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Preparation of low calorie and shelf-life extended yogurt by mixing wood apple powder in the formulation

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Abstract
The study was designed to develop a low calorie and shelf-life extended fruit yogurt mixed with wood apple powder. The fruit powder was supplemented at different levels in order to recommend an appropriate formulation. From the proximate analyses, it was found that the major components such as protein, fat, and moisture contents varied slightly in the yogurt samples. However, the plain yogurt was found to contain a higher amount of carbohydrate (18.83%) than that of wood apple powder yogurt (12.72%). From the organoleptic responses, the yogurt sample containing 6% fruit powder and 20% table sugar secured the highest score in color, texture, and taste. A fruit mixed yogurt sample was prepared with as less as 30% low calorie content than the plain one. The fruit powder yogurts were found to have 5 to 6 days more shelf-life than that of the plain yogurt at refrigeration temperature (7°C).

Practical applications
The food items with low sugar content have proved to be very helpful in maintaining the soundness of health. The current study shows that only an appropriate formulation can provide healthier food, ensuring acceptable qualities. The study demonstrates how the natural fruit sugar and fruit acid contribute in preparing low calorie as well as shelf-life extended yogurt. The laboratory investigations have suggested the appropriate formulation of wood apple yogurt with pros and cons regarding nutritive and organoleptic qualities. The findings of the study are highly expected to be helpful for the bakery and confectionary products manufacturers to prepare the yogurts with low calorie content and naturally enhanced shelf-life.

1 | INTRODUCTION

The current trend of daily life is biased to the desk where the physical movement is minimal. Hence, to avoid health complications, people are now keen on foods, which contain low energy but provide nutrients with satiety feelings. Sugar consumption is evident to have an undeviating relationship with many health-related inconveniences and sicknesses such as obesity, diabetes mellitus, and high blood pressure (Acosta, Vi quez, & Cubero, 2008; Sloan, 2005). Excessive sugar intake may seriously affect the sugar sensitive person that sometimes consequences to death (Acosta et al., 2008). Therefore, the growing concern for healthier food items by the consumers insists on the food manufacturer for new food formulations with low-sugar or low calorie content. People also demand ready-to-eat foods for increased speed of life and convenient usage. Processed and semi-processed dairy products such as cheese, yogurt, and ice cream are always in the preferred list of the consumers for attractive taste, balance nutrient content, and easy digestibility. However, Bangladesh is of the acute deficit in producing fresh milk. Per capita availability of fresh milk is only 52 g/day against the requirement of 250 g/day (Ser-Od, Hussain, & Dugdil, 2008). Only 5%–10% of milk can be delivered to

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the dairy food processing industry (Uddin et al., 2011). Therefore, preparation of the dairy-based products mixed with seasonal fruits can be an option to fulfill the demand of consumers for nutritional first food items (Boghra & Mathur, 2000; Desai, Toro, & Joshi, 1994). Preparation of the fruit-mixed dairy products reduce the pressure on fresh milk consumption. There are several country fruits with seasonal gluts in Bangladesh such as jackfruit, mango, and wood apple. Wood apple is a vastly cultivated fruit throughout Bangladesh but less consumed by people due to short time availability and lack of proper processing and preservation. During peak season huge supply is observed in the markets, but people often avoid this fruit at fresh state for its mildly bitter taste and gluey feeling. Therefore, the investigations are required for minimal processing of wood apple aimed at future utilization as an ingredient in food formulations. The study aims for the preparation of wood apple mixed yogurt, which can be an ideal dairy-based ready-to-eat food item.

Among the milk products, yogurt is a popular item for all age people. Yogurt is not only a delicious and nutritious food item but also healthy and has therapeutic value (Perdigón, LeBlanc, Valdez, & Rachid, 2002). Due to low lactose content, yogurt is easily digestible and palatable than milk. Yogurt is valued for controlling the growth of bacteria and in the curing of intestinal diseases such as constipation, diarrhea, dysentery, anticarcinogenic effect, and lowering of blood cholesterol (Kamruzzaman, Islam, Rahman, Parvin, & Rahman, 2002). It is generally considered as a safer product and its unique flavor is appealing. Hence, attention is being given to incorporate an inexpensive source of nutrients for making yogurt a complete food. Preparation of fruit yogurt has been investigated by many researchers. For example, Sah, Vasiljevic, McKechnie, and Donkor (2016) studied the probiotic yogurt fortified with pineapple peel powder to prepare the fiber-rich yogurt with adequate firmness and storage modulus. Sun-Waterhouse, Zhou, and Wadhwa (2012) investigated the effect of adding apple polyphenols before and after fermentation on the properties of drinking yogurt. Similarly, Tseng and Zhao (2013) tried to mix wine grape pomace in the formulation as a source of antioxidant fiber in yogurt. However, there is hardly any work on the preparation of wood apple fruit yogurt considering the fact of increased shelf-life and decreased calorie value in a natural way. Apart from nutrients, wood apple contains valuable micronutrients such as potassium, magnesium, and phytochemicals such as tannin, phenol, and flavonoids (Dhankar, Ruhi, Balhara, Dhankhar, & Chhillar, 2011; Sharma & Chauhan, 2017). So, the application of this fruit in dairy food items is assumed to give many benefits such as supplementing the valuable phytochemicals, increasing the product shelf-life due to presence of fruit acids and reducing the addition of table sugar due to presence of fruit sugar. Therefore, a thorough investigation is necessary with a principal objective of preparation of low calorie and shelf-life extended yogurt mixed with wood apple fruit. The current study aimed the same and has run with the following specific objectives:

1. Suggesting the appropriate formulation to prepare the low calorie wood apple mixed yogurt with acceptable sensory quality.
2. Assessing the physicochemical properties of prepared wood apple yogurt.
3. Assessing the storage stability of the prepared yogurt.

2 | MATERIALS AND METHODS

2.1 | Materials

The ripe wood apple fruits were purchased from the local market of Gazipur, Bangladesh. Whole milk was collected from the farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. Yogurt was purchased from the local market and used as a starter culture. Chemicals and reagents were used from the laboratory stock.

