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SHORT COMMUNICATION

Technology optimization and characterization of dairy-based beverage with incorporation of natural sweeteners and resveratrol

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Abstract: Milk is considered as a healthy food and consumption of functional beverages helps to prevent nutrition-related deficiency in addition to taste and satisfaction. For preparation of dairy based beverage, low fat milk containing 1.5% fat and 9% SNF was used, and different natural sugars (jaggery, brown sugar and date syrup) was tried (8% w/v) along with resveratrol as functional ingredient in an emulsion form (1.5% w/v). The experimental samples were analyzed for proximate, physicochemical and sensory properties for their acceptability. Based on sensory and physicochemical analysis it was concluded that the milk added with jaggery, and resveratrol emulsion had highest sensory scores for consistency, flavour, sweetness and overall acceptability compared to other treatments except colour and appearance parameter. Beverage added with jaggery also had higher viscosity and antioxidant values compared to other treatments.

Keywords: Dairy-based beverage, Natural sweeteners, Physico-chemical properties, Resveratrol, Sensory properties

India ranks top position in milk production, increased from 146.3 million tonnes in 2014-15 to 230.6 million tonnes in 2022-23 (NDDB, 2024). The growing children and adults are getting enough nutrition from consumption of flavored milk. The period from 2011-2018, flavored milk market grew at a Compound Annual Growth Rate (CAGR) of 23.7%, predicted to reach a value of INR 109.7 billion by the end of 2024 (Anon, 2020). Nowadays consumers are having more awareness and giving importance to healthy lifestyle. Due to their lifestyle habits home food preparation has been reduced, trends towards purchase of ready-to-eat and ready-to-drink healthy foods as per the choices. Sweeteners help to increase the deliciousness and shelf life of food products. Sugar occupies an important role in Indian traditional milk and milk products but provides adverse effects to health which leads to excessive calories, increase body weight, leads to obesity, diabetes, hyperglycemia, hypertension, and dental carries. The diabetes cases are increasing day by day throughout the world (Mahato et al. 2020). Sugars naturally present in many plant foods are obtained through different processing to extract and condense the sugars such as date syrup, jaggery, sugar cane, coconut, brown sugars, sugar beets, corn, etc. The jaggery and brown sugar having cytoprotective and antioxidant activity encourage to use in food and dairy products (Nath et al. 2015). From the research findings, it was observed that high amount of added sugar in food and beverages leads to detrimental effect on food quality and also affect the health of the children and susceptible population (Bayram and Ozturkcan 2022)

Resveratrol is found in the skin of red grapes, peanuts & berries and plays an important role in food and pharmaceutical fields because of its health effects on human health. Its usage as a nutraceutical ingredient is restricted due to its poor water-solubility, chemical instability, and low bioavailability (Cardoso et al. 2019). Encapsulation is a process to entrap active agent resveratrol within a carrier material like whey protein concentrate /maltodextrin and useful tool to improve delivery of bioactive molecules into food. Encapsulated material must be food grade, biodegradable and able to form a barrier between the internal phase and its surroundings. Ultrasonic technology helps to create encapsulating particles and droplets with improved physical and functional properties. Many researches were undertaken in this area, but limited researches were carried out in ready to drink dairy based beverage with incorporation of selective natural sweetener like jaggery, brown sugar, date syrup and resveratrol emulsion in the formulation. By considering all these gaps in knowledge the present study was aimed with objective of technology optimization for development of dairy based beverage added with resveratrol and natural sweeteners. Further beverages were analyzed for physicochemical and sensory properties for their acceptability.

For the present study, mixed milk was collected from Experimental Dairy Plant of the College of Dairy & Food Science Technology,

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Guru Angad Dev Veterinary and Animal Sciences University. The milk was standardized to 1.5% fat and 9% solids not fat (SNF) by partially removing the fat by cream separator. Refined sugar, brown sugar, jaggery powder and date syrup were used as sweeteners and purchased from local market of Ludhiana. Milk protein-based wall materials like whey protein concentrate, soy lecithin, olive oil and maltodextrin were purchased from reputed brands for encapsulation of resveratrol component.

