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Innovative formulation of rice cake for celiac people and its characterization

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ABSTRACT

A segment of the world population suffers from celiac disease. The only effective treatment for celiac disease is gluten free diet throughout the patient's lifetime. Among these rice cake is now very popular. In this study, characterization of physical, antioxidant & sensory property are investigated in rice cake. An innovative formulation is done in rice cake by using milk, wheat grass & coconut milk. It has been found that rice cake prepared using coconut milk has high antioxidant activity and good sensory properties.

KEYWORDS

Rice cake;
Rheology;
Antioxidant;
Wheat grass;
Coconut milk.

INTRODUCTION

Rice is one of the leading food crops in South East Asia including China, and the production of rice in this part of the world is much higher than that of wheat. It can be ground into powder and utilized to produce many kinds of foods, including several types of cakes[1]. Rice cake is one of that types which is shaped & condensed. A wide variety of rice cakes exist in many different cultures in which rice is eaten, and are particularly prevalent in Asia. They are perhaps best known in Japan and the countries of the Pacific region where rice is an economic staple food and the grain is the basis for many meals and foods. The cakes are usually two to three inches in diameter and are made by steaming a batter, which is fermented overnight. People with celiac disease are unable to consume certain gluten proteins from cereals – such as wheat, rye, barley, kamut– and hybrids like triticale. The most common cereal flours used for gluten free bread production are rice. The only effective treatment for celiac disease is a strict adherence to a gluten free diet throughout the patient's lifetime, which, in time, results in clinical and mucosal recovery[2]. Rice flour is one of the most suitable cereal flour for gluten-free products because it has a low level of prolamin. Besides, rice possesses unique nutritional, hypoallergenic, colorless, and bland taste properties[3]. There are many nutritional impacts of rice cake. When people start looking for ways to cut calories, their one of the preferred food is rice cakes. It is one food which is usually eaten by weight loss strugglers, especially those who are dieting. A re-design of the gluten-free bakery goods is needed for obtaining gluten-free baked products with similar nutritional composition to that of their gluten counterparts. Those products would allow celiac patients and/or population with other allergic reactions and intolerances caused by proteins or another component of cereals to meet dietary guidelines without changing their dietary pattern. Research on gluten-free cakes has focused on the effect of wheat flour replacement by rice flour in traditional recipes, as steamed leavened rice cakes[4]. Rice cakes became even more

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popular as treats for festivals and as local specialties. Rice cakes were commonly sold by roadside vendors, a tradition which continues in most of Asia where street vendors sell cakes made of rice and a range of vegetables, sea food.

Coconut milk is one of the popular cooking ingredients in Thailand. Among the popular Thai food dishes using coconut milk are curries and dessert. The importance of coconut milk industries has prompted food scientists and food engineers in this country to develop new products from coconut milk for use as ingredients in household recipes both for the market and for export[5]. It has 27 calorie energy, 1.6 gm protein, 0.4 gm fat, 4.5gm carbohydrate, 26 mg calcium, 36 mg phosphorus and other nutrient also per 100 ml of coconut milk[6]. Coconut milk has anticardio, antiatherosclerotic, anticholecystitic, immunostimulatory, anti-viral, anticancer effect[7]. It is required to supplement food materials with nutritionally rich items for e.g. fruits like citrus, banana and grapes, sprouts and herbs like wheatgrass. They contain antioxidants in addition to the compounds of nutrient elements[8]. Tender wheatgrass and its juice are consumed for healthy growth of human body. Wheatgrass was also reported to be helpful in curing certain diseases such as thalassemia[9] and distal ulcerative colitis[10]. A large proportion of the world cereals production is processed by fermentation prior to consumption. The enhancement of attractive flavour and texture, and the improved shelf-life and digestibility as a result of fermentation are important reasons for this[11]. Therefore the aim of this study was to determine the physical, antioxidant and sensory properties of rice cake enriched with plant polyphenols.