2.2 | Preparation of wood apple powder

The fruit's pulp was separated from the hard shell of wood apple using a spoon, and then the seeds and gums were removed from the pulp to reduce bitterness. The fresh pulp was cut into 1.5 cm thick slices. Then the slices were dried (Figure 1a) in the oven at 60°C for 24 hr. After drying, the slices were ground using a laboratory grinder (2,000 rpm) and the powder was sieved through 75 micro size meshes to achieve smooth flour (Figure 1b). Finally, the prepared wood apple powder was stored into high density polyethylene by vacuumed packaging for further use.

2.3 | Preparation of wood apple yogurt samples

In this study, nine samples containing a different proportion of wood apple powder and sugar were prepared. A control sample that contained the ingredients like a commercial plain yogurt (PY) was also prepared. As suggested in the literature, PY contains 10%–12% sugar of the total raw materials (Hossain, Fakruddin, & Islam, 2012). Considering 12%, 48 g sugar was used with 400 ml milk to prepare the control yogurt for this study. The sugar content of the control sample was considered as 100% and this control sugar was used to compare the fruit yogurts. The low calorie yogurts were prepared by the reduced amount of added sugar than that of the control sample. The experimental samples were prepared by mixing 4%, 6%, and 8% wood apple powder, and 0%, 20%, and 50% sugar as shown in Table 1. It should be noticed that before selecting the above yogurt formulations a series of yogurt samples containing 2%–12% wood apple powder were prepared during laboratory trials. From the preliminary trials it was observed that the samples containing 2%, 10%, and 12% wood apple powder (of total raw material, by weight) failed to set yogurts with satisfactory texture, hence, they were not considered for further analyses.

For the preparation of yogurt, the milk was first boiled until concentrated by reducing its original volume to one-third of the original milk and then the sugar was added in different proportions with continuous stirring. After cooling to room temperature (27°C), wood apple powder was mixed with the milk in various proportions. Then the

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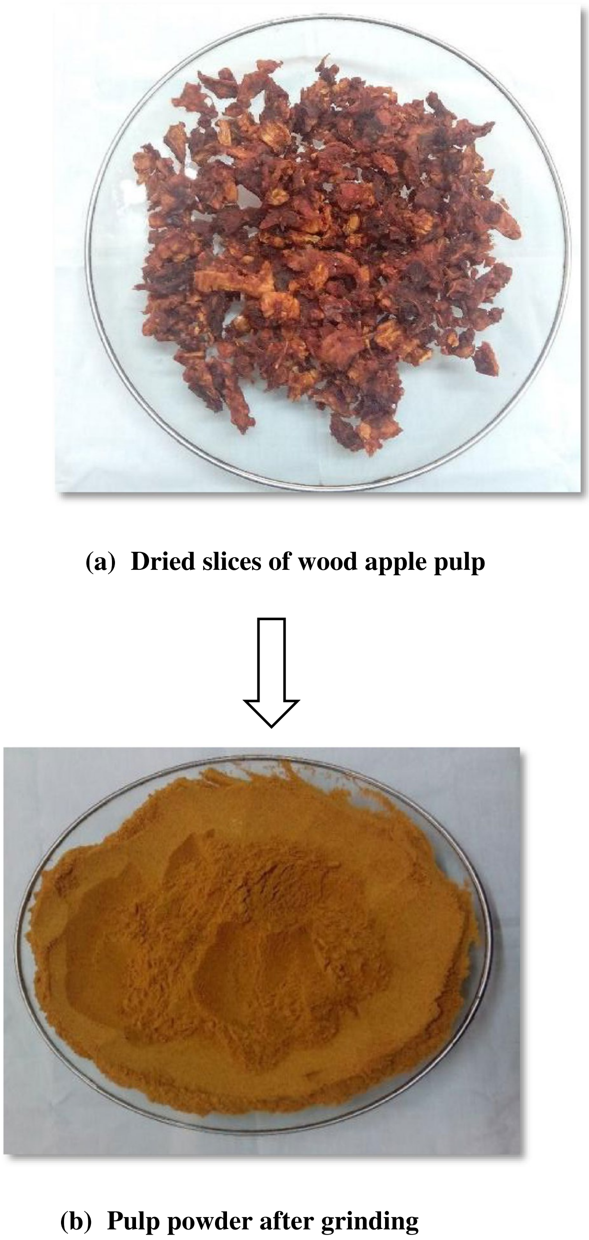

FIGURE 1 Prepared wood apple powder in the current study

prepared samples were heated to 70°C for 10 min and again cooled to 41°C and inoculated with half teaspoon yogurt as a starter culture. The prepared samples were incubated at 37°C for 11 hr approximately until the desired degree of coagulation was achieved. The prepared yogurts were cooled rapidly to 9°C.

2.4 | Sensory evaluation

Combinations of wood apple powder and sugar in yogurt samples were considered as treatments and the experiments were conducted in a completely randomized design (CRD) environment. As mentioned in Table 1, 10 different yogurts were prepared and undergone an organoleptic test. A semi-trained panel consisted of nine members from academics, staffs, and students of the Department

TABLE 1 Formulations of wood apple powder yogurts

Yogurt samples	Addition of wood apple powder and sugar[a]
W_4S_0	4% wood apple powder + 0% sugar
W_6S_0	6% wood apple powder + 0% sugar
W_8S_0	8% wood apple powder + 0% sugar
W_4S_{20}	4% wood apple powder + 20% sugar
W_6S_{20}	6% wood apple powder + 20% sugar
W_8S_{20}	8% wood apple powder + 20% sugar
W_4S_{50}	4% wood apple powder + 50% sugar
W_6S_{50}	6% wood apple powder + 50% sugar
W_8S_{50}	8% wood apple powder + 50% sugar
PY(Plain/controlled yogurt)	0% wood apple powder + 100% sugar

[a]% sugar is estimated considering the plain yogurt sugar as 100%.

of Agro-Processing and judged the sensory properties of the yogurt samples. The panel was prepared by two academics (one male and one female), three staffs (two males and one female) with age range of 30–52 years, and four students (two males and two females) with age range of 22–26 years. They were clearly described about the test methods, test properties, and requirements from the test before starting the evaluation. Then the yogurt samples and a hedonic scale sheet were supplied to each of the members to rate the degree of likings. The hedonic scale is an organoleptic quality rating scale where the judge expresses his degree of likings. According to the scale, the panel members rated the samples with highest rank of 9 for Like Extremely to the lowest rank of 1 for Dislike Extremely. Appearance, color, flavor, texture, taste, and overall acceptance of the samples were evaluated.

