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A comparative study on assessment of physiochemical properties of blended plant based yoghurt alongside commercial dairy yoghurt

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ABSTRACT

Globally people in the years ahead will replace dairy products and adopt milk extracted from plant sources. Adaptation of these plants based milk products, the vegan products has become necessary either for lifestyle improvement or due to some prevailing health conditions. The blended vegan yoghurt was prepared and commercial dairy yoghurt was purchased and the physiochemical properties were assessed. The pH value (4.38) of the developed yoghurt was found similar to that of dairy yoghurt. The total titrable acidity for developed yoghurt (0.78ml NaOH/g) was found to be higher in comparison with others. The plant milk yoghurt differ in several parameters from the usual yoghurt but some important textural attributes for yogurts, such as apparent viscosity and water holding ability, were similar between the dairy and formulated plant-based yogurt.The blended vegan yoghurt developed was found to be nutritionally similar to the dairy yoghurt but there was a slight difference in colour, firmness and water holding capacity. The blended yoghurt had less water holding capacity and in colour it appears to be off white due to the presence of soy milk and barley. This yoghurt can be the best alternative to people suffering from lactose intolerance as it could be a rich source of dietary fibres and proteins.

Keywords : Firmness, apparent viscosity, lactose intolerance.

Rising global food demand will lead to a significant increase in total food production by 2050 [FAO, U., 2009.] due to the global population's expected growth of over one billion people over the next 13 years , reaching 9.8 billion by 2050 [Fent, T., 2008]. In high-income countries, in particular meat, poultry, milk and dairy products, the daily intake of protein has risen from 39 to 52 g per capita between 1961 and 2011 over the last 50 years. The Organization for Food and Agriculture forecasts daily protein intakes of 54 and 57 g per person for 2030 and 2050, respectively [Miller, G.D., et.la.2020]. In addition, the form of food demanded by the customer has changed, is still changing, and will continue to change in the coming years due to the higher living standards in developing countries and urbanization, ultimately leading to an rise in animal feed production if current trends continue uninterrupted [Boland, M.J., et.al.2013,Westhoek, H.J., *et.al.*, 2011]. At the other hand, increased consumer understanding of the environmental and health impacts of food processing and consumption is leading to a decline in demand for food products derived from animals in developing countries [Henchion, M., et.al.,2017]. The attention of many food producers and researchers is therefore on addressing current customer demands and environmental issues through the production of safe and sustainable alternative food products [Guo, J. and Yang, X.Q., 2015.]. The major challenges faced by plant-based yogurt producers are related to appearance and texture properties, as these products usually have textural problems caused by phase separation. Once these plant-based systems are acidified, destabilization of the proteins results in the formation of a non-continuous, poor gel resulting in a serum separation [Banerjee, S. and Bhattacharya, S., 2012.]. For this purpose, hydrocolloids are typically used in plant-based yogurt formulation in order to stabilize the suspended particles, contribute to the creation of structures and assist in imitating the characteristics of a dairy-based yogurt [Silva, J.V. and O'Mahony, J.A., 2018.]. In the food industry, combinations of gelling agents (e.g., natural gums, proteins, starches, pectin, and agar) are also used to provide suitable texture for gel-type food items (e.g. yogurts and puddings)[Pliner, P. and Hobden, K., 1992.]. The aim of this study was to determine the physicochemical and rheological properties of blended plant-based yogurts to gain an understanding of how key quality attributes may be affected by the different formulations. Therefore, a

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dairy-based yogurt was used as a benchmark with a view to understanding which plant-based formulation provided the most similar properties to the benchmark. This research will provide much-needed information on the formulation of plant-based yogurts and the impact on texture and mouth feel of different ingredients (i.e., plant-based substrates and hydrocolloid selection), helping with the production of plant-based yogurt systems of the next decade.