MATERIALS AND METHODS

Raw materials

Rice flour (Vitarich agro food Ltd, India), sugar (Sakthi Sugar, India), salt (Tata Salt, India), milk (Mother dairy, India), coconut milk (Nestlé, India) and vanilla flavor were purchased from the local grocery stores at Jadavpur, Kolkata, India. Compressed baker's yeast (Saf Yeast Company Pvt., Ltd.,Mumbai, India). The seeds of wheat (*Triticum aestivum* L.) were authenticated by the Taxonomists of the Botanical Survey of India, Kolkata [Ref. CNH/1-1/10/2010/ Tech II/ 176]. The wheat grass was freeze dried reported previously[12]. Freeze dried wheat grass were used for fermentation of rice cake.

Chemicals

Ethanol (Jiangsu Huaxi International Trade Co. Ltd, China), Folin-Ciocalteau reagent, Sodium bi carbonate (Merck Specialties Pvt. Ltd, Mumbai, India), DPPH (Sigma-Aldrich, St. Louis, MO, USA), Sodium Nitrite ($NaNO_2$), Aluminium chloride ($AlCl_3$) (LOBA Chemie), Sodium hydroxide (NaOH) (HI Media, Mumbai), Phenolphthalein (RFCL Limited, New Delhi, India).

Processing

The rice cake recipe consisted of rice flour 20%, sugar 20%, salt 3.5%, compressed baker's yeast 3%, wheat grass 1 % and water 50%. Yeast was dissolved in warm water (10 ml at 37° C) and kept for 15 min for activation of the yeast cells. 1 gm of flour and sugar were used as feed for yeast. Mixing is an important step for achieving homogenous and soft dough. Here, mixing was carried out manually according to the straight dough method. The dry ingredients, and the activated yeast, were taken in a beaker; requisite amount of water was added and then kneaded for approximately 10min until the dough was elastic and of required consistency. Then the beaker was covered with a cotton cloth and put in the incubator for 24 hours for 37ºC. The next day vanilla flavor, freeze dried wheat grass were weighed and added to the beaker and mixed into the batter uniformly. After that the batter was poured into mould and steamed for 15-20 minutes. Then the rice cake was prepared & ready to serve. Three different types of rice cake were prepared. In the other two types, instead of water, cow milk and coconut milk were used respectively. Rice cake prepared with water is named as A, prepared with milk is named as B, prepared with coconut milk is named as C.

Evaluation of the rice cake batter

For percent increase in volume, the batter was placed in a measuring cylinder. The initial and final batter volume before and after incubation was noted and the % increase in volume is calculated as:-

{(Final volume-initial volume)/initial volume}×100 [13].

Acidity & pH

1gm batter was dissolved in 10ml distilled water. Then the sample was titrated by 0.1 (N) NaOH using phenolopthalin indicators (1-2 drop) till the end point. Acidity can be calculated as-

Total acidity (%) = (vol in ml of NaOH ×0.1(N) ×0.090×100)/ sample weight.

pH was measured by using pH meter (Thermo Orion Basic pH Meter, Model 420A pH/mV/ORP/temperature meter) for different types of batter as given by Balasubramanian et. al 2006[14].

Antioxidant activity

Extraction of samples

Extracts were prepared for the determination of total phenols and antioxidant activity by weighing 1g sample and mixed with 20 ml of 80% methanol. Then the mixture was sonicated by sonicator (TRANS-O-SONIC/ D150-IM, Mumbai) to agitate the particle in sample. Then it was centrifuged (Hanil, Supra 22K, Koria) at 10000 rpm for 10 min at 4^0C. The extracts were transferred into culture tubes, & kept in the refrigerator until analysis[15].

Total phenolic content

The total phenolic content was determined according to the Folin Ciocalteu method[16]. The results were expressed both as mg of gallic acid equivalents (GAE) per 100 gram of sample.

Total flavonoid content

The total flavonoid content of samples was determined with slight modifications of Xu and Chang 2007[17]. Total flavonoid contents were expressed as milligrams of catechin equivalents (CAE) per 100 gram of defatted sample.