2.5 | Method of determination of proximate compositions

2.5.1 | Determination of moisture content

Moisture contents of the samples were determined by gravimetric analysis (AOAC, 1984) method. Some crucibles were dried and their empty weights were taken by an electric balance. Samples were placed in the crucibles and weighed again. The crucibles with samples were placed in the oven and dried at a temperature of 105°C for 16 hr. The crucibles were taken out and allowed to cool in a desiccator for 1 hr. Then the samples were dried again in the oven dryer for 2 hr and cooled down in the desiccator. These drying and cooling were repeated several times until constant or final weights were attained. From these weights, the moisture content of each sample was calculated by the Equation (1).

$$\text{Percent of moisture content (wb)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (1)$$

where W_1 g = weight of the empty crucible, W_2 g = weight of sample + crucible, and W_3 g = weight of dry sample + crucible.

2.5.2 | Determination of protein content

The nitrogen content of the samples was determined by the Kjeldahl method (AOAC, 1984). Ammonia liberated by making the solution alkaline is distilled into a known volume of a slandered acid, which is then back titrated. The protein contents were estimated by multiplying the nitrogen content and protein conversion factor (6.38) as shown in Equation (2).

$$\text{Percent of protein content} = \left[(c-b) \times 14 \times d \times 6.38 \div (a \times 1000)\right] \times 100 \quad (2)$$

where a = sample weight in gm, b = volume of NaOH to neutralize 25 ml of 0.1N H_2SO_4, c = volume of NaOH to neutralize 0.1N H_2SO_4 in control or back titration, and d = strength of NaOH (normality of NaOH solution).

2.5.3 | Determination of fat content

Fat contents of the yogurt samples were determined by the solvent extraction method (Ranganna, 1991). Approximately 5 g yogurt was taken from each experimental sample into a preweighed thimble. The thimble was dropped into the fat extraction tube of the Soxhlet apparatus. The bottom of the tube was attached to a Soxhlet flask. Approximately 250 ml of petroleum ether was poured into the flask through the sample in the tube. The top of the fat extraction tube was attached to the condenser. The sample was extracted for 8 hr on a water bath at 70°C. The water bath was regulated so that the petroleum ether was volatilized, condensed, and dropped continuously upon the sample without any appreciable loss. At the end of the extraction period, the thimble was removed from the apparatus. The flask was rinsed using petroleum ether. Then the solvent (petroleum ether) was evaporated in a steam bath at 70°C. The residual in the flask was dried at 100°C for 1 hr. The final weight was recorded after cooling the flask. The fat contents of the yogurt samples were estimated from the difference in the weights according to Equation (3).

$$\text{Percent of fat content} = \frac{\text{Weight of extracted fat material}}{\text{Weight of sample}} \times 100 \quad (3)$$

2.5.4 | Determination of ash content

The ash content was determined by the dry ashing method stated by Ranganna (1991). Accurately weighed samples (about 5 g), after drying for moisture content determination, were taken in the cleaned preweighed crucibles. The crucibles were then placed in the muffle furnace and burnt at 550°C for 6 hr. The crucibles were precooled in the dryer and then cooled in a desiccator. The final weights were recorded and the percentage of ash content of each sample was estimated according to Equation (4).

$$\text{Percent of ash content} = \frac{\text{Weight of the residue after burning}}{\text{Weight of the sample}} \times 100 \quad (4)$$

2.5.5 | Determination of carbohydrate content

Recently Fourier-transform infra-red (FTIR) spectroscopy has been used in many types of research for quality and quantity determination (Adina, Florinela, Abdelmoumen, & Carmen, 2010; Mohamed, Shaheen, Khalil, Hussein, & Kamil, 2011). The carbohydrate content of yogurt was estimated from the linear increment of the FTIR spectra (Khurana, Jun, Cho, & Li, 2008; Leopold, Leopold, Deihl, & Socaciu, 2011). A standard curve, containing various concentrations of glucose contents (from 0% to 50%), was prepared for the quantitative analysis. The spectrum range 950–1,200 cm^{-1} considering the baseline at 1,175 cm^{-1} was accounted for this purpose. For the determination of sugar quantity in the yogurt samples, the Perkin-Elmer "Spectrum Quant version 10.05.03" software was used.

2.6 | FTIR spectroscopy for the conformation study of yogurt

The IR spectra were acquired through Perkin Elmer FTIR (Spectrum-2) instrument operated by CPU32M software. The yogurt samples were scanned within 650 to 4,000 cm^{-1} wavenumber using a triglycine sulfate detector. A total of eight scans at 4 cm^{-1} resolutions were accumulated at a scanning speed of 0.2 cm/s. The blank spectrum of water was subtracted from the experimental spectrum. The baseline subtracted yogurt spectra were analyzed by Perkin Elmer's proprietary software (Version 10.05.03) for the conformation study of yogurt.

2.7 | Determination of total soluble solids

Total soluble solids (TSS) of prepared yogurt samples were determined using a refractometer (Model: HI 96801, HANNA Instruments).

2.8 | Determination of pH

The pH of the wood apple yogurt samples and PY was determined using a pH meter (Model: LE pH Electrode LE438-IP67, Mettler Toledo, Hong Kong).