MATERIALS AND METHODS

Yoghurt Products

In this analysis, plant-based yoghurts were evaluated as a benchmark alongside a dairy yogurt. The yoghurts based on the plants were made of soy, coconut and barley. The raw materials for the yoghurt were bought from the local market of Lucknow. In Table 1 and Table 2, respectively, the nutritional composition and details of the ingredients used in the product formulations are given. All samples were reported to be fermented yoghurts, and were plain (i.e. not flavoured) form.

Table 1 Nutritional composition of plant-based milk

	Soy	barley	Coconut
Energy	211/50 kJ/kcal	311/79 kJ/kcal	287/70 kJ/kcal
Fat	1.20 g	3.90 g	4.20 g
Saturated fat	0.20 g	3.90 g	4.20 g
Carbohydrate	2.30 g	7.30 g	8.30 g
sugar	2.20g	3.20g	4.20g
Fibre	1.5g	0..5g	0.30g
Protein	3g	0.4g	0.70g
Salt	1.9 g	0.4 g	0.80 g

Table 2 List of ingredients used in the formulation of yogurts.

Soy milk	Water, soya beans (7.9%), sugar, calcium (tri-calcium citrate), stabiliser (pectin), acidity regulators (sodium citrate, citric acid), sea salt, antioxidants (tocopherol-rich extract, ascorbyl palmitate), yogurt cultures *(S. thermophilus, L. bulgaricus).*
Coconut milk	water, coconut (20%), modified maize starch, dextrose, salt, thickener (pectin), colour (carotene), calcium phosphate, vitamin D2, vitamin B12, natural flavouring, non-dairy yogurt culture *(S. thermophilus, L. bulgaricus)*
Barley milk	Barley mash (97%) (filtered water), yogurt culture *(S. thermophilus, L. bulgaricus)*

pH and Lactic Acid Content

The pH of the industrial yogurts was calculated at 20 °C using a pH meter. An enzymatic reagent kit was used to evaluate D- and L-Lactic acids.

Total Titratable Acidity

Titrable acidity was measured by utilizing 0.11 N NaOH solution neutralizing the acid contained in 10 g of the commercial yoghurt samples. The titration was done using 10 drops of phenolphthalein as predictor until it hit a pink endpoint. To get titrable acidity, the amount of NaOH used to neutralize the solutions was divided by 10.

Colour

The colour of that specimen was taken using a CR-400 Chroma meter (using the CIELAB (L *, a *, b *) coordinates. Before even the test the Chroma meter was adjusted by using white tile. In the CIELAB colour space system, the L * value corresponds to the brightness and the results will differ from 0 (black) to 100 (white), a * calculate the level of redness (positive values) or greenness (negative values), and b * influence the extent of yellowness (positive values) or blueness (negative values).

Water Holding Capacity

For the study of water holding capacity the method mentioned by Silva and O'Mahony [O'Neil, J.M., et.al. 1979] was followed. In short, 20 g of commercial yogurt was placed in 50 mL tubes (Thermo Fisher Scientific, Waltham , MA , USA) and centrifuged for 20 minutes at 4 ° C at 640 g in a Sorvall RC 5C Plus centrifuge equipped with a Sorvall SS-34 rotor (Du Pont Instruments, Wilmington, DE, USA), after which the supernatant was collected and weighed. Water holding capacity (WHC) has been determined as per Equation (1)

Rheological Analysis

The textural properties of commercial yogurts were calculated using the Silva and O'Mahony back extrusion method[O'Neil, J.M., et.al.,1979]. The test was carried out using a Texture Analyser TAXT2i (Stable Micro Systems Ltd., Godalming, Surrey, UK), fitted with a 25 kg load cell and an extrusion disk (Ø = 35 mm), running at a fixed test speed of 1.0 mm s^{-1}, to a depth of 25 mm. Samples (100 g) were weighed and stored in 150 mL beakers at 4 ° C overnight to allow the samples to balance out.

RESULTS AND DISCUSSION

Chemical Composition of yoghurt blended with milk of soy,coconut and barely milk.