Low fat milk was used for preparation of beverages using method described by Hassan et al (2023) with slight modifications. The process for preparation of resveratrol emulsion for fortiûcation in dairy based beverage was optimized as per the protocol (Sivakumar et al. 2016 and 2018). The known quantity of olive oil as source of oil and soy lecithin acts as an emulsifier (5:1) was added at 40 ° C and mixed properly with blender. The wall material (Whey protein concentrate and Maltodextrin) (2:2) was added with required quantity of distilled water at warm temperature and the mixture was stirred until completely dissolved was used as aqueous medium. Addition Resveratrol (1%) at 40°C and then homogenization of all the ingredients were properly mixed at 2200 RPM for 15 minutes for primary emulsion preparation. After primary emulsion, it was further subjected to sonication (Sonics (USA) Vibra Cell TM Model: VCX 750 (750 watt)) at 40 Amplitude for 10 minutes to form a stable emulsion and kept in the refrigerator at 4 °C till usage. The sweeteners and resveratrol emulsion were added after preheating of milk to 35-40°C. Beverages were prepared with different types of sweeteners such as brown sugar (A), Jaggery (B), Date syrup (C) and Sucrose (D) (@ 8% w/v) along with resveratrol emulsion (@ 1.5% each beverage sample). Then it was pasteurized to 72 °C for 15 sec and cooled to 4°C. The beverages were packed and stored in refrigerator until for further analysis.

The organoleptic quality of milk beverage samples was evaluated by trained panelists of the department. The milk beverage samples (20-30 ml) were served at 5°C and analyzed for sensory parameters like colour and appearance, flavour, consistency and sweetness and overall acceptability using 9-point hedonic scale.

Table 1: Chemical composition of low-fat milk

Parameters	Values
Fat %	1.5
SNF %	9.0
Protein%	3.25
Carbohydrate%	5.12
Ash%	0.53
TS%	10.5
Acidity%	0.13
pH	6.7
Viscosity (cp)	0.8
Calorific value (kcal)	47.36

Average value (n=6)

Fat content of low-fat milk and experimental beverage samples was estimated using the Gerber method, Protein content, Ash, total solids and titratable acidity of low-fat milk and beverages were determined by titration method (AOAC, 2019). pH value of milk and beverage samples was determined by using digital pH meter. The viscosity (cP) of samples was measured at 15±1°C by a rotational viscometer (Model LV DV2T, Brookfield Engineering, Inc., USA) equipped with spindle model LV (04).The Antioxidant activity method prescribed by (Moulick et al. 2023) with slight modification was adopted for estimation of free radical scavenging activity for milk beverage by DPPH method.

Statistical Software Package IBM SPSS version 26 was used to compare the results using one-way ANOVA and significant differences between mean values was evaluated by Post Hoc Tukey's test. The significance level (P) was set at 5%. The data was presented as mean ± standard deviation in Microsoft excel (n=6). The average proximate composition and chemical properties of low fat milk was represented in the Table 1.

The statistical data revealed that there was significant ($p<0.05$) variation in the colour and appearance score due to addition of resveratrol nano-emulsion along with natural sweeteners (Table 2). Addition of jaggery significantly affected the colour and appearance of milk beverage compared to other treatments which may be due to deep intense colour of jaggery which was less preferred by the judges. However, no significant difference was observed between brown sugar and date syrup added sample for colour and appearance score. Highest score was observed in beverage containing sucrose as sweetener.

The variation in the score for consistency due to different treatments was found to be significant ($p<0.05$) between samples. The consistency scores of milk beverage with brown sugar, jaggery, date syrup and sugar with resveratrol was 7.42, 7.82, 7.50 and 7.51, respectively. This indicates that addition of resveratrol emulsion was not greatly influenced the consistency score. The highest acceptability score ($P<0.05$) for consistency was found in Jaggery added sample while lowest in brown sugar added sample.