2.9 | Measuring the energy content of yogurt

The energy contents of the yogurt samples were determined using an oxygen bomb calorimeter (Model: 1341, Parr Instrument Company, USA) where benzoic acid was used as a reference. The energy released by the combustion of the samples within the bomb pressure vessel resulted in an increase in temperature. The gross heat of combustion

(Hg, calories per gram) of the yogurt sample was computed from the recorded temperature following Equation (5).

$$\mathrm{Hg} = (tW - e_1 - e_2 - e_3) \div m \quad (5)$$

where t = increase in temperature, W = energy equivalent of the calorimeter, determined under standardization, m = mass of yogurt sample in grams, e_1 = correction in calories for heat of formation of nitric acid (HNO_3), e_2 = correction in calories for the heat of formation of sulfuric acid (H_2SO_4), and e_3 = correction in calories for heat combustion of fuse wire.

2.10 | Storage study of prepared wood apple and PYs

After the sensory evaluation, the organoleptic accepted yogurt samples (W_6S_0 and W_6S_{20}) were stored at refrigeration temperature (7°C) and room temperature (25°C) for storage study. The reason for choosing these two yogurt samples for storage study is discussed at the beginning of Section 3.2. The storability of the yogurts was assessed observing the sensory changes such as color, texture, and flavor of the yogurt samples. Formation of microbial colonies on the top of yogurt samples were observed visually. The samples were observed up to 20 days of storage period at every alternate day started from the 6th day of storage.

2.11 | Statistical analysis

Data collected from the sensory evaluation were analyzed for the analysis of variance by R statistical software. The significant differences were observed at a 5% level. Duncan's multiple range test was used to analyze the mean differences between the samples. Other experiments were carried out in triplicate and the average values are reported in the ensuing sections. The inbuilt program in Microsoft Excel^{TM}, Microsoft Office Excel 2010 was used for this purpose with the same degree of confidence level ($p < .05$).

3 | RESULTS AND DISCUSSION

3.1 | Organoleptic assessment

The yogurt samples showed a varying degree of acceptability in terms of color, flavor, texture, taste, and overall acceptability. The yogurt sample containing 6% wood apple powder + 20% sugar (W_6S_{20}) scored the highest in most of the sensory attributes such as color, texture, and taste (Table 2). Further increment of wood apple powder in the formulations resulted in creased or fractured yogurt surface, which secured a low score in texture (Table 2). Besides, this increment enhanced the wood apple smell in the yogurt, which was not liked by all. The yogurt sample with 20% sugar and 4% wood apple powder (W_4S_{20}) secured the second highest score (8.776) in overall acceptability. Increasing sugar in the wood apple yogurt formulation (W_6S_{50}) increased the sweetness of the yogurt that was not preferred by the panel. Nonetheless, the increment of sugar up to 50% in the formulation secured acceptable rating in the organoleptic indicators with the 3rd highest score (W_6S_{50}, 8.290) in overall acceptability. The presence of fruit sugar in the wood apple powder added extra sweetness in the yogurt. The yogurt formulations without added sugar failed to attract sensory panel. It is worthy to mention that the wood apple samples added with a moderate amount of sugar secured a higher rating than the PY in almost all of the sensory quality attributes. However, further sensory evaluation by a trained panel is recommended for assessing the precise organoleptic differences, if any, in the yogurt samples.

3.2 | Proximate compositions

The yogurt sample W_6S_{20} (contained 6% wood apple powder with 20% sugar) ranked the highest scale in terms of the sensory responses. Hence, this sample was selected together with PY for further investigations such as chemical analyses and storage performance. W_6S_0 (contained 6% wood apple powder with 0% sugar) was also included in these analyses, as many consumers look for the low calorie food item in the market.

3.2.1 | Moisture Content

The moisture contents of the wood apple yogurt samples were found as 71.42% and 71.53% in W_6S_0 and W_6S_{20}, respectively (Table 3), which are comparable with measured moisture content in mango yogurt (71.11%) and jackfruit yogurt (71.82%) (Ara, Uddin, Rahman, & Saha, 2010; Onik, Ali, Rahman, Ali, & Iqbal, 2015). The moisture content of PY was 73.14%, which was slightly higher than those of wood apple yogurts. Lower retention of moisture in the wood apple yogurt might be due to the creation of intermolecular pore in yogurt texture by a higher amount of fiber content in wood apple powder (Sharma, Bhatia, Bansal, & Sharma, 2007). The higher release of moisture from wood apple yogurt resulted in higher TSS content in these samples (Table 3). The TSS values of the fruit mixed yogurts were observed as 27.50 ± 0.05% whereas, this value is significantly less in PY (25.86%).

3.2.2 | Protein content

Average values of the protein content of the wood apple yogurt samples (W_6S_0 and W_6S_{20}) were 3.80% and 3.83%, respectively (Table 3). These values are approximately similar to the results found by (Roy et al., 2016) who obtained the average protein content of yogurt samples supplemented with fruit pulps such as banana, papaya, and watermelon ranged from 3.53% to 3.84%. Another study conducted by Ara, Uddin, Saha, Khan, and Baset (2015) reported that the jackfruit- and mango pulp-supplemented yogurt contain protein in the range of 3.61% to 3.51%. The protein content found in the PY (3.71%) is slightly less than the wood apple yogurt. The addition of fruit pulp in the solid powder form, containing 4.03% protein (Table 3), contributed in the increment of protein percentage in fruit powder mixed yogurts.

3.2.3 | Fat content

The fat contents of wood apple yogurts samples W_6S_0 and W_6S_{20} were found as 4.24% and 4.27%, respectively (Table 3). These results are