Table 3 Nutritional composition of blended yoghurt

Parameters	Unit	Concentration
Energy	kJ/kcal	287
Fat	g	4.20
Saturated fat	g	6.20
Carbohydrate	g	9.30
sugar	g	4.20
Fibre	g	0.30
Protein	g	0.90
Salt	g	0.80

Total Titratable Acidity, pH and Lactic Acid

The pH values of all examined yoghurt was 4.38 (Table 4). Such pH data can be clarified by the ingredients used in yoghurts, such as acidity regulators (e.g. citric acid and sodium citrate) that produce a pH that is desirable or necessary to some food processes, such as yogurt production [Chandan, R.C., 2017]. The total titrable acidity (TTA) value for the blended yoghurt (0.78mL NaOH / g) was found to be higher, in accordance with the values stated by Laye et al.[Grasso, N., et.al.,2020]. A similar pattern was observed for the L-lactic acid content, with the highest value of yogurt (1.42 g/100 g), suggesting that the bacterial fermentation achieved was more successful with a lactose substrate than with the carbohydrate substrates in plant-based yoghurts. The form of lactic acid isomer formed (D- or L-) during yogurt fermentation is species-specific[Laye, I., et.al.1993], therefore the plants utilized for yogurt production were L-lactic acid producers as L-lactic acid concentrations were significantly higher than those used for D-lactic acid for all samples.

Table 4 Table illustrating values for Titrable acidity, lactic acid content and pH

TTA (mL NaOH/g)	0.78 ± 0.01
pH (-)	4.38 ± 0.00
D-LacticAcid g/100 g	0.00 ± 0.00
L-LacticAcid g/100 g	1.42 ± 0.01

Colour

Colour is an important factor for customer acceptance of food items, and the results of the CIELAB device colour (L *, a *, b *) for the samples are shown in Table 5. The dairy commodity had the highest L * prices, and the lowest a *. The brightness of yogurts is related to the particle size of both fat globules and proteins, which affect their light reflectance and dispersion ability; the size of these molecules is strongly affected by the choice of unit operations and processing parameters used (e.g., homogenization) [Kandler, O., 1983,16].

Table 5 Colour space values of yoghurts

L*	64.2 ± 0.03
a*	?2.83 ± 0.01
b*	9.69 ± 0.01

Uniaxial Compression Testing

Reports from uniaxial compression testing (Table 6) revealed blended yoghurt had higher strength, consistency, cohesiveness, and viscosity index. Such textural properties can be related to the presence in the product formulation of the agar and the rice starch ingredients. Agar is commonly used in the food industry for its ability to shape strong gels at low concentrations and is also readily incorporated in food formulations because it does not allow cations to gel, meaning that any differences in the cations concentrations contributed by the other components used in the formulation do not affect the agar gel performance [Tamime, A.Y. and Robinson, R.K., 1999.].

Table 6 Uniaxial Compression Test

Firmness (N)	0.46 ± 0.03
Consistency (N·s)	9.98 ± 0.97
Cohesiveness (N)	0.28 ± 0.02
Index of Viscosity (N·s)	5.63 ± 0.74
WHC (%	96.3 ± 1.40

CONCLUSION

The plant-based blended yoghurt was analysed for specified chemical, rheological, properties. The results revealed that chosen yogurts based on plants had similar characteristics to the milk product. For example, the uniaxial compression testing showed that the soy, coconut, and barely blended yogurt was roughly comparable with the dairy product, attributing this to the use of hydrocolloids in plant-based yoghurts. Furthermore, certain important textural attributes for yogurts, such as apparent viscosity and water holding ability, were similar between the dairy and selected plant-based yoghurts. The outcomes acquired in this research enabled key quality attributes of plant-based yogurts to be identified and highlighted important interrelationships between such attributes and formulation that can be exploited in future product development. These physiological and rheological analysis tests performed clearly states that the plant based can be the better source of nutrition globally in near future.

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