Radical DPPH scavenging capacity

The free radical scavenging capacity of sample extracts was determined using the TABLE 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH). The antioxidant reaction was initiated by transferring 0.1 ml of sample into a test tube containing 3.9 ml of reagent 100% ethyl alcohol in ice cold condition. The reaction was monitored by reading absorbance at 517 nm[18].

Rheology

Rheological analysis was performed using a controlled stress rheometer (Anton Paar, Physica MCR 51, India) with parallel plate geometry (60 mm diameter). The batter was placed between parallel plates, the gap adjusted to 1 mm and the excess batter removed. To prevent drying at the edges, a thin layer of oil was applied to cover the exposed batter surfaces. Tests were performed at 20^0 C. Oscillatory tests, with a frequency sweep from 0.1 to 10 Hz were conducted with a different aliquot of the samples. 5% stress is applied here. The dynamic rheological properties of samples were assessed by the storage modulus G' (elastic modulus), the loss modulus G" (viscous modulus).

Microbial assay

All varieties of rice cake batter prepared were plated to determine lactic acid bacteria, total plate count and yeast and molds. The microbial load at 20 h fermentation was measured by suspending the respective batter in 0.5% sterile saline and plating it out at appropriate dilutions. For lactic acid bacteria, de Man, Rogos and Sharpe (MRS) media; for yeast and molds, potato dextrose agar (PDA); and for Mesophilic aerobes, plate count agar (PCA) media were used. The techniques employed were spread plate and pour plate method. Counts of the colonies were made after incubation for 24 h for PDA at 30^0C and PCA and MRS at 37^0 C[19].

Texture

Rice cake has a circular shape of approximately 7–10 cm diameter (depending on the mold size), flat with upper surface bulging, so that the product is thick at the center (2–2.1 cm). Texture of the rice cake was analyzed by instron (Instron Ltd., High Wycombe, Bucks, UK). The double compression test was done in the centre of the rice cake where the average thickness was 2–3 cm using probe in the normal mode at 10 mm/ s up to a depth of 10 mm.

Sensory analysis

Rice cake samples were coded and presented to 30 panel members for sensory scoring. The panel members, who were familiar with sensory analysis techniques, were postgraduate students and research scholars of the Department of Food Technology and Bio-chemical Engineering (Jadavpur University, India). Three sets of blend ratio samples were analyzed on separate occa-

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sions. Water was used for mouth rinsing before and after each sample testing. Each set contained one control (with water) and the other two samples prepared with cow milk and coconut milk. Samples were scored for appearance, taste, color, texture, aroma and overall acceptability according to numerical scoring system. The model used in this analysis was an acceptance test on the hedonic scale, with values ranging from "1" (extremely disliked) to "9" (extremely liked). The sensory analysis data were subjected to statistical analysis. Mean and standard deviation were individually calculated for scores obtained for all quality attributes of each product.

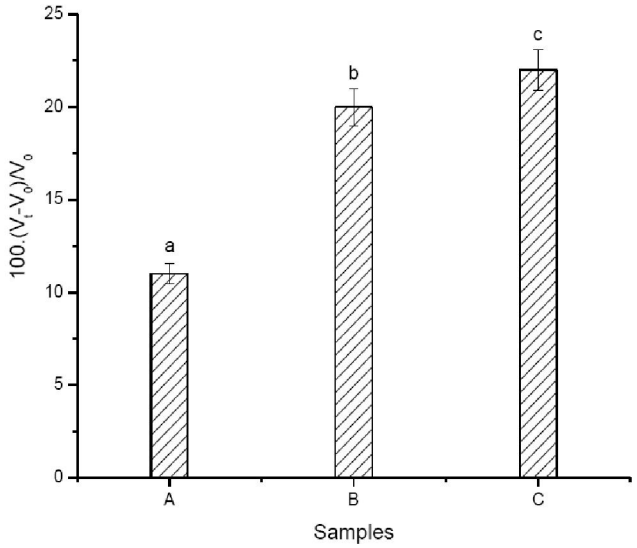
Statistical analysis

All the studies were replicated 3 times and the means were reported. All the experimental data were analyzed statistically for analysis of variance (ANOVA) with Microsoft Excel 2007. Means were compared by Fisher's least significant difference test at a significance level of pd™0.05.