TABLE 2 Sensory evaluation of wood apple yogurts

Percent of wood apple powder	Color 4%	6%	8%
No sugar	6.050^{a} (W_4S_0)	6.944^{a} (W_6S_0)	6.555^{a} (W_8S_0)
20% sugar	8.444^{a} (W_4S_{20})	8.555^{a} (W_6S_{20})	7.166^{b} (W_8S_{20})
50% sugar	8.330^{ab} (W_4S_{50})	8.554^{a} (W_6S_{50})	7.444^{b} (W_8S_{50})
Control	6.6110^{a} (PY)	6.111^{a}	6.111^{a}
	Flavor		
No sugar	5.911^{a} (W_4S_0)	6.444^{a} (W_6S_0)	6.777^{a} (W_8S_0)
20% sugar	8.944^{a} (W_4S_{20})	8.366^{a} (W_6S_{20})	6.888^{b} (W_8S_{20})
50% sugar	8.111^{a} (W_4S_{50})	8.388^{a} (W_6S_{50})	8.966^{a} (W_8S_{50})
Control	7.111^{a} (PY)	7.111^{a}	7.111^{a}
	Texture		
No sugar	7.666^{a} (W_4S_0)	7.277^{ab} (W_6S_0)	6.166^{b} (W_8S_0)
20% sugar	8.277^{a} (W_4S_{20})	8.722^{a} (W_6S_{20})	6.722^{b} (W_8S_{20})
50% sugar	8.444^{a} (W_4S_{50})	8.277^{a} (W_6S_{50})	6.111^{b} (W_8S_{50})
Control	7.611^{a} (PY)	7.611^{a}	7.611^{a}
	Taste		
No sugar	5.833^{a} (W_4S_0)	6.477^{a} (W_6S_0)	6.777^{a} (W_8S_0)
20% sugar	8.833^{a} (W_4S_{20})	8.942^{a} (W_6S_{20})	7.388^{b} (W_8S_{20})
50% sugar	8.000^{a} (W_4S_{50})	7.833^{a} (W_6S_{50})	7.611^{a} (W_8S_{50})
Control	7.333^{a} (PY)	7.333^{a}	7.333^{a}
	Overall acceptability		
No sugar	6.422^{a} (W_4S_0)	6.575^{a} (W_6S_0)	6.513^{a} (W_8S_0)
20% sugar	8.776^{a} (W_4S_{20})	8.962^{a} (W_6S_{20})	7.040^{b} (W_8S_{20})
50% sugar	8.207^{a} (W_4S_{50})	8.290^{a} (W_6S_{50})	7.276^{b} (W_8S_{50})
Control	7.207^{a} (PY)	7.207^{a}	7.207^{a}

Note: Different letters denote a significant difference between the percent of wood apple powder used in each row at a 5% level.

TABLE 3 Proximate composition of formulated wood apple yogurts and plain yogurt

Chemical composition				W_6S_0		W_6S_{20}		PY		Wood apple powder	
Moisture (%)				71.42 ± 3.41		71.53 ± 2.52		73.14 ± 1.82		7.75 ± 2.42	
Protein (%)				3.80 ± 0.24		3.83 ± 0.32		3.71 ± 0.41		4.03 ± 0.60	
Fat (%)				4.24 ± 0.41		4.27 ± 0.71		4.62 ± 0.33		1.21 ± 0.12	
Ash (%)				0.82 ± 0.04		0.84 ± 0.05		0.70 ± 0.02		1.15 ± 0.30	
Carbohydrate (%)				12.72 ± 1.04		16.53 ± 1.21		18.83 ± 1.18		84.26 ± 2.4	
Energy value (kcal/100 g)				44.43 ± 2.14		53.71 ± 1.48		76.87 ± 3.42		295 ± 3.58	
Total soluble solids (%)				27.55 ± 1.14		27.47 ± 0.92		25.86 ± 1.84		–	
pH				4.50 ± 0.08		4.78 ± 0.41		5.30 ± 0.62			
W_6S_0	4.50	4.60	4.77	4.82	4.90	4.95	5.02	5.09	5.10	5.11	5.10
W_6S_{20}	4.78	4.80	4.85	4.91	4.98	5.06	5.14	5.34	5.47	5.47	5.48
Days	0	2	4	6	8	10	12	14	16	18	20

Note: W_6S_0 = 6% wood apple powder + 0% sugar; W_6S_{20} = 6% wood apple powder + 20% sugar; PY = plain yogurt.

supported by the findings of (Khedkar, Choudhari, Pawar, & Kadam, 2015), who reported that the fruit base yogurts contained fat within the range from 4.16% to 4.62%. As seen in Table 3, the fat content of PY (4.62%) was slightly higher than the wood apple yogurts. Fat content decreased with the addition of wood apple powder because wood apple powder contains lower fat (1.21%) than fresh milk (4.00%, approximately). It is a general observation that fruit contains a low level of fat, so the addition of fruit juice or powder should result in a food formulation with lower fat content.

3.2.4 | Ash content

The ash content of wood apple yogurt samples W_6S_0 and W_6S_{20} was 0.82% and 0.84%, respectively (Table 3) which were higher than the ash content of normal PY which was 0.70%. The increment of ash content in fruit yogurts agrees on the findings of Roy et al. (2016) where they observed enhanced mineral contents in the yogurt samples supplemented with several fruit pulps. Ara et al., (2015) found that the jackfruit mixed yogurt and mango mixed yogurt contained up to 0 0.82% and 0.90% ash, respectively, whereas the PY contained 0.68% ash. The increased ash contents in the fruit mixed yogurts are assumed to have higher amount of mineral contents in the samples.

3.2.5 | Carbohydrate content

The pictorial views of the determination of carbohydrate by FTIR are shown in Figures 2–4, and the results are presented in Table 3. Clear and visible increments were seen with increasing glucose concentration within the mentioned spectrum range (Figure 2). The increased values were linearly fitted with 0.982 R^2 value and 5.46% error (Figure 3). As can be seen in Figure 4, the PY has given the highest peak, which was followed by W_6S_{20} and W_6S_0, respectively. The PY was found to contain 18.83% carbohydrate and the wood apple powder yogurt samples W_6S_{20} and W_6S_0 were found to contain 16.53% and 12.72% carbohydrate, respectively. The estimated values of the carbohydrate content are comparable with the fruit juice yogurts made by (Hossain et al., 2012), which ranged from 16.60% to 18.91%. In this study, the carbohydrate content of PY (18.83%) was higher than that of the wood apple yogurts. The low estimated value of carbohydrate content is due to the usage of no or decreased amount of table sugar (W_6S_0; 0% and W_6S_{20}; 20%) in preparation of wood apple powder yogurts.

