (*Spirulina* 0.6% and 2% replacement of cane sugar with honey), T4 (*Spirulina* 0.6% and 3% replacement of cane sugar with honey), T5 (*Spirulina* 0.6% and 4% replacement of cane sugar with honey), T6 (*Spirulina* 0.6% and 5% replacement of cane sugar with honey) and T7 (*Spirulina* 0.6% and 6% replacement of cane sugar with honey). The developed protein enriched and honey fortified yoghurt was subjected to textural and organoleptic evaluation. Accordingly, *spirulina* at the rate of 0.6 per cent and 50 per cent replacement of cane sugar with natural honey was found to be superior in terms of sensory and textural qualities for inclusion in protein enriched functional yoghurt and was found to be more beneficial with numerous therapeutic properties and good probiotic viability.

Keywords: Functional yoghurt, natural honey and *spirulina*

1. Introduction
Yoghurt is widely consumed throughout the world for its sensory and nutritional benefits and is made from milk with high solid content, a lactic culture and sugar and can be enriched with the milk powder, proteins, vitamins, minerals and fruits. Yoghurt is a product obtained by the lactic fermentation of whole, skimmed or standardized milk by the action of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus*, and can be accompanied by other lactic bacteria, which for their part contribute to the characteristics of the final product (Aryana, 2007) [1]. The dairy product, yoghurt is gaining widespread consumer acceptance due to its health attributes (Guldas and Irkin, 2010) [2].
Spirulina is a microscopic blue-green vegetable algae that have been used as a significant food source for centuries. It thrives in hot sunny climates and in alkaline waters around the world and produces twenty times as much protein as soybeans when grown on an equal size of land. It is 100% natural and a highly nutritious micro salt-water plant.
Spirulina is the most nutrient-dense food currently known with a protein content of more than 60% and with high availability of essential amino acids. It is an excellent source of vitamins including beta–carotene, thiamine, riboflavin, niacin, vitamin C, vitamin E and biotin. The pigments include chlorophylls, xanthophylls, carotenoids and phytocyanin. It is highly digestive 85-95% due to its thin wall and low nucleic acid contents (4%).The other valuable constituent is gamma-linolenic acid, which is a polyunsaturated fatty acid. This along with superoxide dismutase acts as an antioxidant and is hence useful in chemoprevention (Al-Khader, 2001) [3]. It is widely used in developing countries as an effective and readily available treatment of various wounds, particularly burns. They have anti-viral, anti-inflammatory and anti-tumour effects and reduce blood lipid profile, blood sugar, body weight and wound healing time.
The use of sucrose in the yoghurt has a negative impact on the diabetic patients. Bee honey, a natural food product, is the oldest sweetening substance. It is a good source of many valuable nutritious compounds for the human body. Bee honey has pro-health, anti-oxidative and anti-bacterial properties that are commonly used in apitherapy. Honey can be used as a sucrose replacer and/or supplemented in yoghurt formulation.

Honey has broad consumer appeal as a natural sweetener and flavouring agent. Considering the above facts, an attempt has been made to prepare protein-enriched yoghurt using honey and *spirulina* with good sensory and textural attributes.

2. Materials and Method

Fresh cow milk was purchased from the Integrated Livestock Farm Complex, Veterinary College and Research Institute, Namakkal. Spray-dried skim milk powder (Aavin Dairy, Salem) testing 5 per cent moisture and 95 per cent solubility was used to adjust the solids-not-fat content in yoghurt. Freeze-dried DVS cultures containing yoghurt bacteria *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus salivarius* ssp. *thermophiles* obtained from Chr. Hansen, Denmark were used in this study. Commercially available good quality *Spirulina* powder was purchased from TVS Biotech, Salem. Commercially available good quality honey was purchased from the local market. Cane Sugar, purchased from the local market, was used in the experiment.

2.1 Experimental design

2.1.1 S*pirulina* enriched yoghurt

Different treatments of s*pirulina*-enriched yoghurt were designed as detailed below.