RESULTS & DISCUSSION

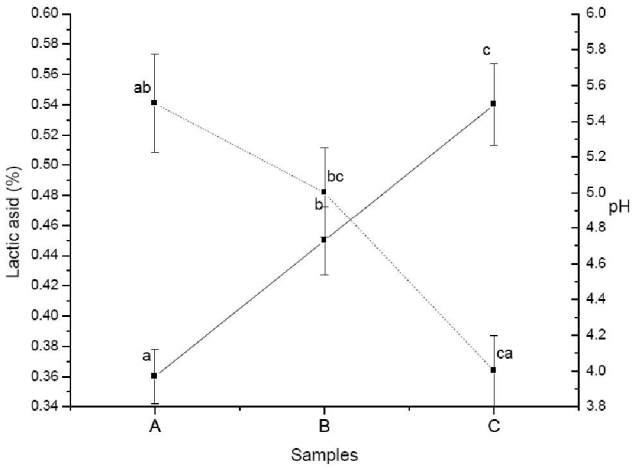
Batter volume

Yeast is used as a leavening agent. From figure 1. it is seen that percent increase in volume of rice cake by water (A) is 11% whereas percent increase in rice cake by cow milk (B) is 20% & in coconut milk (C) it is 22%. In water yeast cannot get its sufficient food, where as in cow milk & coconut milk yeast can get sufficient food for growth. 100 ml coconut milk has 6gm protein, 0.4 gm fat, 4.5gm carbohydrate, 26 mg calcium, 36mg phosphorus and also other nutrients[6]. Thus leavening is optimum & volume is increased. Volume expansion of yeast-leavened rice cakes (YLRC) correlates positively to the amylose content of the batter. Amylose probably slowed the viscosity increase during cooking and delayed the time of setting of the batter, thus helping in the retention of the expanding gas bubble before the batter becomes a cake. Mohamed and Hamid in 1995[20] reported that the increase in batter volume correlates well with the increased sensory evaluation score for firmness, taste, elasticity, texture and overall acceptability of the rice cakes and may indicate the optimum degree of amylase/ amylopectin balance for this product.



The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'

Figure 1 : Effect of different types of rice cake on batter volume (%) at p≤0.05



The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'

Figure 2 : Variation in pH and lactic acid in different types of rice cake at p≤0.05

pH & acidity

pH is the negative logarithm of hydrogen ion. pH is inversely proportional to acidity i.e when pH is increased then acidity is decreased. It is seen in figure 2. that pH of rice cake by water (A) is 4, whereas rice cake by cow milk (B) pH is 4.9, & by coconut milk (C) it is 5.5. Percentage of acidity in rice cake by water is (A) 0.36, whereas in rice cake by cow milk (B) the acidity is 0.47, & in coconut milk (C) acidity is 0.53 respectively. In 1780, Swedish chemist Carl Wilhelm Scheele

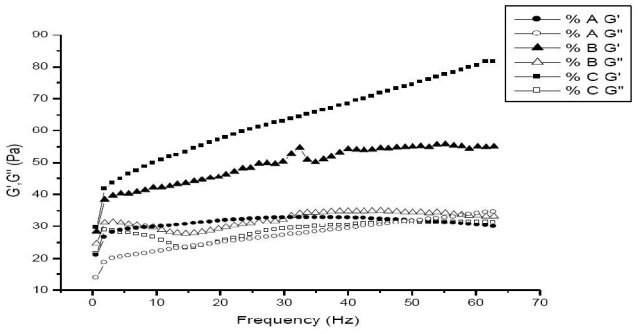
found that in cow milk, lactic acid is present and pH of fresh cow milk is 4. The role of lactic acid bacteria is to reduce the pH of the batter to an optimum level (4.4–4.5) for yeast activity[21]. Freshly extracted coconut milk has pH 6 and at this pH, the stability of coconut milk is high. Tangsuphoom and Coupland (2008)[22] reported that coconut milk proteins are easily coagulated and precipitate d at pH 4. Coconut milk emulsion can be separated by adjusting pH of the coconut milk emulsion between pH 3 and 5.6.

