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Original article

Volarisation of Brewer's spent grain for noodles preparation and its potential assessment against obesity

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Summary Brewer's spent grain is the most prevalent low-cost by-product of brewing industry, contributing to about 85% of all by-products produced. It is of interest for food industry applications because of its high nutritional value (fibres, protein and bioactive substances). The objective of this study was to determine the effects of different brewer's spent grain composition usage on various quality criteria of noodles as well as to investigate the possible usage opportunities and assessments of them in the production of noodles against obesity. For this purpose, noodle production was carried out using five different compositions of brewer's spent grain barley, barley and wheat, barley and rice, barley and maize, barley and finger millets, all at different concentrations (5%, 10%, 15% and 20%). Various quality criteria of the noodles were determined. Noodles made with the addition of barley and maize spent grains were found to be high in physio-chemical and nutritional properties, and amylase and lipase inhibition assay. Concentration above 15% of spent grains affected the texture of the noodles. From the sensory evaluation, 10% concentration of barley and maize noodles was selected as it had good texture, colour and appearance. It was comparatively good in taste and aroma from other samples.

Keywords Amylase assay, Brewer's spent grain, lipase assay, noodles, obesity, value-added product.

Introduction

Brewers' spent grains (BSG) are now widely regarded as one of the most plentiful and low- cost brewing by-products, with considerable potential as a beneficial food ingredient. BSG is the most prevalent by-product of the brewing industry, which contributes to about 85% of all by-products generated (Verni *et al.*, 2020). It is available in large quantities all year, but its primary use has been limited to animal feed. However, it can also be used as an effective supplement in human nutrition and animal feed due to its high protein and fibre content and its low cost (Muthusamy, 2014; Jin *et al.*, 2022). Therefore, BSG is of interest for food industry applications due to its enrichment of fibres and proteins that can easily use it to make various fortified and value-added products (Parekh *et al.*, 2017).

Many studies are being done to determine if BSG can be utilised in the production of various food items and added to human nutrition. The major use of BSG in the food industry has been in biscuits, cookies, bread, among other baked goods. (Lynch *et al.*, 2016). The reason for choosing noodles in this study is that they are a staple food in East Asian countries, and their consumption is also high in India. Advancements in the food and processing sectors have increased the consumption of noodles worldwide. It has become the choice of many consumers due to its availability and

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ease of preparing (Sikander *et al.*, 2017). Thus, various researchers have focused their efforts on the enhancement of the nutritional value of noodles through effective fortification with the goal of improving the health status of the population.

Noodles are made from wheat flour and a combination of various other flours mixed with water, eggs and salt, which is used as a common preservatives (an alkaline salt mixture of potassium carbonate, sodium phosphate and sodium carbonate), as well as other ingredients that enhance the flavour and texture of the noodles (Gulia *et al.*, 2018). Nowadays, consumers all over the world are increasingly at risk of diseases such as diabetes, high cholesterol and cardiovascular diseases as a result of obesity and various food intolerance and allergies. Additionally, an unhealthy diet, low in vital nutrients, including dietary fibre, phytochemicals and antioxidants, is to blame for these risk factors (Heo *et al.*, 2013; Omeire *et al.*, 2014; Ivanova *et al.*, 2017). Thus, consumers may avoid products with a high carbohydrate content such as noodles. Functional foods offer health benefits and aid in disease prevention by adding nutraceutical ingredients and other essential nutrients. BSG is a dietary fibre-rich compound with antioxidant properties, so the noodles prepared with BSG can be used as a value-added product. Noodles fortified with BSG had high protein content and dietary fibre content, and they showed a higher percentage of antioxidant activity and nutritional value. To the best of our knowledge, there is no study investigating the effects of BSG composition usage on noodle quality. Therefore, in this study, we aim to utilise the leftover of the industrial food raw material, to determine the effects of different BSG composition usage on various quality criteria of noodles and to investigate the possible usage opportunities and assessment of them in the production of noodles against obesity.

Methods

This study was conducted in the laboratory of the Food Technology and Nutrition Department, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India. The noodles were prepared from different concentrations (5%, 10%, 15% and 20%) of spent grains of different compositions. The five different compositions of spent grains used for the production of noodles are barley, barley and wheat (1:1), barley and rice (1:1), barley and maize (1:1), barley and finger millets (1:1), which are encoded as BB, BW, BR, BM and BF respectively.

Noodles preparation

The noodles were prepared using the method described by Singh *et al.* (2018) with some modifications. For control noodles, 100 g of wheat flour were combined with 50 mL of water, and for the other samples, different types of spent grains were blended in different concentrations (5%, 10%, 15% and 20%) with wheat flour, then 50 mL of distilled water was mixed with the blended flour to prepare a dough and rested for 20 min at ambient temperature. The dough was extruded into a 1.5 mm thick sheet of noodles using a hand extruder. The dough sheet was divided into strips for the noodles, which were then dried at room temperature for 6–8 h and packed in zip pouches until further analysis. The sample code of different concentrations of noodles are given in Table 1.

Water-holding capacity (WHC) of flour dough

The water-holding capacity of flour dough was determined by the method given by Tan *et al.* (2018). A total quantity of 5 g of flour was taken in a centrifuge vial, and 25 mL of water was added to it, then mixed by the vortex mixer for 15–20 s. The dough and water mixture were centrifuged at 12 298 g for 15 min. The supernatant was discarded, and the WHC was calculated using the following formula.

$$\text{WHC} = \frac{\text{Weight of hydrated sample} - \text{Weight of dry sample}}{\text{Weight of dry sample}}$$

Table 1 Sample code of different concentrations of noodles

Type of spent grains	Usage level (%)	Sample code
Control	0	Control
Barley	5	BB-05
Barley	10	BB-10
Barley	15	BB-15
Barley	20	BB-20
Barley and Wheat	5	BW-05
Barley and Wheat	10	BW-10
Barley and Wheat	15	BW-15
Barley and Wheat	20	BW-20
Barley and Rice	5	BR-05
Barley and Rice	10	BR-10
Barley and Rice	15	BR-15
Barley and Rice	20	BR-20
Barley and Maize	5	BM-05
Barley and Maize	10	BM-10
Barley and Maize	15	BM-15
Barley and Maize	20	BM-20
Barley and Finger millet	5	BF-05
Barley and Finger millet	10	BF-10
Barley and Finger millet	15	BF-15
Barley and Finger millet	20	BF-20

Cooking properties of noodles

Cooking properties were estimated by the methods given by Tan *et al.* (2018). Ten strands of each type of uncooked noodles were taken, and the weight was noted. Then it was boiled in 400 mL of distilled water. The optimum cooking time was checked by withdrawing the noodles strands from the boiling water after 5 min and subsequently at 30 s time interval. The noodles were rinsed and placed in between two glass sheets and gently squeezed. The central core of the noodles was then checked. The time at which the white central core disappeared was considered as the optimum cooking time.

Cooked noodles were rinsed with cold distilled water for 30 s and then drained for 5 min before weighing. The cooking yield of noodles was calculated by the formula.

$$\text{Cooking yield } (\%) = \frac{\text{Noodles weight after cooking}}{\text{Weight of uncooked noodles}} \times 100$$

Cooking loss was calculated by evaporating 100 mL of the cooking water to a constant weight in a hot air oven at 105 °C. The weight of the solid material lost from the noodle strand in the cooking water was used to calculate the cooking loss.

$$\text{Cooking loss } (\%) = \frac{\text{Remaining solid content after drying noodles (g)}}{\text{Weight of noodles (g)}} \times 100$$

Total protein content

Protein estimation was done by the Kjeldahl method. This method was used to determine the percentage of nitrogen content, and a conversion factor of 6.25 was used to calculate the protein content. The procedure was performed in three steps as follows: digestion, distillation and titration.

Digestion

A total quantity of 0.2 g of the sample was digested with 20 mL of concentrated sulphuric acid and 5 g of digestion mixture, which contained potassium sulphate and copper sulphate in the ratio of 5:1 in a Kjeldahl digestion flask. The content was cooled, diluted with a small amount of distilled water and transferred into a 50 mL volumetric flask. The volume was made up to the mark with the addition of distilled water.

Distillation

A 5 mL aliquot was taken in a distillation flask, followed by the addition of 10 mL of 40% NaOH. Liberated ammonia was collected through a condenser in a flask containing 10 mL of 0.1 N HCl to which methyl red indicator was prior added.

Titration

Methyl red indicator containing liberated ammonia solution was titrated against 0.1 N HCl. The amount of HCl used to neutralise the indicator was recorded. One blank sample containing concentrated sulphuric acid and a digestion mixture was also run along with the experimental samples (Rizvi *et al.*, 2022).

$$\text{Nitrogen } (\%) = \frac{[A-B] \times 0.0014 \times \text{volume of digest}}{\text{Aliquot taken} \times S} \times 100$$

Where A is the sample titre (mL), B is the blank titre (mL) and S is the weight of the sample taken.