3.3 | Conformational study of yogurt

From the FTIR spectra (Figure 4), it is found that the yogurt samples are dominant with carbohydrate (band region 900–1,150 cm^{-1}). The peak region for carbohydrate is principally resulted by stretching vibration of C–C and C–O bonds and deformation of C–O–H and C–O–C bonds (Grube, Bekers, Upite, & Kaminska, 2002; Naumann, 2000). As seen in the figure, the protein units produced the characteristics IR band through C=O stretching at the amide-I region (1,600–1,700 cm^{-1}), N–H bending, and C–N stretching at amide II region (1,500–1,600 cm^{-1}) and C–N bedding and N–H stretching at amide III region (1,200–1,350 cm^{-1}) (Kong and Yu (2007); Surewicz & Mantsch, 1988. The fat contents of the yogurt samples produced the peaks within the band region 2,800–2,970 cm^{-1}.

3.4 | TSS content

The total solid contents of wood apple yogurt samples W_6S_0 and W_6S_{20} were 27.58% and 27.47%, respectively (Table 3) which was slightly higher than the findings by (Hossain et al., 2012). They found that the total solids of different fruit juice mixed yogurts ranged from 25.33% to 27.17%. The higher TSS of wood pale powder yogurts than the PY (25.86% in this study) is agreed by previous researches that the PY contained a lower amount of total solids compared to that of fruit yogurt (Ghosh & Rajorhia, 1987; Kamruzzaman et al., 2002). Some other literature reported that the TSS content was found as 23.58% in dragon fruit yogurt (Jayasinghe, Fernando, & Jayamanne, 2015) and 27.67% in jackfruit yogurt (Ara et al., 2015). Moreover, Tarakci and Kucukoner (2003) determined 18.25% and 17.69% TSS