Rheology

The viscoelastic behavior of gluten-free dough samples was investigated by oscillation frequency sweep experiments conducted in the linear viscoelastic range. For all gluten-free doughs, G' was higher than G" in all the frequency range studied, which was indicative of a solid-elastic behavior[23]. From figure 3. batter with both cow milk (B) and coconut milk (C) presented higher G' and G" values than the control (A). The higher values found in dynamic moduli (G' and G") of batter clearly indicate that the presence of different ingredients introduces new interactions into the system and that their effect will also depend on the type of hydrophilic and hydrophobic interactions established. Batter reinforcement phenomenon could take place in gluten-free systems, where starch and proteins are the main dough components[24]. Figure 4. measures variation of shear stress with shear rate in different types of rice cake. The size and distribution of bubbles in the batter would be also important although density do not give any information about them[25,26]. The retention of air in the batter would be favored by high consistency levels. From figure 4 it is observed that the visco-elastic property of coconut milk rice cake is higher than rice cake by water & rice cake prepared by cow milk. Thus, batters elaborated with wholegrain flours would have lower capacity to retain the air entrapped. It is important to take into account that the changes in density which could occasionally change in batter rheology[27]. In consequence; the decrease observed in the wholegrain batter consistency could also be related to the increase in the quantity of entrapped air.

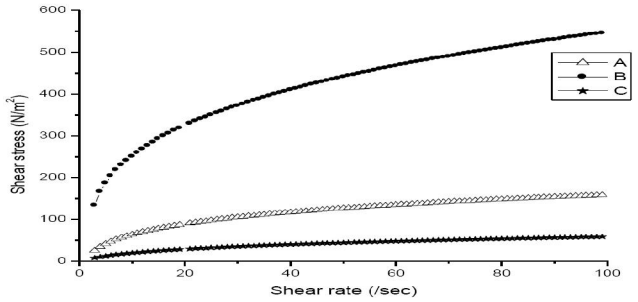
Microbial profile

Microbial profile analysis is very important for determining product quality. From figure 5. it is observed that mesophilic aerobes is higher in sample B than in sample A, & mesophilic aerobes is highest in sample C. Lactic acid bacteria is highest in sample B, it is slightly higher in sample C than sample A. Yeast & mould growth is higher in sample B than sample A & sample C. Lactic acid bacteria (LAB) is a fastidious organism so it can get sufficient nutrient from cow milk & coconut milk.



The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'

Figure 3 : Viscoelastic properties of different types of rice cake at 20°C p≤0.05



The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'

Figure 4 : Variation of shear stress with shear rate in different types of rice cake

Total antioxidant content

Several studies have shown that 80% methanol is an effective solvent in extracting phenolics, flavonoids and other polar substances in samples[28,29]. In this study, 80% methanol extracts from samples were used for the determination of total phenol content and antioxidant properties[29]. The total phenolic is expressed as mmol equivalents of gallic acid/100 g of sample. Flavonoids are secondary metabolites of plants. Structurally, they are benzo-c-pyrone derivatives consisting of polyphenolic and pyrane rings[17]. TABLE 1. Express the effect