The protein content was estimated by the following formula:

$$\text{Protein } (\%) = \text{Nitrogen } (\%) \times 6.25$$

Crude fibre content

A total quantity of 2 g moisture and fat-free sample were digested with 200 mL of 1.25% sulphuric acid by gentle boiling for 1 h. The content was filtered, and the residue was washed several times with hot distilled water until it became free from acid. The acid-free residue was then transferred to the flask with 200 mL of 1.25% NaOH added. The content was again digested for 1 h, filtered and the residue was again washed with hot distilled water until it became alkali free. The residue was dried at 100 °C for overnight, and then it was placed in a muffle furnace at 600 °C (±50 °C) for 4 h. The loss in weight after the ignition of the sample represents the crude fibre content in the sample (Madubuike & Okolo, 2016).

The percentage of crude fibre was calculated as follows:

$$\text{Crude fibre content } (\%) = \frac{(W2-W1)}{(w1-W)} \times 100$$

Where W is the weight of empty crucible (g), $W1$ is the weight of crucible + sample before ignition (g) and $W2$ is the weight of crucible + sample after ignition (g).

Gluten content

Gluten content was estimated by the method of FSSAI Method No. 03.012:2022, 2022. A total quantity of 25 g of flour was weighed in a dish, about 15 mL of water was added and the dough was made. The dough was gently kept in a beaker filled with water and left for 1 h. It was then removed in a piece of bolting silk

cloth with an aperture of 0.16 mm, and washed with a gentle stream of water until the water passing through the silk did not change to a blue colour when a drop of iodine solution was added. The silk tight was spread on a porcelain plate to facilitate scraping. The residue was collected to form a ball, squeezed in the palms to remove excess water, transferred to a watch glass or Petri dish and kept in the oven at 100 °C for drying. When partially dried, it was removed and cut into several pieces with a scissor and again kept in the oven to dry, cooled in a desiccator and weighed. It was then returned to the oven for a half an hour, cooled and weighed to ensure constant weight.

$$\text{Gluten on dry weight basis (\%)} = \frac{\text{weight of dry gluten} \times 100}{25\,(100-\text{Moisture content})}$$

Estimation of antioxidant efficacy

The antioxidant activity was determined using the $DPPH^{\bullet}$ assay. The calibration curve was plotted using ascorbic acid as a reference. A total quantity of 0.1 g sample was dissolved in 10 mL ethanol, and 250 µL solution was taken and mixed with 2.0 mL of 0.1 mM $DPPH^{\bullet}$ ethanol solution and incubated for 30 min in the dark. Then the absorption of the solution was measured at 517 nm using a spectrophotometer to determine the reduction of the $DPPH^{\bullet}$ free radical (Abeynayake *et al.*, 2022).

$$\text{Percentage Inhibition of DPPH}^{\bullet} = \frac{(A-A1)}{A} \times 100$$

Where A is the absorbance of the control, and $A1$ is the absorbance of the extract.

Determination of free phenolic acid content

The free phenolic acid content of spent grains was determined by the Folin–Ciocalteu assay. The calibration curve was plotted using gallic acid as a reference. Briefly, a stock solution of ethanolic extract was prepared by dissolving 0.1 g sample in 10 mL ethanol. For the working solution, a 500 µL solution was taken from the stock solution, and the volume was made up to 2 mL by adding 1500 µL ethanol. A total quantity of 20 µL of fresh Folin–Ciocalteu reagent was mixed thoroughly into the extract solution and incubated for 10 min. in the dark room. A 200 µL of Na_2CO_3 (7.5%) aqueous solution was then added to the reaction solution, and samples were incubated for 30 min at 30 °C. The absorbance of the samples was measured at 765 nm. Free phenolic acid content was found from the regression equation and expressed as mg gallic acid equivalent per gram (Zago *et al.*, 2022).

Determination of free flavonoid content

Quercetin was used as a reference standard to plot a calibration curve. A quantity of 0.1 g of the sample was dissolved in 10 mL ethanol medium, and 500 µL of the sample was taken from the stock solution in the test tube, and volume was made up to 2 mL using triple distilled water. A total quantity of 20 µL of 5% $NaNO_2$ aqueous solution was added and incubated for 5 min at ambient temperature. After that, 20 µL of 10% $AlCl_3$ aqueous solution was added and given a 6 min rest at ambient temperature. Then, 200 µL of 1 M NaOH aqueous solution was added to the mixture, and absorbance was taken at 510 nm. The free flavonoid content was found from the regression equation and expressed as mg quercetin equivalent per gram (Merten *et al.*, 2022).

Amylase inhibition assay

Alpha-amylase inhibition is a significant therapeutic target in controlling the postprandial rise in blood glucose in diabetes patients. The amylase inhibition activity was estimated according to the method of Kumar *et al.* (2020). The substrate solution was prepared by mixing soluble starch (500 mg) in 25 mL of 0.4 M NaOH and heating for 5 min at 100 °C. The pH of the solution was adjusted to 7.0 (HCl), and the volume was made to 100 mL by adding triple distilled water. The samples were prepared in acetate buffer and maintained a pH of 6.5. Then, 200 µL of the sample was taken, and 400 µL of substrate solution and 200 µL of α-amylase solution (50 µg mL^{-1}) were added to it and incubated for 15 min at 25 °C. Then 800 µL of 0.1 M HCl and 2000 µL (2 mL) of 1 mM iodine solution were added. The optical density was measured at 650 nm using a visible spectrophotometer. Amylase inhibitory activity was calculated as follows:

$$\text{Amylase inhibitory activity (\%)} = 1-\frac{(\text{ODb}-\text{ODa})}{(\text{ODd}-\text{ODc})} \times 100$$

Where ODa is the optical density of solution containing sample extract, starch and amylase, ODb is the optical density of solution containing sample extract and starch, ODc is the optical density of solution containing starch and amylase and ODd is the optical density of the solution containing starch.

Lipase inhibition assay

Lipase inhibition assay is helpful in lowering cholesterol levels and is one of the powerful mechanisms against obesity. The lipase inhibition assay was estimated according to the literature. First of all, the

substrate solution was prepared by dissolving the lecithin (10 mg), sodium cholate (5 mg) and glycerol trioleate (80 mg) in 9 mL of 0.1 M TES buffer by maintaining pH 7. Extract of every sample was prepared in 0.1 M TES buffer. Then, 500 µL of lipase solution was added to 1000 µL sample and 1000 µL substrate solution in the test tube, and it was incubated for 30 min at 37 °C. The optical density was measured at 550 nm using a visible spectrophotometer. Lipase inhibitory activity was calculated as follows:

$$\text{Lipase inhibitory activity } (\%) = 1 - \frac{(OD2 - OD1)}{(OD4 - OD3)} \times 100$$

Where OD1 is the optical density of solution containing sample extract, substrate and lipase, OD2 is the optical density of solution containing sample extract and substrate, OD3 is the optical density of solution containing substrate and lipase and OD4 is the optical density of the solution containing substrate (Patil *et al.*, 2017).

Fourier transform infrared spectroscopy (FTIR)

Functional groups present in spent grains powder were evaluated, and spectra were recorded using FTIR analysis (PerkinElmer FTIR spectrophotometer, equipped with KBr beam splitter) using approximately 5 mg of dried sample and 5 mg KBr for the qualitative analysis. The FTIR spectrophotometer used a spectrum range of 400–4000 cm^{-1} using nitrogen as the background with a resolution of 4 cm^{-1} and diamond type crystal was used for analysis (Singh *et al.*, 2022).

Microbiological analyses

For the microbiological analyses, total plate count and total fungal count were determined. The main purpose of the total plate count and the total fungal count is to estimate the number of microorganisms in a food sample and to check whether the food is consumable or not.

Total plate count

The total plate count was determined by AOAC, 2019 method. A quantity of 1 g of the sample was added to the test tube and dried in a hot air oven; 9 mL of double distilled water was added and the sample was mixed properly. Then, 1 mL from the sample was transferred to a 10^{-1} (first dilution) labelled test tube, which contains 9 mL of double distilled water. Similarly, up to 10^{-6} dilutions of the sample were prepared. Then, 1 mL of the sample was transferred into 10^{-6} sterilised Petri dish. A quantity of 20 mL of prepared nutrient agar was poured into a petri dish and allowed to solidify after mixing it properly by clockwise and anti-clockwise rotation. The petri dish was incubated for 24 h at 37 °C. The colonies were counted with the help of a colony counter and multiplied with the dilution factor.

$$\text{Total plate count (CFU/mL)} = \frac{\text{No. of colonies} \times \text{dilution factor}}{\text{Volume of culture plate}}$$

Total fungal count

The total fungal count was determined by AOAC, 2019 method. A total of 1 g of the sample was added to the test tube and dried in a hot air oven, 9 mL of double distilled water was added and the sample was mixed properly. Then, 1 mL from the sample was transferred to a 10^{-1} (first dilution) labelled test tube, which contains 9 mL of double distilled water. Similarly, up to 10^{-6} dilutions of the sample were prepared. Then, 1 mL of the sample was transferred into 10^{-6} sterilised petri dish. A total quantity of 20 mL of prepared potato dextrose agar was poured into a petri dish and allowed to solidify after mixing properly by clockwise and anti-clockwise rotation. After that, the petri dish was incubated for 24 h at 37 °C. The colonies were counted with the help of a colony counter and multiplied with the dilution factor.

$$\text{Total fungal count (CFU/mL)} = \frac{\text{No. of colonies} \times \text{dilution factor}}{\text{Volume of culture plate}}$$

Sensory evaluation of noodles

The sensory evaluation of the prepared noodle samples was performed by 50 semi-trained panellists (25 males and 25 females of age 20–35 years). The panellists were given a pre-idea about the product's sensory attributes (colour and appearance, body and texture, taste and aroma). The 9-point hedonic scale was used for the sensory evaluation of the noodle samples. The freshly cooked warm noodle samples were served in odourless plastic containers in an isolated booth. Panellists received one sample at a time with 2 min break in between two samples with samples not exceeding four per test session. Potable water at room temperature was used to rinse the mouth in between samples (Singh *et al.*, 2018).