Treatments	Details
Control	Plain yoghurt without the addition of *Spirulina* solution
ST1	Yoghurt + 0.2% *Spirulina* solution
ST2	Yoghurt + 0.4% *Spirulina* solution
ST3	Yoghurt + 0.6% *Spirulina* solution
ST4	Yoghurt + 0.8% *Spirulina* solution

2.1.2 S*pirulina* enriched and honey fortified yoghurt

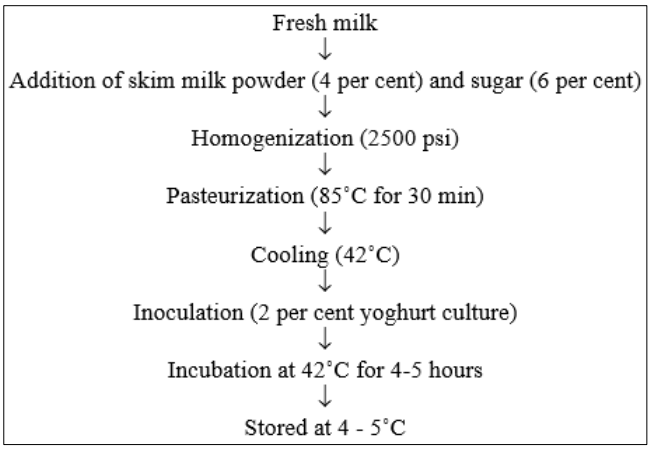
Different treatments of s*pirulina* enriched and honey fortified yoghurt were designed as detailed below.

Treatments	Details
Control	Plain yoghurt without the addition of *Spirulina* and honey
T1	Yoghurt + *Spirulina* 0.6% without replacement of cane sugar
T2	Yoghurt + *Spirulina* 0.6% and 1% replacement of cane sugar with honey
T3	Yoghurt + *Spirulina* 0.6% and 2% replacement of cane sugar with honey
T4	Yoghurt + *Spirulina* 0.6% and 3% replacement of cane sugar with honey
T5	Yoghurt + *Spirulina* 0.6% and 4% replacement of cane sugar with honey
T6	Yoghurt + *Spirulina* 0.6% and 5% replacement of cane sugar with honey
T7	Yoghurt + *Spirulina* 0.6% and 6% replacement of cane sugar with honey

2.2 Procedure for the preparation of plain yoghurt

Plain yoghurt was prepared using fresh milk. Skim milk powder at the rate of 4 per cent (w/v) and sugar at the rate of 6 per cent (w/v) were added to it, and homogenized at 2500 psi. The contents were mixed well and pasteurized at 85˚C for 30 minutes and cooled to 42˚C. The yoghurt mix was inoculated with 2 per cent of yoghurt cultures containing *Lactobacillus delbrueckii* ssp. *bulgaricus*, and *Streptococcus salivarius* ssp. *thermophilus*. It was then mixed well and incubated at 42˚C for 4 to 5 hours and finally stored at 4-5 ˚C.

2.3 Flow diagram for preparation of plain yoghurt

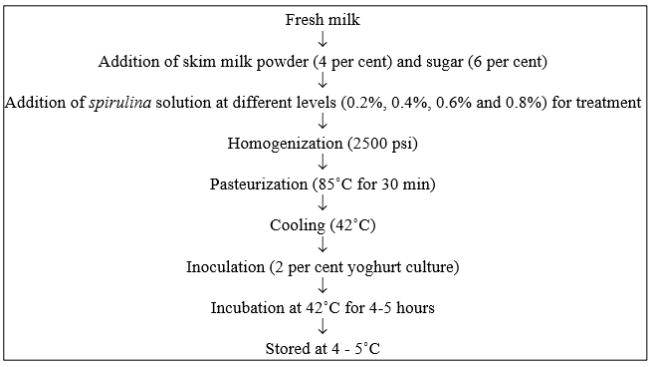


2.4 Preparation of *Spirulina* solution for incorporation into yoghurt

The desired amount of *Spirulina* powder was dissolved in 15 ml distilled water at 25°C and mixed with the help of a magnetic stirrer for 20 minutes. This solution was kept overnight at refrigeration temperature for hydration. Just before use for product preparation, this was remixed for 15 minutes using a magnetic stirrer.