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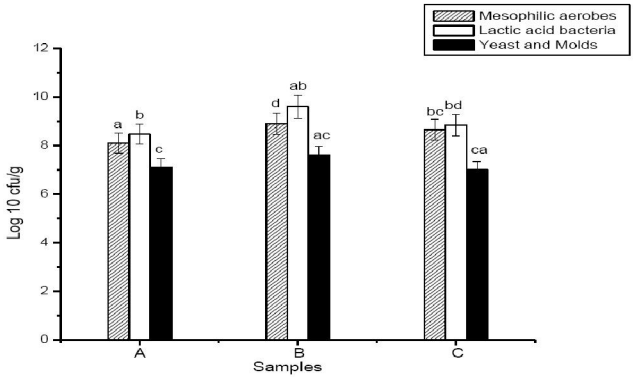
of different types of rice cake on total antioxidant at pd™0.05. Sugar and salt have no phenolic and flavonoid content, but as an ingredient wheat grass has high antioxidant activity. In rice flour the phenolic content is 0.323 mg, flavonoid content is 0.126 mg and total antioxidant activity is 6.29% whereas in wheat grass phenolic content is 1.09 mg, flavonoid content is 0.320 mg, and total antioxidant activity is 45%. Antioxidant properties of wheat sprout extracts where it is reported that these extracts inhibit the DNA oxidative damage and are effective in suppressing the superoxide radical that can further lead to various diseases[30] (Falcioni, Calzuola, Marsili, & Gianfranceschi, 2002). In milk the phenolic content is 0.252 mg, flavonoid content is 0.415 mg and total antioxidant activity is 36.77%, but when rice cake is prepared with milk, in sample B the phenol, flavnoid content is 1.89,0.75 mg respectively and antioxidant activity is 69%. Coconut milk itself has phenolic content 0.458 mg and antioxidant activity is 54%, but when sample C is prepared the antioxidant activity becomes 81%. It can be concluded that when raw ingredient is used as food material, phenolic and flavonoid content is less, but when product is prepared with these ingredients, the phenolic and flavonoid content become higher. As DPPH measures the total antioxidant capacity, so the increase in polyphenolic content and flavonoid content affect the total antioxidant capacity. Antioxidant activity could be related to the presence of bioactive constituents. A number of parameters, such as total polyphenols, total flavonoids, radical scavenging activity, antioxidant capacity and Fe-chelating activity, have been defined to characterize this activity[31]. Haard and Chism (1996)[32] have mentioned that total phenolics, including all the phenolic acid compounds, occur in plants as the metabolic intermediates and usually accumulate in the vacuoles. It is assumed that processing of food might accelerate the release of more bound phenolic compounds due to the breakdown of cellular constituents.



The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'

Figure 5 : Effect of different types of rice cake on microbial profile at p≤0.05

TABLE 1 : Effect of different types of rice cake on total antioxidant at p≤0.05

Sample	Phenolic Content(mg/100gm of sample)	Flavonoid content mg/100gm of sample)	DPPH(%)
Rice flour	$0.323\pm0.011_{a}$	$0.126\pm0.017_{ca}$	$6.29\pm0.8_{b}$
Sugar	0	$0.202\pm0.012_{b}$	$10.1\pm0.85_{c}$
Salt	0	$0.064\pm0.002_{c}$	$2.57\pm0.3_{d}$
Milk	$0.252\pm0.017_{b}$	$0.415\pm0.011_{d}$	$36.77\pm0.50_{a}$
Coconut milk	$0.458\pm0.020_{c}$	$0.85\pm0.03_{e}$	$54.25\pm0.55_{bd}$
Wheat grass	$1.09\pm0.023_{d}$	$0.320\pm.012_{f}$	$45\pm0.58_{e}$
Batter(water)	$1.63\pm0.03_{e}$	$0.34\pm0.01_{ab}$	$55.51\pm0.72_{da}$
Product(water)(A)	$1.71\pm0.029_{f}$	$0.39\pm0.011_{ac}$	$67\pm0.65_{dc}$
Batter(milk)	$1.75\pm0.025_{ab}$	$0.71\pm0.04_{ad}$	$63\pm0.652_{db}$
Product(milk)(B)	$1.89\pm0.03_{ac}$	$0.75\pm0.041_{bc}$	$69\pm0.68_{ad}$
Batter(coconut milk)	$1.73\pm0.02_{ad}$	$0.81\pm0.035_{bd}$	$72\pm0.45_{ae}$
Product(coconut milk)(C)	$1.92\pm0.032_{af}$	$0.94\pm0.035_{da}$	$81\pm0.53_{df}$

The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'.; Data represents means of three samples analyses (n=3) ± s.d.; Means with the same superscript within the same row are not significantly different (p>0.05) as determined by Fisher's least significant difference test.