Statistical analysis

Microsoft Excel, 2019 (Microsoft Corp., Redmond, WA, USA) was used to calculate the standard error mean. Statistical difference in terms of significant and

non-significant values was confirmed by one-way and two-way analysis of variance, and comparison between means was made by critical difference value.

Results and discussion

In this study, the different compositions of noodles were prepared from 5%, 10%, 15% and 20% of spent grains of different compositions, and further analysis were done. Their images are given in Fig. 1.

Water-holding capacity (WHC)

The WHC results are given in Table 2. The WHC of noodles containing spent grains showed a higher capacity than the control (0.71 g g^{-1}). The 5% concentration of BW (0.73 g g^{-1}) and 5% concentration of BM (0.74 g g^{-1}) showed a non-significant difference ($P > 0.05$) compared with the control (0.71 g g^{-1}). The 5% (0.79 g g^{-1}) and 10% (0.83 g g^{-1}) concentrations of BB showed non-significant difference ($P > 0.05$), whereas 15% (0.90 g g^{-1}) and 20% (0.94 g g^{-1}) concentration of BB showed significant difference ($P < 0.05$) with each other. The 5% (0.73 g g^{-1}) and 10% (0.87 g g^{-1}) concentration of BW showed significant difference ($P < 0.05$); similarly, 15% (0.92 g g^{-1}) and 20% (0.93 g g^{-1}) concentration of BW showed non-significant difference ($P > 0.05$) with each other. The 5% (0.97 g g^{-1}), 10% (0.98 g g^{-1}) and 15% (1.00 g g^{-1}) concentration of BR showed significant difference ($P < 0.05$) with 20% (1.16 g g^{-1}) concentration of BR. The 5% (0.74 g g^{-1}) and 10% (0.80 g g^{-1}) concentration of BM showed significant difference ($P < 0.05$), with 15% (0.90 g g^{-1}) and 20% (0.90 g g^{-1}) concentrations of BM. The 5% (0.93 g g^{-1}) and 20% (1.11 g g^{-1}) concentrations of BF showed significant difference ($P < 0.05$), with 10% (0.97 g g^{-1}) and 15% (1.01 g g^{-1}) concentrations of BF.

The 5% concentration of BW (0.73 g g^{-1}) and BM (0.74 g g^{-1}) showed a non-significant difference ($P > 0.05$) with each other, whereas BB (0.79 g g^{-1}), BR (0.97 g g^{-1}) and BF (0.93 g g^{-1}) showed significant difference ($P < 0.05$) with each other. The 10% concentration of BB (0.83 g g^{-1}) BM (0.80 g g^{-1}), BR (0.98 g g^{-1}) and BF (0.97 g g^{-1}) showed a non-significant difference ($p > 0.05$). The concentration 15% of BB (0.90 g g^{-1}) and BM (0.90 g g^{-1}), BR (1.00 g g^{-1}) and BF (1.01 g g^{-1}) showed a non-significant difference ($P > 0.05$). The 20% concentration of BB (0.94 g g^{-1}) and BW (0.93 g g^{-1}) showed non-significant with each other, whereas BM (0.91 g g^{-1}), BR (1.16 g g^{-1}) and BF (1.11 g g^{-1}) showed significant difference ($P < 0.05$) with each other. According to Tan *et al.* (2020), the WHC of sodium chloride and salt substitutes containing noodles lies between the range of 0.53–1.10 g g^{-1}. WHC of hydro-colloids containing noodles ranges from 0.7 to 1.3 g g^{-1} (Tan *et al.*, 2018). With the addition of BSG, the WHC of noodles was significantly increased. This could be due to the high water absorption capacity of spent grains, as they are rich in dietary fibre, which contains a hydroxyl group that binds with water through a hydrogen bond. The small size particles show higher WHC due to the high surface area for protein and water interaction. It might also be because BSG contains hydrophilic groups with a strong affinity for binding water (Razi *et al.*, 2018).

Cooking properties

Common noodle attributes like cooking yield and cooking loss are utilised by both consumers and businesses to forecast total cooking performance. Noodles with a high cooking yield and minimal cooking loss are ideal and can be regarded as having a high cooking quality. The cooking properties of the noodles are also given in Table 2. The cooking time of control was 7 min and 5%, 10% and 15% concentrations of BB; 5% and 10% concentrations of BF showed the same cooking time as the control. While 20% concentration of BB, 5% and 10% concentrations of BW and 15% concentration of BF showed a higher time of 7 min 30 s. A duration of 8 min time is taken by 15% and 20% concentrations of BW; 5%, 10% and 15% concentrations of BM; 20% concentration of BF, whereas 5% and 10% concentrations of BR; 20% concentration of BM taken 8 min 30 s the higher cooking time is taken by 15% and 20% concentrations of BR. The cooking time of mushroom fortified instant noodles is 7–8 min (Arora *et al.*, 2018). The cooking time of noodles lies between 6 and 9 min (Rani *et al.*, 2018). The optimal cooking time was influenced by the amount of BSG, and higher optimum cooking times for noodles were obtained at increasing levels of BSG addition. This is due to presence of higher content of fibre (non-starchy polysaccharides) and protein content in BSG, which show the higher water absorption properties (Yitayew *et al.*, 2022).

The cooking yield of the control sample is 240% and 15% and 20% concentrations of BW (235% and 225.5%); 5% concentration of BM (225%) showed a lower cooking yield than the control (240%). A percentage of 20% concentration of BW (225.5%) and 5% concentration of BM (225%); 15% concentration of BB (258%) and 5% concentration of BF (258%); 5% concentration of BR (260.5%) and 15% concentration of BM (260%); 20% concentration of BM (269%) and 10% concentration of BF (268.5%); 5% concentration of BB (267%) and 5% concentration of BW (267%) showed non-significant difference ($P > 0.05$) with each other. The highest cooking yield

Figure 1 Noodles images.

(m) BR-20 (n) BM-05 (o) BM-10

(p) BM-15 (q) BM-20 (r) BF-05

(s) BF-10 (t) BF-15 (u) BF-20

was shown by the noodles prepared from a 10% concentration of BM (274%).

The cooking loss of the control sample was 2.12%, and 15% of BB (2.03%) and 10% of BM (1.92%) showed lower cooking loss than the control (2.12%). A percentage of 15% of BB (2.03%) and 10% of BM (1.92%) showed a non-significant difference ($P > 0.05$) with control noodles (2.12%). The 5% concentration of BB (2.36%); 15% concentration of BR (2.29%); 5% concentration of BM (2.34%); 5% (2.19%), 10% (2.26%) and 20% concentrations (2.39%) of BF showed non-significant difference ($P > 0.05$) with each other. The 10% (2.58%) and 20% (2.42%) concentration of BB, 5% concentration of BW (2.53%), 5% concentration of BR (2.47%) and 20% concentration of BM (2.51%) showed non-significant difference ($P > 0.05$) with each other. The 10% (2.82%) and 20% (2.63%) concentrations of BW, 10% (2.69%) concentration of BR, 15% (2.63%) concentration of BM and 15% (2.75%) concentration of BF showed non-significant difference ($P > 0.05$) with each other. The 15% (2.94%) concentration of BW and 20% (3.04%) concentration of BR showed non-significant difference ($P > 0.05$) with each other. The lowest cooking loss was shown by the noodles prepared from a 10% concentration of BM (1.92%).

Total protein content

Total protein content of the samples are given in Table 3. The total protein content of the noodles containing spent grains showed a higher concentration

Table 2 Water holding capacity and cooking properties of different samples of noodles