The significant ($p<0.05$) variation in the score for sweetness was observed in treated samples which might be due to the difference in the sweetness ratio. From the results, it was found that milk beverage containing date syrup and resveratrol emulsion had lowest score while jaggery had highest sweetness score compared to beverage sweetened with sucrose.

The results indicate flavor scores for milk beverage with brown sugar, jaggery, date syrup and sugar with resveratrol emulsion was 7.65, 7.81, 7.72 and 7.43, respectively indicating that flavour scores of all the samples in acceptable range but significantly ($p<0.05$) different from each other. The highest flavour score was found in beverage added with jaggery and did not differ

significantly with flavor score of date syrup added sample while lowest score was in beverage sweetened with sucrose.

The scores for overall acceptability of milk beverage containing brown sugar, jaggery, date syrup and sugar with resveratrol emulsion was 7.54, 7.78, 7.66 and 7.43 respectively. From the Table 2, it is indicated that the highest overall acceptability score was recorded in milk beverage with jaggery followed by date syrup, brown sugar, and sugar. Thus, for the production of the most acceptable quality functional beverage, a suitable level of natural sweetener was 8% jaggery and 1.5% (w/v) resveratrol emulsion. The similar results were reported by Gartaula & Bhattarai, (2014) and Ubale et al. (2014) in different milk products prepared by adding date palm, brown sugar and jaggery with acceptable sensory qualities.

Table 3 represents the physicochemical and antioxidant properties of milk beverages. The mean fat per cent of milk beverage containing brown sugar, jaggery, date syrup and sugar along with resveratrol emulsion was 1.55. There is slight increase in the fat content from 1.5% to 1.55% because of inclusion of oil/fat from resveratrol emulsion. However, significant difference was not observed between the treatments. The protein content for milk beverage with brown sugar, jaggery, date syrup and sugar along with resveratrol emulsion was 2.95%, 2.98%, 3.42% and 2.95%. The highest protein content was observed in beverage added with date syrup while no significant difference was observed in other treatments. Differences between the protein content of milk beverage was influenced by different types of natural sweeteners. The carbohydrate content was lowest in beverage containing date syrup while highest in beverage containing brown sugar. The ash content for milk beverage with brown sugar, jaggery, date syrup and sugar along with resveratrol emulsion was 0.55, 0.57, 0.557 and 0.51%, respectively found to be significant ($p<0.05$) between the samples. The total solid content for milk beverage with brown sugar, jaggery, date syrup and sugar along with resveratrol emulsion was 16.79%, 16.35%, 14.70% and 16.63% respectively. Beverage containing date syrup had lower solids compared to all other treatments which might be due to lesser solids in date syrup. The titratable acidity (expressed as % lactic acid) of milk beverage with brown sugar, jaggery, date syrup and sugar along with resveratrol

Table 2: Effect of addition of sweeteners and resveratrol on sensory evaluation of milk beverage

Sensory attributes	Samples			
	A(Brown Sugar)	B(Jaggery)	C (Date Syrup)	D(Sugar)
Colour & appearance	7.42±0.092^{b}	7.403±0.092^{c}	7.673±0.092^{b}	7.714±0.092^{a}
Consistency	7.423±0.077^{ab}	7.823±0.077^{a}	7.503±0.077^{b}	7.513±0.077^{ab}
Sweetness	7.625±0.09^{ab}	7.794±0.09^{a}	7.564±0.09^{c}	7.652±0.09^{ab}
Flavor	7.653±0.09^{b}	7.812±0.09^{a}	7.722±0.09^{a}	7.435±0.09^{c}
Overall acceptability	7.543±0.08^{b}	7.785±0.08^{a}	7.663±0.08^{a}	7.431±0.08^{c}

Table representing the values (Mean± S.D.)
$^{a-c}$ Superscripts in each row represent significant difference between the samples ($p<0.05$)

Table 3: Effect of addition of sweeteners and resveratrol on physicochemical composition of milk beverage