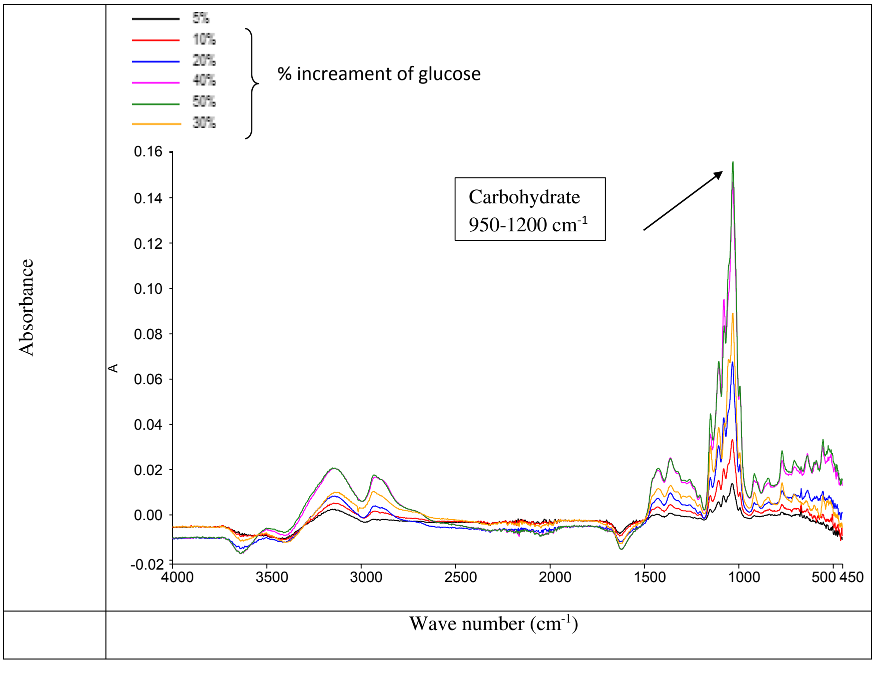

FIGURE 2 Change of FTIR absorbance spectra with increasing glucose percentage

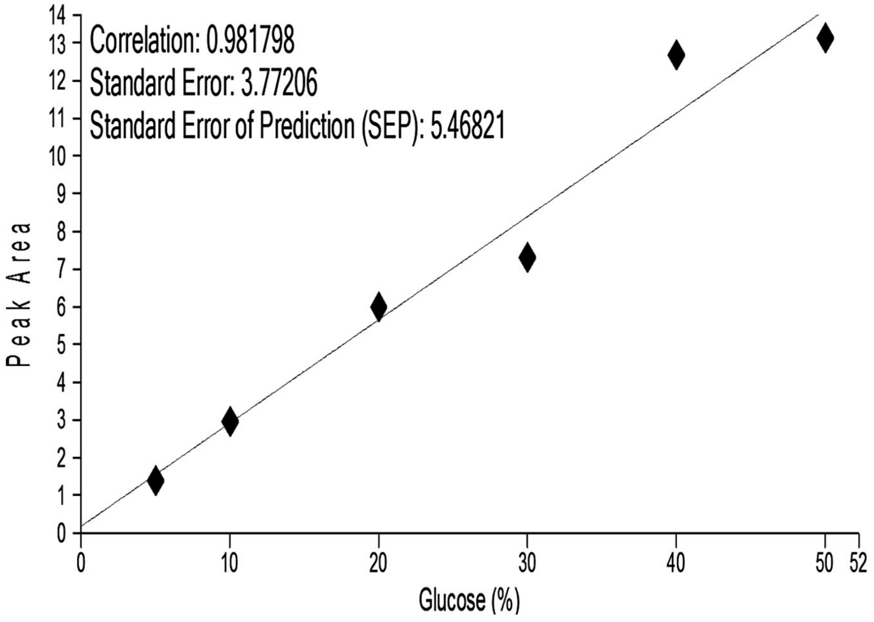

FIGURE 3 Standard curve prepared by increasing the glucose concentration

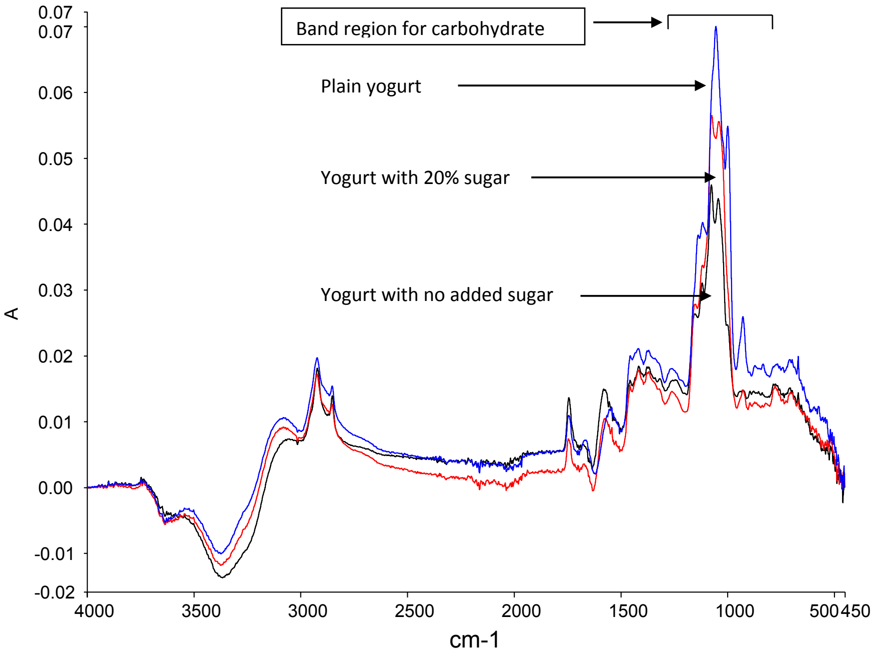

FIGURE 4 FTIR absorbance spectra of yogurts mentioning the band region for carbohydrate

in date pulp and grape molasses yogurts, respectively. The variation of TSS recommends that the total solid content not only depends on mixed fruit in the formulation but also it depends on the added sugar and inherent sugar and fiber contents of the fruit.

3.5 | pH value

As seen in Table 3, the average pH values of the wood apple yogurt samples (W_6S_0;4.50 and W_6S_{20}; 4.78), were less than that of the plain yogurt (5.30). The slight declination of pH value in the fruit yogurts seems attributed to the mixing of wood apple powder which contains various organic acids such as tartaric acids and oxalic acids (Bansal & Bansal, 2011). The findings comply with the pH of other fruit yogurts such as date pulp yogurt (pH 4.0), grape molasses yogurt (pH 4.07) (Tarakci & Kucukoner, 2003), and dragon fruit yogurt (pH 4.05) (Jayasinghe et al., 2015). The increased amount of fruit portion in the formulation reportedly decreases the pH value of the yogurt; such as an increment of mango juice from 10% to 25% decreased the pH value from 4.25 to 3.92 (Teshome, Keba, Assefa, Agza, & Kassa, 2017).

3.6 | Energy value content

The average values of energy contents per 100 gm of wood apple yogurt samples of W_6S_0 and W_6S_{20} were found as 44.43 and 53.71 Kcal, respectively. Moreover, the same amount of PY contained much higher energy, 76.87 Kcal (Table 3). The estimated energy values of yogurt samples are supported by previous researches (Weerathilake, Rasika, Ruwanmali, & Munasinghe, 2014). They assessed the energy content

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TABLE 4 Storage study of wood apple and plain yogurt samples at refrigeration temperature (7°C)

Days	Sample	Color	Flavor	Texture	Taste	Remarks
0	W_6S_0	Ok	Ok	Ok	Ok	Good quality
	W_6S_{20}	Ok	Ok	Ok	Ok	Good quality
	PY	Ok	Ok	Ok	Ok	Good quality
6	W_6S_0	Ok	Ok	Ok	Ok	Good quality
	W_6S_{20}	Ok	Ok	Ok	Ok	Good quality
	PY	Ok	Ok	Ok	Ok	Good quality
8	W_6S_0	Ok	Ok	Ok	Ok	Good quality
	W_6S_{20}	Ok	Ok	Ok	Ok	Good quality
	PY	Ok	Ok	Ok	Ok	Good quality
10	W_6S_0	Ok	Ok	Ok	Ok	Good quality
	W_6S_{20}	Ok	Ok	Ok	Ok	Good quality
	PY	Ok	Ok	Ok	Ok	Good quality
12	W_6S_0	Ok	Ok	Ok	Ok	Good quality
	W_6S_{20}	Ok	Ok	Ok	Ok	Good quality
	PY	Ok	Ok	Ok	Slightly unpleasant	Medium quality
14	W_6S_0	Ok	Ok	Ok	Ok	Good quality
	W_6S_{20}	Ok	Ok	Ok	Ok	Good quality
	PY	Whitish spots found	Slightly unpleasant	Little watery surface	Unpleasant	Bad quality
16	W_6S_0	Ok	Ok	Ok	Slightly unpleasant	Medium quality
	W_6S_{20}	Ok	Ok	Ok	Slightly unpleasant	Medium quality
	PY	Whitish moldy structures found	Bad odor	Watery surface	Unpleasant	Bad quality
18	W_6S_0	Whitish spots found	Slightly unpleasant	Ok	Unpleasant	Bad quality
	W_6S_{20}	Whitish spots found	Slightly unpleasant	Ok	Unpleasant	Bad quality
	PY	Moldy structures found	Bad odor	Watery surface	Unpleasant	Bad quality
20	W_6S_0	Whitish spots found	Slightly unpleasant	Ok	Unpleasant	Bad quality
	W_6S_{20}	Whitish spots found	Slightly unpleasant	Ok	Unpleasant	Bad quality
	PY	Moldy structures found	Bad odor	Watery surface	Unpleasant	Bad quality

of different varieties of PYs such as low-fat yogurt, whole milk yogurt, etc., ranged from 54 to 79 Kcal. The estimated values mean that samples prepared with no added sugar and 20% of PY sugar (W_6S_0 and W_6S_{20}) contained 42% and 30% low calorie, respectively than the PY. However, the mild sweetness contributed by the fruit sugar from wood apple fruit contributed to an appealing taste of yogurt samples, which resulted in an acceptable sensory score.