Different levels of *Spirulina* (0.2%, 0.4%, 0.6% and 0.8%) were added to the yoghurt treatment samples to assess the optimum level of inclusion based on the sensory evaluation (Malik *et al.*, 2013) [4]. Therefore, *Spirulina* solution was dispersed in milk at 0.2, 0.4, 0.6, and 0.8 per cent levels for yoghurt preparation before homogenization.

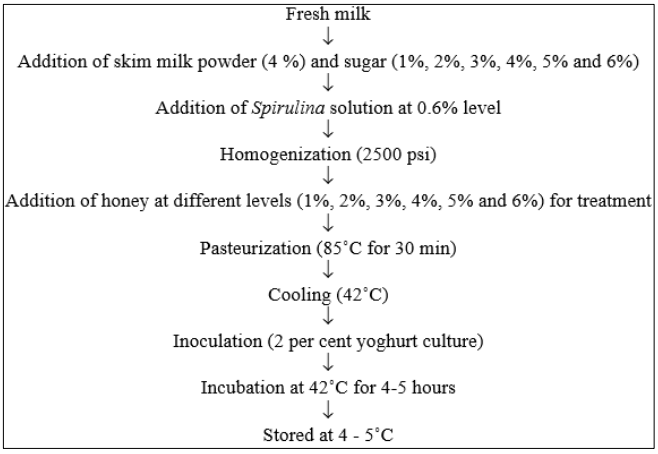
2.5 Flow diagram for preparation of *spirulina* enriched yoghurt



2.6 Preparation of *spirulina* enriched and Honey fortified yoghurt

Skim milk powder at the rate of 4 per cent, sugar at the rate of the desired percentage (0%, 1%, 2%, 3%, 4%, 5% and 6%) and *Spirulina* solution at the rate of 0.6% were added to the fresh milk and homogenized at 2500 psi. Honey was added at different levels (0%, 1%, 2%, 3%, 4%, 5% and 6%) for treatments T1 to T7 respectively. The contents were mixed well and pasteurized at 85˚C for 30 minutes and cooled to 42˚C. The yoghurt mix was inoculated with 2 per cent of yoghurt cultures containing *Lactobacillus delbrueckii* ssp. *bulgaricus*, and *Streptococcus salivarius* ssp. *thermophilus*. It was then mixed well and incubated at 42˚C for 4 to 5 hours and finally stored at 4-5 ˚C.

2.7 Flow diagram for preparation of *spirulina* enriched and Honey fortified yoghurt



2.8 Texture analysis of yoghurt

The rheological characteristics of yoghurt (Firmness, Consistency, Cohesiveness and Index of Viscosity) were analyzed by using the texture analyzer (model: TA HD plus, Stable Microsystems), connected to a computer programmed with the texture analysis software. Six measurements for each sample were recorded using a 5 mm diameter stainless steel probe attached to a 5 kg load cell. The penetration depth at the geometrical centre of the samples was 30 mm and the penetration speed was set at 1.0 mm/s. The firmness of the samples was determined as the peak compression force during penetration. The maximum negative force was taken as the indication of the cohesiveness of the sample, which gives an indication of consistency/resistance to flow off the disc during back extrusion. All determinations were carried out at 15 °C.

2.9 Organoleptic evaluation

Yoghurt samples were evaluated for appearance, flavour, body and texture and total sensory by a panel using a 9-point Hedonic scale (Dubey *et al.*, 2011) [5]. All the samples were appropriately coded before being subjected to sensory evaluation.

2.10 Statistical analysis

The data obtained in all the experiments were analyzed statistically by applying two-way ANOVA by approved statistical methods of SPSS (version 20.0).

3. Results and Discussion

3.1 Sensory evaluation of different inclusion levels of *Spirulina* in yoghurt

Sensory scores of different inclusion levels of *Spirulina* in yoghurt are shown in Table 1. The high mean (± SE) value for overall acceptability of the different levels of inclusion of *Spirulina* in yoghurt was observed at 0.6 per cent.

There was a highly significant ($P< 0.01$) difference between different levels of inclusion of *Spirulina* in yoghurt. Among the different levels of inclusion of *Spirulina* in yoghurt, 0.6 per cent inclusion level scored the highest overall acceptability scores. Hence, this inclusion level was fixed as standard for different treatments with different levels of cane sugar replacement with honey yoghurt.