	Samples			
Parameters	A (Brown Sugar)	B (Jaggery)	C (Date Syrup)	D (Sugar)
Fat%	1.550±0.005^{a}	1.552±0.004^{a}	1.553±0.003^{a}	1.551±0.003^{a}
Protein %	2.951±0.002^{b}	2.983±0.02^{a}	3.422±0.002^{a}	2.953±0.003^{b}
Carbohydrate%	11.743±0.00^{a}	11.252±0.002^{c}	9.222±0.002^{d}	11.623±0.003^{b}
Ash%	0.550±0.002^{b}	0.570±0.002^{a}	0.557±0.001^{b}	0.510±0.003^{d}
Titratable acidity (%LA)	0.141±0.001^{c}	0.170±0.001^{a}	0.160±0.001^{b}	0.131±0.001^{d}
Total solids%	16.792±0.007^{a}	16.351±0.006^{c}	14.704±0.010^{d}	16.631±0.006^{b}
pH	6.710±0.012^{a}	6.502±0.006^{b}	6.552±0.009^{b}	6.753±0.007^{a}
Viscosity (cP)	0.880±0.00^{b}	0.904±0.004^{a}	0.860±0.001^{c}	0.890±0.001^{b}
Caloric value (Kcal)	72.710±0.05^{a}	70.870±0.035^{c}	64.310±0.023^{d}	72.233±0.043^{b}
Antioxidant activity%	37.433±0.082^{c}	44.732±0.082^{a}	42.612±0.045^{b}	33.120±0.054^{d}

Table representing the values (Mean± S.D.)
$^{a-d}$Superscripts in each row represent significant difference between the samples ($p<0.05$)

emulsion was 0.14%, 0.17%, 0.16% and 0.13%, respectively and differed significantly. Highest acidity was found in jaggery added beverage due to the presence of acidic substances while lowest acidity in beverage containing sucrose. The results were correlated with the findings of Ubale et al. (2014) who prepared milk shake with jaggery as sweetning agent shown acidity in the range of 0.16-0.18%.

Variation in the values for pH due to different treatments was found to be significant($p<0.05$). The pH of milk beverage with brown sugar, jaggery, date syrup and sugar was 6.71, 6.5, 6.55 and 6.75 respectively. The viscosity value for milk beverage with brown sugar, jaggery, date syrup and sugar along with resveratrol emulsion was 0.88, 0.90, 0.86 and 0.89 centipoise, respectively. Lowest viscosity was observed in beverage added with date syrup due to lower solids content in the beverage than other samples. Temperature, total solids concentration, protein content, and preheat treatment all have an impact on the viscosity of milk concentrates (Agarwal et al. 2015). The caloric value differed significantly ($p<0.05$) for different treatments. The caloric value for milk beverage with brown sugar, jaggery, date syrup and sugar along with resveratrol emulsion was 72.71, 70.87, 64.31 and 72.23 kcal, respectively. Lowest caloric value was observed in beverage containing date syrup which is obvious that this beverage contains lesser nutrients or lesser solids than other treatments. Variation in the values for antioxidant activity due to different treatments found to differ significantly ($p<0.05$) between the samples. The antioxidant activity for milk beverage with brown sugar, jaggery, date syrup and sugar along with resveratrol emulsion was 37.43, 44.73, 42.61 and 33.12%, respectively. Highest antioxidant activity was observed in jaggery added beverage while lowest in sugar added beverage. Date syrup and jaggery based beverage has highest antioxidant activity than others which is due to the presence of phenolic compounds present in the natural sweeteners (Sohaimy et al. 2015). Milk also contain both lipophilic and hydrophilic antioxidants (Gra¿yna et al. 2017).

Conclusion

Based on sensory and physicochemical analysis it was concluded that the milk added with jaggery (8% w/v) and resveratrol emulsion (1.5% w/v) had highest scores for consistency, flavour, sweetness and overall acceptability compared to other treatments except colour and appearance parameter. Beverage added with jaggery also had higher viscosity and antioxidant values compared to other treatments.

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