Sample code	Water holding capacity (g g^{-1})	Cooking time	Cooking yield (%)	Cooking loss (%)
Control	0.71 ± 0.03^{a}	7 min	240 ± 0.35^{c}	2.12 ± 0.13^{a}
BB-05	0.79 ± 0.04^{b}	7 min	267 ± 0.44^{k}	2.36 ± 0.19^{b}
BB-10	0.83 ± 0.04^{b}	7 min	263.5 ± 0.39^{j}	2.58 ± 0.15^{c}
BB-15	0.90 ± 0.02^{c}	7 min	258 ± 0.42^{g}	2.03 ± 0.11^{a}
BB-20	0.94 ± 0.02^{d}	7 min 30 s	251 ± 0.37^{e}	2.42 ± 0.22^{c}
BW-05	0.73 ± 0.02^{a}	7 min 30 s	267 ± 0.46^{k}	2.53 ± 0.25^{c}
BW-10	0.87 ± 0.03^{c}	7 min 30 s	259 ± 0.31^{h}	2.82 ± 0.23^{d}
BW-15	0.92 ± 0.02^{d}	8 min	235 ± 0.34^{b}	2.94 ± 0.19^{e}
BW-20	0.93 ± 0.03^{d}	8 min	225.5 ± 0.46^{a}	2.63 ± 0.12^{d}
BR-05	0.97 ± 0.03^{e}	8 min 30 s	260.5 ± 0.46^{i}	2.47 ± 0.09^{c}
BR-10	0.98 ± 0.01^{e}	8 min 30 s	256 ± 0.39^{f}	2.69 ± 0.16^{d}
BR-15	1.00 ± 0.02^{e}	9 min	246.5 ± 0.32^{d}	2.29 ± 0.21^{b}
BR-20	1.16 ± 0.04^{g}	9 min	251 ± 0.47^{e}	3.04 ± 0.12^{e}
BM-05	0.74 ± 0.02^{a}	8 min	225 ± 0.34^{a}	2.34 ± 0.17^{b}
BM-10	0.80 ± 0.04^{b}	8 min	274 ± 0.48^{o}	1.92 ± 0.08^{a}
BM-15	0.90 ± 0.05^{c}	8 min	260 ± 0.52^{i}	2.63 ± 0.21^{d}
BM-20	0.91 ± 0.04^{c}	8 min 30 s	269 ± 0.49^{l}	2.51 ± 0.18^{c}
BF-05	0.93 ± 0.04^{d}	7 min	258 ± 0.37^{g}	2.19 ± 0.13^{b}
BF-10	0.97 ± 0.01^{e}	7 min	268.5 ± 0.46^{l}	2.26 ± 0.14^{b}
BF-15	1.01 ± 0.06^{e}	7 min 30 s	270.5 ± 0.5^{m}	2.75 ± 0.26^{d}
BF-20	1.11 ± 0.02^{f}	8 min	272 ± 0.55^{n}	2.39 ± 0.18^{b}

Data are presented as mean ± SD; $^{a–n}$Means with the same superscript in a row do not vary significantly ($P < 0.05$) from each other.

than the control (10.12%). The 5%, 10%, 15% and 20% concentration of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other. The 5% concentration of BB (10.82%) and BW (10.93%) showed a non-significant difference ($P > 0.05$) with each other, whereas 5% concentration of BR (11.48%), BM (12.65%) and BF (11.79%) showed significant difference ($P < 0.05$) with each other. The 10% concentration of BB (11.34%) and BW (11.46%), 15% concentration of BB (11.76%) and BW (11.89%) showed non-significant difference ($P > 0.05$) with each other, whereas 10% concentration of BR (11.97%), BM (13.11%) and BF (12.24%); 15% concentration of BR (12.65%), BM (13.99%) and BF (12.96%); 20% concentration of BB (12.02%), BW (12.17%), BR (13.12%), BM (14.84%) and BF (13.47%) showed significant difference ($P < 0.05$) with each other.

The total protein content of mushroom-fortified instant noodles was 9.65%–14.34% (Arora *et al.*, 2018). The protein content was observed at 2.28%–2.97% in rice noodles fortified with cassava

Table 3 Protein content, crude fibre content and gluten content of different samples of noodles

Sample code	Protein content (%)	Crude fibre (%)	Gluten content (%)
Control	10.12 ± 0.09^{a}	8.27 ± 0.09^{a}	5.29 ± 0.05^{n}
BB-05	10.82 ± 0.11^{b}	9.64 ± 0.10^{b}	5.01 ± 0.04^{l}
BB-10	11.34 ± 0.12^{c}	11.02 ± 0.12^{e}	4.78 ± 0.03^{i}
BB-15	11.76 ± 0.10^{d}	12.56 ± 0.14^{i}	4.46 ± 0.04^{f}
BB-20	12.02 ± 0.11^{e}	14.02 ± 0.11^{m}	4.22 ± 0.02^{c}
BW-05	10.93 ± 0.12^{b}	9.89 ± 0.11^{c}	5.07 ± 0.06^{m}
BW-10	11.46 ± 0.11^{c}	11.34 ± 0.14^{f}	4.82 ± 0.04^{j}
BW-15	11.89 ± 0.13^{d}	12.79 ± 0.13^{g}	4.54 ± 0.03^{g}
BW-20	12.17 ± 0.10^{f}	14.32 ± 0.12^{n}	4.28 ± 0.04^{d}
BR-05	11.48 ± 0.14^{c}	10.86 ± 0.16^{d}	4.97 ± 0.05^{l}
BR-10	11.97 ± 0.09^{e}	12.12 ± 0.14^{g}	4.76 ± 0.04^{i}
BR-15	12.65 ± 0.13^{g}	13.65 ± 0.09^{k}	4.41 ± 0.04^{e}
BR-20	13.12 ± 0.12^{i}	14.98 ± 0.13^{o}	4.13 ± 0.06^{b}
BM-05	12.65 ± 0.14^{g}	11.00 ± 0.09^{d}	4.99 ± 0.03^{l}
BM-10	13.11 ± 0.10^{i}	12.37 ± 0.13^{h}	4.71 ± 0.05^{h}
BM-15	13.99 ± 0.13^{k}	13.85 ± 0.14^{l}	4.36 ± 0.06^{e}
BM-20	14.84 ± 0.12^{l}	15.60 ± 0.13^{p}	4.09 ± 0.04^{a}
BF-05	11.79 ± 0.11^{d}	10.97 ± 0.08^{d}	4.91 ± 0.04^{k}
BF-10	12.24 ± 0.13^{f}	12.31 ± 0.11^{h}	4.69 ± 0.05^{h}
BF-15	12.96 ± 0.12^{h}	13.78 ± 0.14^{k}	4.32 ± 0.06^{d}
BF-20	13.47 ± 0.15^{j}	15.01 ± 0.15^{o}	4.04 ± 0.04^{a}

Data are presented as mean ± SD; $^{a–p}$Means with the same superscript in a row do not vary significantly ($P < 0.05$) from each other.

leaves (Poonsri *et al.*, 2019). 8.83%–14.76% protein content was shown in noodles prepared with combination of oat and wheat flour (Kudake *et al.*, 2017). The total protein content of multigrain noodles and Maggie noodles was identified as 16.63% and 10.53% (Rani *et al.*, 2018). The total protein content of multigrain noodles was found to be 19.10% (Rani *et al.*, 2020). The protein content ranges between 12.80% and 20.44% in Spirulina biomass-enriched pasta (Koli *et al.*, 2022). The total protein content was influenced by the amount of BSG due to the presence of globulin, hordein, albumin and glutelin compound (Naibaho *et al.*, 2022). Similarly, the higher protein content for noodles was obtained at increasing levels of BSG addition. The noodles prepared with BM spent grains showed a higher concentration of protein as compared to others due to presence of higher content of protein which directly affect the texture, strengthen, water absorption improved, gas retention and also impart the physical characteristics of food (Kaur *et al.*, 2022; Yitayew *et al.*, 2022).

Crude fibre content

Crude fibre content of the samples are also given in Table 3. The total crude fibre content of noodles containing spent grains showed a higher concentration than the control (8.27%). The 5%, 10%, 15% and

20% concentrations of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other. The 5% concentration of BR (10.86%), BM (11.00%) and BF (10.97%) showed non-significant difference ($P > 0.05$) with each other. The 10% concentration of BB (11.02%), BW (11.34%) and BR (12.12%) showed a significant difference ($P < 0.05$) with BM (12.37%) and BF (12.31%). The 15% concentration of BB (12.56%), BW (12.79%) and BM (13.85%) showed a significant difference ($P < 0.05$) with BR (13.65%) and BF (13.78%), whereas the 20% concentration of BB (14.02%), BW (14.32%) and BM (15.60%) showed significant difference ($P < 0.05$) with BR (14.98%) and BF (15.01%).

The total fibre content of mushroom-fortified instant noodles was 1.8%–2.18% (Arora *et al.*, 2018). The fibre content was observed at 0.77%–5.44% in rice noodles fortified with cassava leaves (Poonsri *et al.*, 2019). Fibre content (0.41%–1.40%) was shown in noodles prepared with combination of oat and wheat flour (Kudake *et al.*, 2017). The total fibre content of multigrain noodles and Maggie noodles was identified as 4.78% and 0.41% (Rani *et al.*, 2018). The total fibre content of multigrain noodles was found to be 5.48% (Rani *et al.*, 2020). The noodles prepared with BM spent grains showed a higher concentration of crude fibre as compared to others. The crude fibre content was influenced by the amount of BSG, and higher crude fibre content for noodles was obtained at increasing levels of BSG addition due to presence of higher fibre content in BSG. It constituted with the lignin, arabinoxylans and cellulose which directly affect the structure of product and also showed several therapeutic properties such as reduce the cholesterol content, improved glycaemic content, gut microbiota and also enhance the absorption of minerals (Sahin *et al.*, 2021).

Gluten content

Gluten content of the samples are also given in Table 3. The total gluten content of noodles containing spent grains showed lower values as compared to the control (5.29%). The 5%, 10%, 15% and 20% concentrations of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other. The 5% concentration of BB (5.01%), BR (5.07%) and BM (4.97%); 10% concentration of BB (4.78%) and BR (4.76%); BM (4.71%) and BF (4.69%); 15% concentration of BR (4.41%) and BM (4.36%); 20% concentration of BM (4.09%), and BF (4.04%) showed non-significant difference ($P > 0.05$) with each other. Whereas the 5% concentration of BW (5.07%) and BF (4.91%), 10% concentration of BW (4.82%), 15% concentration of BB (4.46%), BW (4.54%) and BF (4.32%), 20% concentration of BB (4.22%), BW (4.28%) and BR (4.13%) showed significant difference ($P < 0.05$).