The results are in accordance with the findings of Malik*etal*. (2013) [4], who reported that the various proportions of *Spirulina* like 0.2%, 0.4%, 0.6% and 0.8% were incorporated into yoghurt and 0.6% of *Spirulina* incorporated yoghurt was highly acceptable by a panel of judges.

Table 1: Standardization of *Spirulina* incorporated Yoghurt by Sensory evaluation using a 9-point hedonic scale

Treatments	Appearance and Colour	Body and Texture	Flavour	Overall acceptability
Control	$8.13^{a} \pm 0.04$	$7.90^{a} \pm 0.05$	$8.14^{ab} \pm 0.05$	$8.16^{a} \pm 0.07$
ST1 (0.2%)	$8.12^{a} \pm 0.00$	$8.23^{a} \pm 0.25$	$7.75^{ab} \pm 0.18$	$7.78^{ab} \pm 0.19$
ST2 (0.4%)	$8.28^{a} \pm 0.23$	$8.24^{a} \pm 0.19$	$8.24^{ab} \pm 0.25$	$7.79^{ab} \pm 0.21$
ST3 (0.6%)	$8.46^{a} \pm 0.25$	$8.17^{a} \pm 0.19$	$8.21^{a} \pm 0.25$	$8.27^{a} \pm 0.22$
ST4 (0.8%)	$8.21^{a} \pm 0.25$	$7.83^{a} \pm 0.22$	$7.28^{b} \pm 0.30$	$7.37^{b} \pm 0.25$

Different lowercase superscripts in a column differ significantly $p< 0.01$

3.2 Sensory evaluation of enriched *Spirulina* honey fortified yoghurt: The respective mean ±SE values of appearance and colour, body and texture, flavour and overall acceptability of *Spirulina* enriched and honey fortified yoghurt are given in Table 2. Statistical analysis showed that a significant ($P< 0.05$) difference was present between treatments with regard to all sensory parameters. The highest mean value for all sensory parameters was recorded for the treatment of T4 followed by T3 and T2. The results revealed that enrichment of *Spirulina* at 0.6% and fortification of honey at up to 3 per cent level by 50 per cent replacement of cane sugar in yoghurt scored highest in the sensory evaluation.

Table 2: Sensory evaluation of enriched *Spirulina* honey fortified yoghurt

Treatments	Appearance and Colour	Body and Texture	Flavour	Overall acceptability
Control	$8.45^{a} \pm 0.02$	$8.42^{a} \pm 0.03$	$8.40^{a} \pm 0.05$	$8.51^{a} \pm 0.06$
T1	$8.28^{b} \pm 0.09$	$8.21^{b} \pm 0.10$	$8.31^{b} \pm 0.16$	$8.25^{b} \pm 0.22$
T2	$8.15^{c} \pm 0.03$	$8.10^{c} \pm 0.05$	$8.19^{c} \pm 0.07$	$8.17^{c} \pm 0.09$
T3	$8.16^{c} \pm 0.01$	$8.16^{c} \pm 0.15$	$8.20^{c} \pm 0.17$	$8.20^{c} \pm 0.19$
T4	$8.30^{b} \pm 0.14$	$8.31^{b} \pm 0.18$	$8.29^{b} \pm 0.22$	$8.32^{b} \pm 0.33$
T5	$8.00^{d} \pm 0.03$	$8.04^{d} \pm 0.07$	$8.22^{c} \pm 0.06$	$8.12^{c} \pm 0.09$
T6	$8.04^{d} \pm 0.05$	$7.89^{d} \pm 0.06$	$8.11^{d} \pm 0.04$	$8.10^{d} \pm 0.05$
T7	$8.00^{d} \pm 0.01$	$7.78^{e} \pm 0.12$	$8.09^{d} \pm 0.11$	$8.09^{d} \pm 0.01$

Different lowercase superscripts in a column differ significantly

3.3 Texture analysis of *Spirulina* enrichedand honey fortified yoghurt

The mean (± S.E.) values of firmness, consistency, cohesiveness and index of viscosity of texture analysis of control and treatment yoghurt are presented in Table 3. Statistical analysis showed that a highly significant ($P< 0.01$) difference was present between treatments and control with regard to all textural properties. Regarding firmness, a highly significant ($P< 0.01$) difference was observed between treatments and control; this might be due to the addition of *Spirulina* into yoghurt.