Texture

Texture is defined as sensory and functional manifestation of structural, mechanical and surface properties of foods detected through the senses of sight, hearing, touch and kinetics. Instrumentally, the texture profile analysis (TPA) involves compressing the test sample at least once and quantifying the mechanical parameters from the force–deformation curve. Hardness is the measure of how resistant solid matter is to various kinds of permanent shape change when a force is applied. In TABLE 2. the hardness of rice cake by water (A) is 6N, whereas the hardness of rice cake by cow milk (B) is 4N and hardness of rice cake by coconut milk (C) is 3.2N. The physic chemical property of cow milk & coconut milk is to increase sponginess. Hard-

ness of the products is inversely proportional to sponginess of product. Here hardness of sample A is higher than sample B &sample C, so the sponginess is very low in sample A than sample B & sample C.

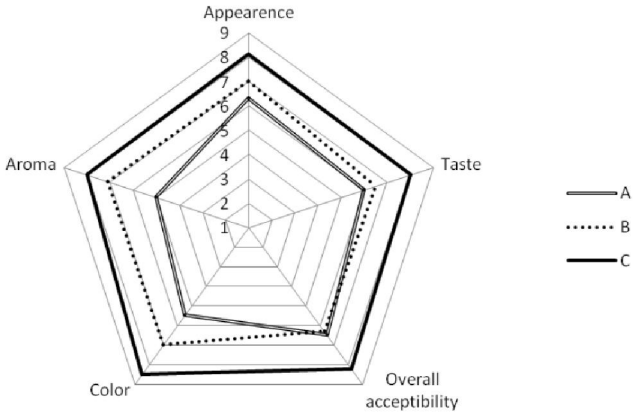
TABLE 2 : Effect of different types of rice cake on hardness of the rice cake at p≤0.05

Sample	A	B	C
Hardness(N)	6±0.523[a]	4±0.825[b]	3.2±0.478[c]

The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'.; Data represents means of three samples analyses (n=3) ± s.d.; Means with the same superscript within the same row are not significantly different (p>0.05) as determined by Fisher's least significant difference test

Sensory analysis

Sensory data of the acceptance level of different rice cake samples are presented (Figure 6). Conventionally, panelists prefer rice cake by coconut milk and fortified by wheat grass. In figure 6 the taste of the samples A, B, C are 6, 6.5, 8 respectively. The colour of the samples is 5.5, 7, 8.5 respectively. Overall acceptability of sample B is 8. So it is concluded that in respect of color, aroma, taste, the overall acceptability is higher in sample C than in sample A and B. Supplementation of wheat grass is a new approach towards fortification of every different type's samples rice cake. The addition of natural herbs enhances moisture retention capacity, slows staling rate, and gives rich antioxidant content, better baking characteristics, and improved sensory properties in terms of color, texture, mouth feel, and flavor.



The control rice cake is designated as 'A' and the rice cake by milk designated as 'B' and rice cake by coconut milk is designated as 'C'

Figure 6 : Studies on sensory quality of rice cake at p≤0.05

CONCLUSION

In this study we observe the antioxidant property, phenol content and sensory property of rice cake. From this study it can be concluded that when raw ingredient is used as food material, phenol and flavonoid content is less, but when product is prepared with these ingredients, the phenol and flavonoid content become higher. Rice cake by coconut milk has highest antioxidant; sensory property & less microbiological quantity than other two types viz rice cake by water & rice cake by cow milk. In sensory property, by Hedonic scale overall acceptability of rice cake by coconut milk is 8, whereas rice cakes by cow milk it is 7 & rice cake by water it is 6. Rice cake by coconut milk has less mesophilic bacteria, less yeast & mould than the other two types of rice cakes. Wheat grass supplementation to it adds better nutritive value. Rice cake by coconut milk has best quality than other types of rice cake. Rheological property of coconut milk cake is better than those prepared with cow milk and water.

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