The gluten content of noodles lies between 8% and 14% (Yao *et al.*, 2020). High gluten content leads to an increase in the hardness of the noodles. The gluten content was influenced by the amount of BSG, and the percentage of gluten content is decreasing with the increasing concentration of BSG. The noodles prepared with BF and BM spent grains showed the lowest concentration of gluten content as compared to others because the maize and finger millet is naturally free from the gluten and barley content the low amount due to presence of higher amount of fibre (Devi *et al.*, 2014; Camelo-Méndez *et al.*, 2018).

Antioxidant activity

The DPPH$^{\bullet}$ inhibition assay results of the noodles are given in Table 4. DPPH$^{\bullet}$ inhibition assay of noodles containing spent grains showed higher capacity compared to the control (28.60%). The 5%, 10%, 15% and 20% concentrations of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other. The 5% concentration of BB (29.22%), BW (29.34%), BR (29.68%) and BF (29.84%) showed non-significant difference ($P > 0.05$) with each other. The concentration 10% of BB (29.93%), BW (30.13%) and BR (30.36%) showed significant difference ($P < 0.05$) with each other, while BM (31.04%) and BF (30.89%) showed non-significant difference ($P < 0.05$) with each other. The 15% concentration of all the samples BB (30.72%), BW (31.08%), BR (31.43%), BM (31.97%) and BF (31.78%) showed significant difference ($P < 0.05$) with each other. The 20% concentration of all the samples BB (31.39%), BW (31.67%), BR (32.02%), BM (32.75%) and BF (32.56%) showed significant difference ($P < 0.05$) with each other.

The DPPH$^{\bullet}$ inhibition assay of mushroom-fortified instant noodles was 22.15% to 51.53% (Arora *et al.*, 2018). DPPH$^{\bullet}$ inhibition (14.18%–34.39%) was shown by noodles prepared with the combination of oat and wheat flour (Kudake *et al.*, 2017). DPPH$^{\bullet}$ inhibition assay of multigrain noodles and Maggie noodles were identified as 19.64% and 37.98% (Rani *et al.*, 2018). The DPPH$^{\bullet}$ inhibition of multigrain noodles was found to be 19.64% (Rani *et al.*, 2020). The DPPH$^{\bullet}$ inhibition assay ranges from 43.95% to 50.69% Spirulina biomass-enriched pasta (Koli *et al.*, 2022). The antioxidant activity ranges between 74.25% and 82.85% in black carrot-fortified instant noodles (Singh *et al.*, 2018). Noodles fortified with sorghum powder showed 9.39%–28.45% DPPH$^{\bullet}$ inhibition assay (Kim *et al.*, 2013). The noodles prepared with BM spent grains showed higher percentage inhibition of DPPH$^{\bullet}$. The percentage inhibition of DPPH$^{\bullet}$

Table 4 Percentage inhibition of DPPH, free phenolic acid content and free flavonoid content of different samples of noodles

Sample code	Percentage inhibition of DPPH	Free phenolic acid content (mg GAE/g)	Free flavonoid content (mg QE/g)
Control	28.60 ± 0.11^{a}	127.83 ± 0.43^{a}	120.44 ± 0.36^{a}
BB-05	29.22 ± 0.14^{b}	129.25 ± 0.46^{b}	120.89 ± 0.34^{a}
BB-10	29.93 ± 0.12^{d}	130.91 ± 0.39^{d}	121.76 ± 0.39^{c}
BB-15	30.72 ± 0.16^{g}	132.04 ± 0.44^{e}	122.54 ± 0.41^{d}
BB-20	31.39 ± 0.13^{j}	133.41 ± 0.40^{h}	123.23 ± 0.37^{e}
BW-05	29.34 ± 0.09^{b}	129.92 ± 0.41^{c}	121.23 ± 0.42^{b}
BW-10	30.13 ± 0.11^{e}	131.65 ± 0.43^{e}	122.12 ± 0.45^{c}
BW-15	31.08 ± 0.13^{i}	132.87 ± 0.42^{g}	122.96 ± 0.38^{e}
BW-20	31.67 ± 0.15^{k}	133.99 ± 0.47^{i}	123.86 ± 0.41^{f}
BR-05	29.68 ± 0.17^{c}	129.41 ± 0.46^{b}	121.11 ± 0.37^{b}
BR-10	30.36 ± 0.12^{f}	130.98 ± 0.38^{d}	121.98 ± 0.39^{c}
BR-15	31.43 ± 0.19^{j}	132.27 ± 0.45^{f}	122.74 ± 0.44^{d}
BR-20	32.02 ± 0.15^{l}	133.62 ± 0.42^{h}	123.63 ± 0.41^{f}
BM-05	29.98 ± 0.10^{d}	130.35 ± 0.37^{c}	122.43 ± 0.37^{d}
BM-10	31.04 ± 0.14^{h}	132.06 ± 0.45^{e}	123.80 ± 0.42^{f}
BM-15	31.97 ± 0.17^{l}	133.32 ± 0.49^{g}	124.46 ± 0.39^{g}
BM-20	32.75 ± 0.13^{n}	134.54 ± 0.41^{j}	125.34 ± 0.46^{h}
BF-05	29.84 ± 0.16^{c}	129.53 ± 0.50^{b}	121.95 ± 0.43^{c}
BF-10	30.89 ± 0.18^{h}	131.01 ± 0.40^{d}	122.89 ± 0.41^{d}
BF-15	31.78 ± 0.13^{k}	132.39 ± 0.42^{f}	123.78 ± 0.36^{f}
BF-20	32.56 ± 0.14^{m}	133.68 ± 0.46^{h}	124.62 ± 0.40^{g}

Data are presented as mean ± SD; $^{a–n}$Means with the same superscript in a row do not vary significantly ($P < 0.05$) from each other.

was influenced by the amount of BSG, and the percentage inhibition of DPPH$^{\bullet}$ is increasing with the increasing concentration of BSG due to presence of phenolipids, peptides and polyphenols (Parekh *et al.*, 2017).

Free phenolic acid content

The free phenolic acid contents of the noodles are also given in Table 4. The free phenolic acid content of noodles containing spent grains showed a higher concentration than the control (127.83 mg GAE/g). The 5%, 10%, 15% and 20% concentrations of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other. The 5% concentration of BB (129.25 mg GAE/g), BR (129.41 mg GAE/g) and BF (129.53 mg GAE/g); BW (129.92 mg GAE/g) and BM (130.35 mg GAE/g); 10% concentration of BB (130.91 mg GAE/g), BR (130.98 mg GAE/g) and BF (131.01 mg GAE/g); BW (131.65 mg GAE/g) and BM (132.06 mg GAE/g); 15% concentration of BR (132.07 mg GAE/g) and BF (132.39 mg GAE/g); BW (132.87 mg GAE/g) and BM (133.32 mg GAE/g); 20% concentration of BB (133.41 mg GAE/g), BR (133.62 mg GAE/g) and BF (133.68 mg GAE/g) showed non-significant difference ($P > 0.05$) with each other.

The total phenolic content of mushroom-fortified instant noodles was 117.031–161.411 mg GAE/100 g (Arora *et al.*, 2018). The phenolic content was observed at 0.5–6 g GAE/100 g in rice noodles fortified with cassava leaves (Poonsri *et al.*, 2019). The total phenolic content of multigrain noodles and Maggie noodles were identified as 84.57 mg/100 g GAE and 40.76 mg/100 g GAE (Rani *et al.*, 2018). The total phenolic content of multigrain noodles was found to be 85.57 mg GAE/100 g (Rani *et al.*, 2020). The total phenolic content ranged from 54.63 to 88.75 mg GAE/100 g in Spirulina biomass-enriched pasta (Koli *et al.*, 2022). The phenolic content showed by the wheat noodle was 334.3 μg GAE/g (Li *et al.*, 2015). Qingke barley noodle's phenol content was 71.80 mg/100 g (Tuersuntuoheti *et al.*, 2020). Noodles fortified with sorghum powder showed 28.46–49.44 mg GAE/100 g phenolic content (Kim *et al.*, 2013). The noodles prepared with BM spent grains showed higher free phenolic acid content concentration. The free phenolic acid content was influenced by the amount of BSG, and the percentage of free phenolic acid content is increasing with the increasing concentration of BSG due to presence of phenolic compound in free, insoluble and soluble conjugate form. It also shows the higher hydrogen donating capability and stability of compounds (Parekh *et al.*, 2017).

Free flavonoid content

The free flavonoid contents of the noodles are also given in Table 4. The free flavonoid content of noodles containing spent grains showed a higher concentration compared to the control (120.44 mg QE/g). The 5%, 10%, 15% and 20% concentrations of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other. The 5% concentration of BW (121.23 mg QE/g) and BR (121.11 mg QE/g); 10% concentration of BB (121.76 mg QE/g), BW (122.12 mg QE/g) and BR (121.98 mg QE/g); 15% concentration of BB (122.54 mg QE/g) and BR (122.74 mg QE/g); and 20% concentration of BW (123.86 mg QE/g) and BR (123.63 mg QE/g) showed non-significant difference ($P > 0.05$) with each other. Whereas 5% concentration of BB (120.89 mg QE/g), BM (122.43 mg QE/g) and BF (129.53 mg QE/g), 10% concentration of BM (123.80 mg QE/g) and BF (122.89 mg QE/g), 15% concentration of BW (122.96 mg QE/g), BM (124.46 mg QE/g) and BF (123.78 mg QE/g), 20% concentration of BB (123.23 mg QE/g), BM (125.34 mg QE/g) and BF (124.62 mg QE/g) showed non-significant difference ($P > 0.05$) with each other.