Highly significant ($P< 0.01$) difference was observed with regards to consistency, cohesiveness and index of viscosity between control and other yoghurt treatments, which might be due to the combined effects of the addition of *Spirulina* and honey reduction in treatment yoghurt.

Table 3: Texture analysis of enriched *Spirulina* honey fortified yoghurt

Parameters / Treatments	Firmness (g)	Consistency (g. sec)	Cohesiveness (g)	Index of Viscosity (g. sec)
Control	$110.59^{b} \pm 2.64$	$3784.40^{b} \pm 167.58$	$681.12^{a} \pm 6.65$	$590.99^{a} \pm 3.60$
T1	$217.60^{a} \pm 16.69$	$5133.97^{a} \pm 41.09$	$541.39^{b} \pm 22.48$	$442.53^{b} \pm 7.46$
T2	$217.44^{a} \pm 16.63$	$5108.20^{a} \pm 46.41$	$531.69^{b} \pm 27.75$	$431.24^{b} \pm 7.46$
T3	$215.89^{a} \pm 16.31$	$5130.28^{a} \pm 109.66$	$522.31^{b} \pm 10.01$	$428.32^{b} \pm 7.46$
T4	$214.55^{a} \pm 17.21$	$5165.41^{a} \pm 64.22$	$533.69^{b} \pm 8.64$	$448.87^{b} \pm 7.46$
T5	$208.52^{a} \pm 17.26$	$5035.24^{a} \pm 117.35$	$520.58^{b} \pm 8.59$	$443.83^{b} \pm 7.46$
T6	$207.47^{a} \pm 17.16$	$5007.55^{a} \pm 117.39$	$537.41^{b} \pm 20.43$	$427.38^{b} \pm 7.46$
T7	$206.77^{a} \pm 17.16$	$5062.40^{a} \pm 28.52$	$516.16^{b} \pm 5.97$	$411.50^{b} \pm 7.46$

Different superscripts in a column differ significantly

4. Conclusion

Yoghurt has gained widespread consumer acceptance for its nutritional and sensory attributes nowadays primarily by women, children and teenagers. It is an excellent source of calcium, phosphorus and other nutritional properties, but as it is typical of all dairy products, contains very little protein. Therefore, dairy products are logical vehicles for protein fortification, because, they have high nutritive values, reach the target population and are widely consumed. However, protein fortification is difficult in food processing due to potential oxidized off-flavours, colour changes, and metallic flavours, probably because of lipid pro-oxidation of milk fat. Based on the above findings, it was concluded that the production of *Spirulina*-enriched honey fortified yoghurt with 0.6 per cent *Spirulina* and up to 50 per cent replacement of cane sugar with a 3% level of honey was found to be more beneficial with numerous therapeutic properties. Hence, the developed yoghurt will not only provide nutrients qualities but also possess the minimum required therapeutic levels of yoghurt probiotic cultures, which will definitely meet the demand of the health-conscious consumers at a reasonable cost.

5. References

1. Aryana KJ, McGrew P. Quality attributes of yoghurt with Lactobacillus casei and various prebiotics. LWT-Food Science and Technology. 2007;40(10):1808-1814.
2. Guldas M, Irkin R. Influence of *Spirulina platensis* powder on the microflora of yoghurt and acidophilus milk. Mljekarstvo. 2010;60(4):237-243.
3. Al-Khader AA. Impact of diabetes in renal diseases in Saudi Arabia. Nephrology Dialysis Transplantation. 2001;16(11):2132-2135.
4. Malik P, Kempanna C, Paul A. Quality characteristics of ice cream enriched with *Spirulina* powder. International Journal of Food and Nutrition Science. 2013:2(1):44-50.
5. Dubey RP, Kumari P. Preparation of low fat and high protein frozen yoghurt enriched with papaya pulp and Spirulina. 2011;4(2):182-184.