3.7 | Storage condition

The storage ability of a food product provides great importance on the quality of the food. The current study observed that both the wood apple yogurt samples prepared without any preservatives maintained their color, texture, taste, and flavor for 2 weeks at refrigeration temperature (7°C). However, all the yogurt samples stored at room temperature (25°C) spoiled within 6 days. Nonetheless, fruit powder mixed yogurts remained edible two days longer than the control sample considering taste, color, flavor, and microbial counts (data are not presented). After 15 days of refrigerated storage, the samples started to change their qualities. Moreover, the shelf-life of PY was found to be a good condition for only 10 days without changing any quality (Table 4). A nice smooth texture of the fruit yogurts was maintained for a considerably extended time than that of PY. It was observed that the sensory parameter 'taste' of the yogurts initiated to degrade first then other attributes such as color and flavor. Degradation rate accelerated with the formation of microbial spots on the yogurt surfaces (Figure 5).

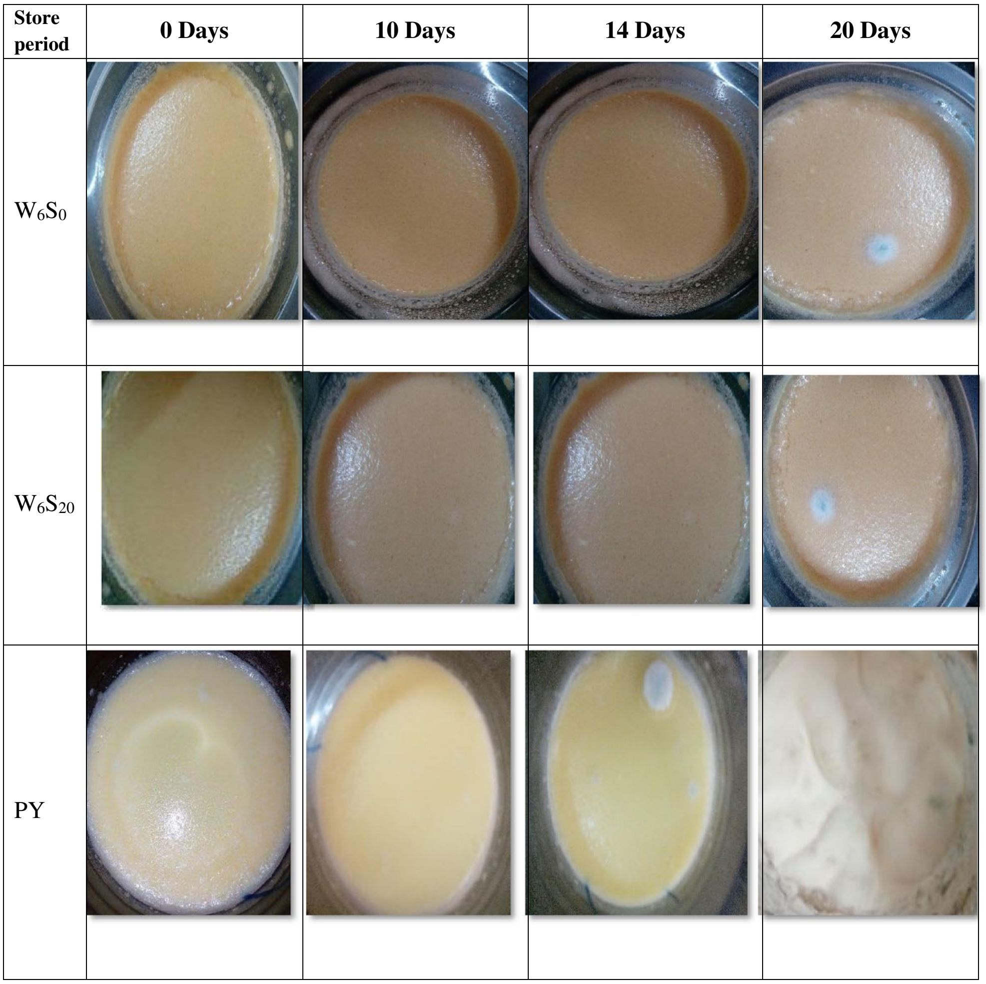

FIGURE 5 Storage study of yogurt samples for 20 days. W6S0 = 6% wood apple powder + 0% sugar, W6S20 = 6% wood apple powder + 20% sugar, and PY = plain yogurt

The extended shelf-life for wood apple powder yogurt might be attributed to the presence of organic acids such as ascorbic acid, malic acid, and tartaric acid in the wood apple powder (Bansal & Bansal, 2011; Yadav, Tyagi, Deepak, & Mehrotra, 2011). The result is also reflected in our pH determination, where the pH values of the fruit yogurt samples were less than that of PY (Table 3). In another experiment, the changes in pH of wood apple yogurts during refrigerated storage were observed and presented at the lower portion of Table 3. It was found that the pH of the yogurts slightly increased with storage time, which is agreed by previous researches (Chavan, Pawar, & Pawar, 2015; Kohinkar, Chavan, Pawar, & Amarowicz, 2014) that the percent acidity of fruit toffee decreased during storage at refrigeration temperature. However, the increment of pH in the current study was ceased when the yogurts were spoiled.

4 | CONCLUSIONS

Wood apple was successfully added in the formulation to prepare low calorie and shelf-life extended yogurt. Assessing the physicochemical parameters and storage stability, it can be concluded that mixing of 6% wood apple powder and 20% sugar in the formulation yielded yogurt with attractive sensory attributes such as color, flavor, and overall acceptability. The yogurt by this formulation contained 30% less calorie than the plain yogurt. The variation of nutritive values was in an acceptable range without showing remarkable changes except for carbohydrate content. Due to the variation of mixing table sugar and wood apple powder, the estimated carbohydrate contents of the yogurt samples varied from 12.72% in wood apple yogurt to 18.83% in PY. The fruit powder-fortified yogurts led to a greater shelf-life than that of PY for around 5 days. The last but not least, the addition of wood apple powder not only makes a dairy-based product with different tastes, shelf-life, and calorie content but also it would widen the usage of this healthy fruit.

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

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