The total flavonoid content ranges from 92.06 to 167.31 pmol QE gram in Spirulina biomass-enriched

Table 5 Amylase inhibition assay and lipase inhibition assay of different samples of noodles

Sample code	Percentage inhibition of amylase	IC50	Percentage inhibition of lipase	IC50
Control	30.12 ± 0.24[a]		25.43 ± 0.21[b]	
		18.97		16.78
BB-05	31.62 ± 0.21[b]		24.43 ± 0.18[a]	
BB-10	34.02 ± 0.29[c]	21.42	27.87 ± 0.19[c]	19.84
BB-15	36.48 ± 0.33[d]		31.21 ± 0.15[d]	
BB-20	39.85 ± 0.45[e]		33.67 ± 0.21[e]	
BW-05	41.11 ± 0.41[f]		31.27 ± 0.24[d]	
BW-10	43.67 ± 0.48[g]	25.83	35.64 ± 0.28[f]	23.41
BW-15	46.32 ± 0.42[h]		39.99 ± 0.23[g]	
BW-20	49.89 ± 0.47[j]		44.23 ± 0.26[i]	
BR-05	52.84 ± 0.50[l]		47.56 ± 0.39[k]	
BR-10	55.41 ± 0.53[n]	33.46	49.03 ± 0.41[l]	31.26
BR-15	57.71 ± 0.49[o]		53.48 ± 0.38[m]	
BR-20	60.99 ± 0.58[p]		57.00 ± 0.43[n]	
BM-05	82.12 ± 0.70[q]		81.34 ± 0.61[o]	
BM-10	85.98 ± 0.71[r]	66.40	83.80 ± 0.64[p]	64.22
BM-15	88.76 ± 0.75[s]		86.76 ± 0.62[q]	
BM-20	91.43 ± 0.77[t]		89.43 ± 0.58[r]	
BF-05	47.89 ± 0.34[i]		35.35 ± 0.29[f]	
BF-10	51.45 ± 0.37[k]	31.67	39.97 ± 0.31[g]	33.49
BF-15	53.92 ± 0.32[m]		41.45 ± 0.34[h]	
BF-20	57.49 ± 0.31[o]		44.94 ± 0.30[j]	

Data are presented as mean ± SD; [a–t]Means with the same superscript in a row do not vary significantly ($P < 0.05$) from each other.

pasta (Koli *et al.*, 2022). The flavonoid content shown by the wheat noodle was 154.2 μg RE/g (Li *et al.*, 2015). Qingke barley noodle's flavonoid content was 36.30 mg/100 g (Tuersuntuoheti *et al.*, 2020). The flavonoid content ranges between 25.23 and 56.43 mg QE/100 g in black carrot-fortified instant noodles (Singh *et al.*, 2018). Noodles fortified with sorghum powder showed 3.32–11.97 mg CE/100 g flavonoid content (Kim *et al.*, 2013). The noodles prepared with BM spent grains showed higher free flavonoid content concentration.

Amylase inhibition assay

The amylase inhibition assay results of the noodles are given in Table 5. The amylase inhibition assay of noodles containing spent grains showed higher capacity compared to the control (30.12) and the IC50 value for control noodles is 18.97. The 5%, 10%, 15% and 20% concentrations of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other. The 15% concentration of BR noodles (57.71%) showed a non-significant difference ($P > 0.05$) with 20% concentration of BF noodles (57.49%). The IC50 values for BB, BW, BR, BM and BF noodles are 21.42, 25.83, 33.46, 66.40 and 31.67 respectively. The percentage inhibition of amylase was influenced by the amount of BSG, and the percentage inhibition of amylase is increasing with the increasing concentration of BSG. The noodles prepared with BM spent grains showed a higher amylase inhibition assay. The possible reason that amylase content was higher in barley and its start activating during the malting process (Zhang & Li, 2017). Similarly, maize naturally content the amylase enzyme during the development stage (Aljabi & Pawelzik, 2022).

Lipase inhibition assay

The lipase inhibition assay results of the noodles are also given in Table 5. The lipase inhibition assay of noodles containing spent grains showed higher capacity compared to the control (25.43%) except 5% concentration of BB noodles (24.43%) and the IC50 value for control noodles is 16.78. The 5%, 10%, 15% and 20% concentrations of all the samples (BB, BW, BR, BM and BF) showed significant difference ($P < 0.05$) with each other.

The 15% (31.21%) concentration of BB noodles showed a non-significant difference ($P > 0.05$) with a 5% (31.27%) concentration of BW noodles. The 10% (35.64%) concentration of BW noodles showed a non-significant difference ($P > 0.05$) with 5% (35.35%) concentration of BF noodles. The 15% (39.99%) concentration of BW noodles showed a non-significant difference ($P > 0.05$) with 10% (39.97%) concentration of BF noodles. The IC50 values for BB, BW, BR, BM and BF noodles are 19.84, 23.41, 31.26, 64.22 and 33.49 respectively. The percentage inhibition of lipase was influenced by the amount of BSG, and the percentage inhibition of lipase is increasing with the increasing concentration of BSG. The noodles prepared with BM spent grains showed a higher lipase inhibition assay. The major reason behind the influence was hydrolysis and catalyses process occur for triacylglycerides during the interface of lipid and water (Schwarz *et al.*, 2002).

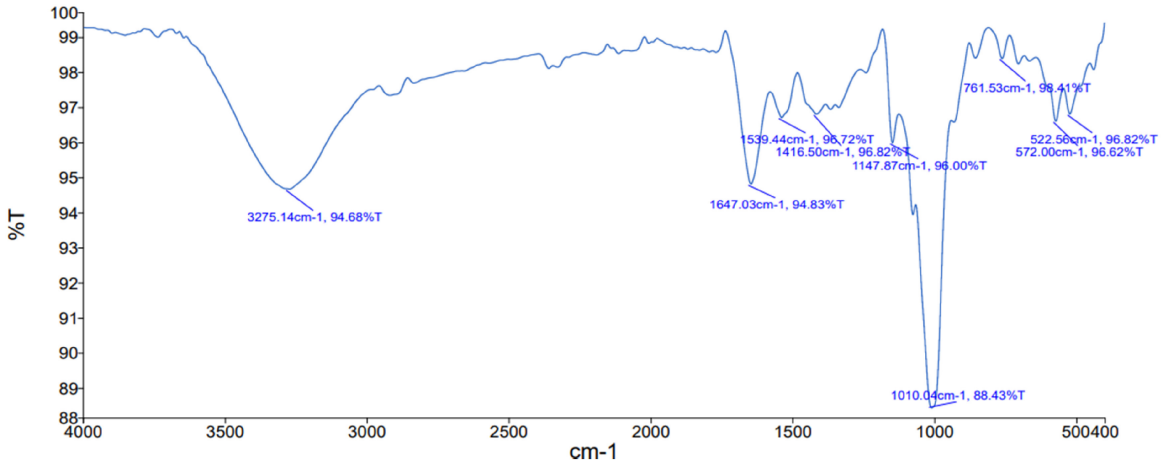
Fourier transform infrared spectroscopy (FTIR)

Fourier transform infrared spectroscopy is also used for the analysis of the secondary structure of proteins. Using FTIR, two broad absorption bands, often known as the amide I and amide II bands, have been found for proteins at wavenumbers of 1700–1600 cm^{-1} and 1600–1500 cm^{-1} respectively. The Amide I band, which is more frequently used to describe the secondary structure, is produced by the peptide bonds' C=O stretching vibrations, which are regulated by the secondary structure such as the α-helix (1650–1657 cm^{-1}), β-sheet (1655–1675 cm^{-1}), *etc.* Similarly, the B-sheet and random structure are obtained at 1626–1640 cm^{-1}

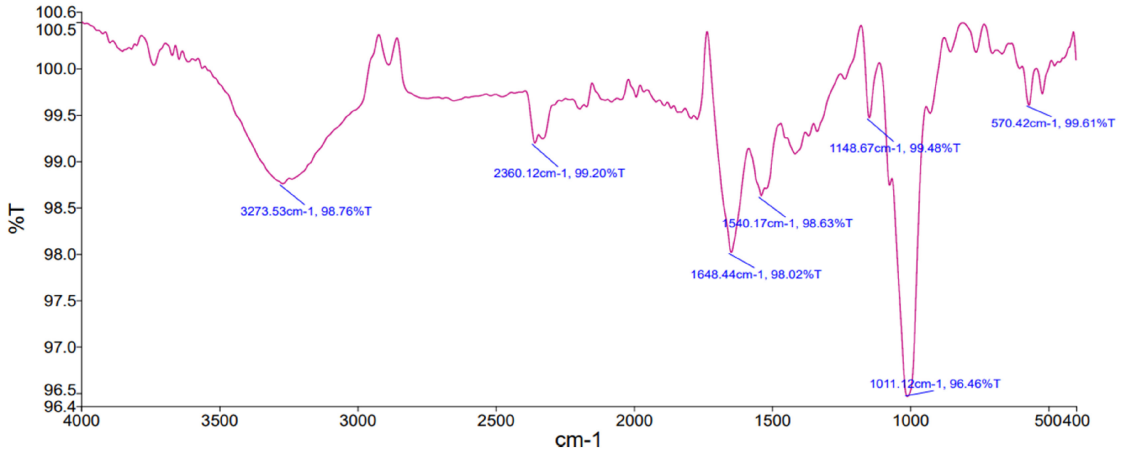
and 1640–1651 cm^{-1} (Arunkumar *et al.*, 2019). FTIR images are shown in Fig. 2. Control noodles revealed nine peaks detected at 3275.14 cm^{-1}, 1647.03 cm^{-1}, 1539.44 cm^{-1}, 1416.50 cm^{-1}, 1147.87 cm^{-1}, 1010.04 cm^{-1}, 761.53 cm^{-1}, 572.00 cm^{-1} and 522.56 cm^{-1}. The peak of 3275.14 cm^{-1} of control noodles showed vibrations in the hydroxyl group (Wahyono *et al.*, 2019). Peak 1647.03 cm^{-1} of control noodles shows C=C stretching of alkene (Chavan & Gaikwad, 2021) and random secondary structure of a protein (Arunkumar *et al.*, 2019). Peak 1539.44 cm^{-1} of control noodles shows the stretching vibrations of the C=C bond (Bui *et al.*, 2015). In control noodles, peak 1416.50 cm^{-1} showed bending of N–H of amines (Brice *et al.*, 2021). Control noodles showed strong stretching in the C–O vibration bond at peaks 1147.87 cm^{-1} and 1010.14 cm^{-1}. Strong stretching in the C–Cl vibrational bond is observed at a peak of 761.53 cm^{-1} in control noodles. Peaks 572.00 cm^{-1} and 522.56 cm^{-1} of control noodles showed the strong stretching in vibration bonds of C–Br. The peak at 1647.03 cm^{-1} and 1010.14 cm^{-1} reflects the adsorbed water bending vibration and amorphous fractions respectively (Zhang *et al.*, 2022).

The 5% concentration of BB revealed seven peaks detected at 3273.53 cm^{-1}, 2360.12 cm^{-1}, 1648.44 cm^{-1}, 1540.17 cm^{-1}, 1148.67 cm^{-1}, 1011.12 cm^{-1} and 570.42 cm^{-1}. The 10% concentration of BB revealed 10 peaks detected at 3280.48 cm^{-1}, 2360.32 cm^{-1}, 1647.17 cm^{-1}, 1539.98 cm^{-1}, 1416.82 cm^{-1}, 1148.12 cm^{-1}, 1010.38 cm^{-1}, 855.70 cm^{-1}, 571.76 cm^{-1} and 523.05 cm^{-1}. The 15% concentration of BB revealed 10 peaks detected at3275.04 cm^{-1}, 2360.00 cm^{-1}, 1647.06 cm^{-1}, 1539.73 cm^{-1}, 1416.87 cm^{-1}, 1148.05 cm^{-1}, 1010.52 cm^{-1}, 761.55 cm^{-1}, 571.39 cm^{-1} and 523.24 cm^{-1}. The 20% concentration of BB revealed 10 peaks detected at 3276.63 cm^{-1}, 2360.62 cm^{-1}, 1771.63 cm^{-1}, 1647.33 cm^{-1}, 1540.11 cm^{-1}, 1417.10 cm^{-1}, 1010.27 cm^{-1}, 761.39 cm^{-1}, 571.57 cm^{-1} and 523.05 cm^{-1}. The 5%, 10%, 15% and 20% concentrations of BB noodles showed stretching vibration of the OH group at peaks 3273.53 cm^{-1}, 3280.48 cm^{-1}, 3275.40 cm^{-1} and 3276.63 cm^{-1} (Tabugon *et al.*, 2021). Peak 2360 cm^{-1} showed the N^{+}-H stretching of vibrational bond in 5%, 10%, 15% and 20% concentrations of BB noodles (Raharja *et al.*, 2017). Strong stretching of the C=O vibrational bond occurs at a peak of 1771.63 cm^{-1} in 20% concentration of BB noodles. Peaks 1648.44 cm^{-1}, 1647.17 cm^{-1}, 1647.06 cm^{-1} and 1647.33 cm^{-1}; 1540.17 cm^{-1}, 1539.98 cm^{-1}, 1539.73 cm^{-1} and 1540.11 cm^{-1} showed C=C stretching of alkene in 5%, 10%, 15% and 20% concentration of BB noodles (Bui *et al.*, 2015; Chavan & Gaikwad, 2021). Peaks 1648.44 cm^{-1}, 1647.17 cm^{-1}, 1647.06 cm^{-1} and 1647.33 cm^{-1} showed the random secondary structure of a protein (Arunkumar *et al.*, 2019). Bending of N–H of amines showed by 1416.82 cm^{-1}, 1416.87 cm^{-1} and 1417.10 cm^{-1} at 10%, 15% and 20% concentration of BB noodles (Brice *et al.*, 2021). Peaks 1148.67 cm^{-1}, 1148.12 cm^{-1} and 1148.05 cm^{-1} at 5%, 10% and 15%; peaks 1011.12 cm^{-1}, 1010.38 cm^{-1}, 1010.52 cm^{-1} and 1010.27 cm^{-1} at 5%, 10%, 15% and 20% concentration of BB noodles showed strong stretching in C–O vibration bond. Strong bending in = C–H occurred at a peak of 855.70 cm^{-1} in 10% concentration of BB noodles. Peak 761.55 cm^{-1}, 761.39 cm^{-1} at 15% and 20% concentration of BB noodles showed strong stretching in the C–Cl vibrational bond. Peaks 570.42 cm^{-1}, 571.76 cm^{-1}, 571.39 cm^{-1} and 571.57 cm^{-1} at 5%, 10%, 15% and 20%; 523.05 cm^{-1}, 523.24 cm^{-1} and 523.05 cm^{-1} at 10%, 15% and 20% concentration of BB noodles showed strong stretching in vibration bonds of C–Br.

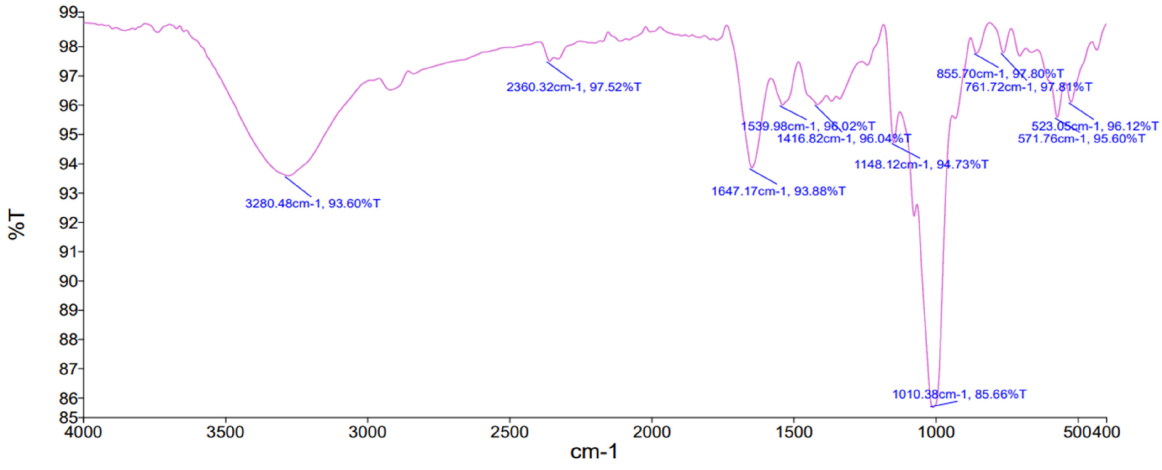
The 5% concentration of BW revealed nine peaks detected at 3273.58 cm^{-1}, 2360.86 cm^{-1}, 1771.91 cm^{-1}, 1648.16 cm^{-1}, 1540.53 cm^{-1}, 1417.68 cm^{-1}, 1011.48 cm^{-1}, 762.09 cm^{-1} and 572.96 cm^{-1}. The 10% concentration of BW revealed 10 peaks detected at 3273.73 cm^{-1}, 2361.20 cm^{-1}, 1772.11 cm^{-1}, 1647.40 cm^{-1}, 1540.10 cm^{-1}, 1417.23 cm^{-1}, 1009.57 cm^{-1}, 761.65 cm^{-1}, 572.23 cm^{-1} and 523.01 cm^{-1}. The 15% concentration of BW revealed five peaks detected at 3276.17 cm^{-1}, 1646.84 cm^{-1}, 1417.05 cm^{-1}, 1006.88 cm^{-1} and 571.86 cm^{-1}. The 20% concentration of BW revealed 11 peaks detected at 3274.97 cm^{-1}, 2360.98 cm^{-1}, 1771.96 cm^{-1}, 1647.64 cm^{-1}, 1540.27 cm^{-1}, 1417.44 cm^{-1}, 1148.07 cm^{-1}, 1007.78 cm^{-1}, 761.63 cm^{-1}, 571.74 cm^{-1} and 522.88 cm^{-1}. The 5%, 10%, 15% and 20% concentration of BW noodles showed stretching vibration of the OH group at peaks 3273.58 cm^{-1}, 3273.73 cm^{-1}, 3276.17 cm^{-1} and 3274.97 cm^{-1} (Tabugon *et al.*, 2021). Peaks 2360.86 cm^{-1}, 2361.20 cm^{-1} and 2360.98 cm^{-1} showed the N^{+}-H stretching of vibrational bond in 5%, 10% and 20% concentrations of BW noodles (Raharja *et al.*, 2017). Strong stretching of the C=O vibrational bond occur at peaks 1771.91 cm^{-1}, 1772.11 cm^{-1} and 1771.96 cm^{-1} in 5%, 10% and 20% concentrations of BW noodles. Peaks 1648.16 cm^{-1}, 1647.40 cm^{-1}, 1646.84 cm^{-1} and 1647.64 cm^{-1} at 5%, 10%, 15% and 20%; 1540.53 cm^{-1}, 1540.10 cm^{-1} and 1540.27 cm^{-1} at 5%, 10% and 20% concentration of BW noodles showed C=C stretching of alkene (Bui *et al.*, 2015; Chavan & Gaikwad, 2021). Peaks 1648.16 cm^{-1}, 1647.40 cm^{-1}, 1646.84 cm^{-1} and 1647.64 cm^{-1} showed the random secondary structure of a protein (Arunkumar *et al.*, 2019). Bending of N–H of amines showed by 1417.68 cm^{-1}, 1417.23 cm^{-1}, 1417.05 cm^{-1} and 1417.44 cm^{-1} at 5%, 10%, 15% and 20% concentration of BW noodles (Brice *et al.*, 2021). Peak 1148 cm^{-1} at 20%, peaks



(a) Control

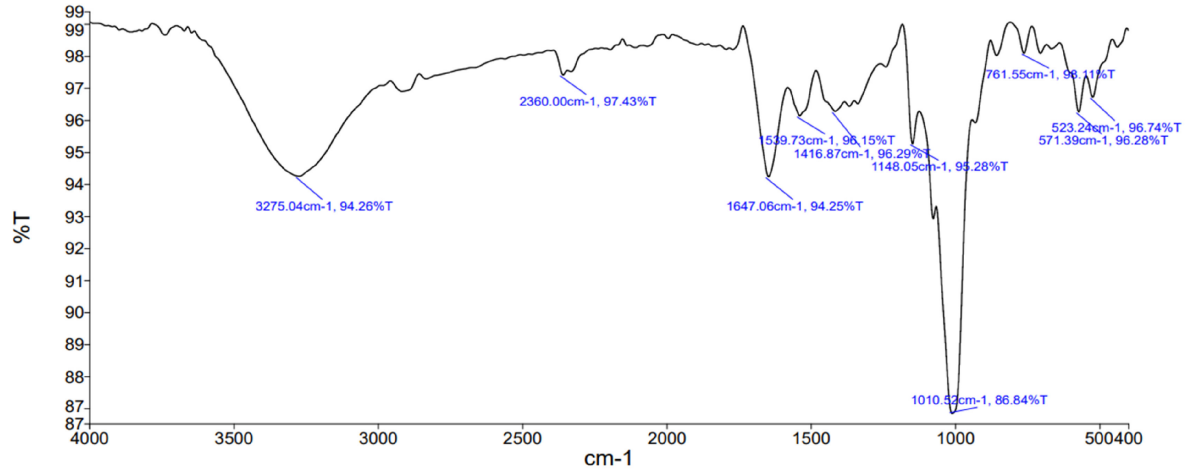


(b) BB-05

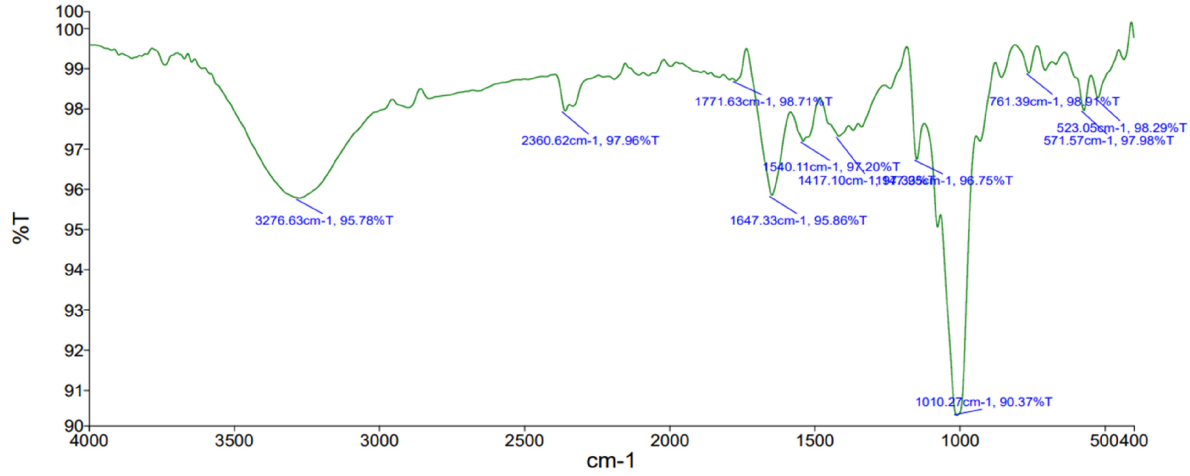


(c) BB-10

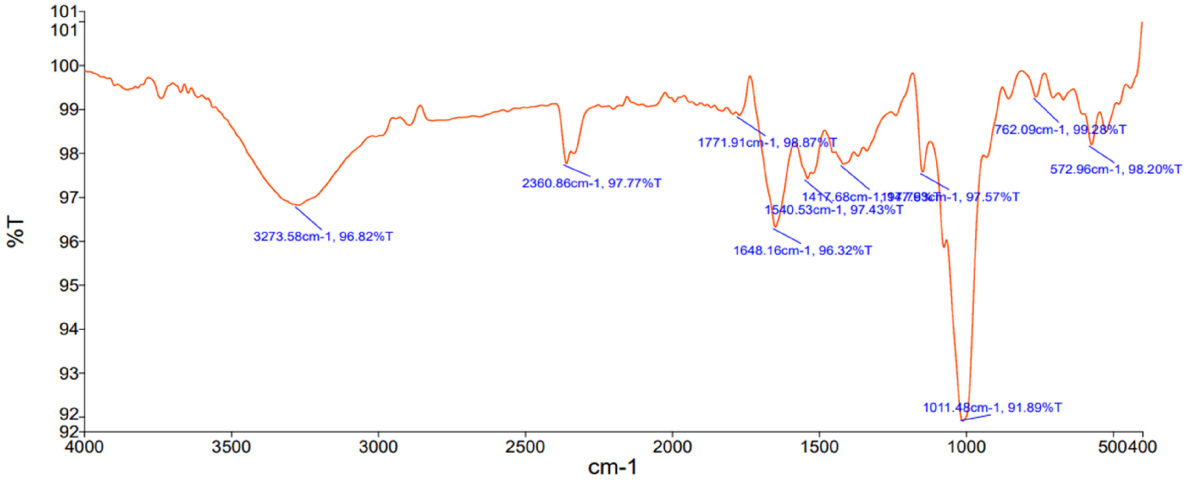
Figure 2 FTIR images of the samples.



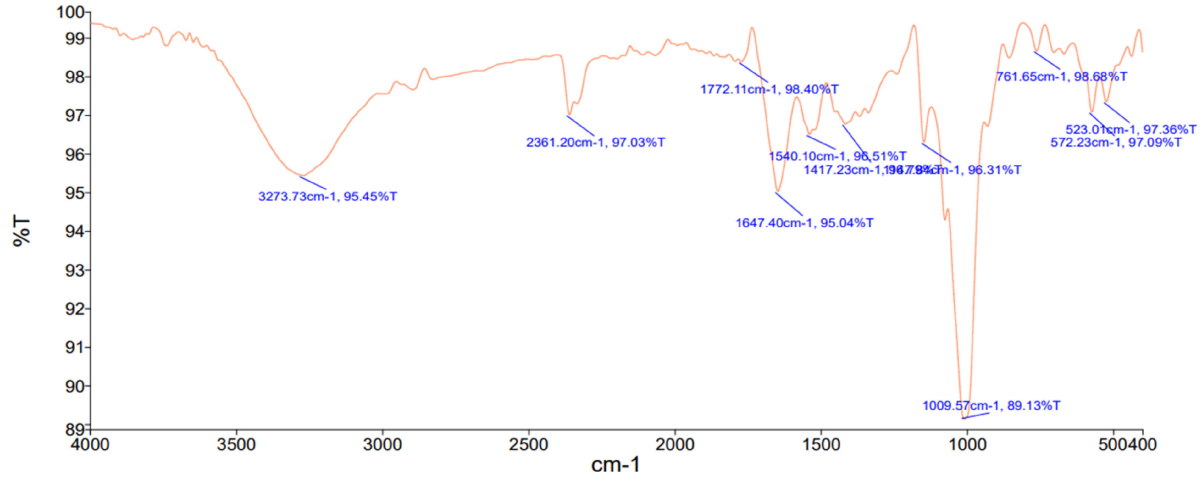
(d) BB-15



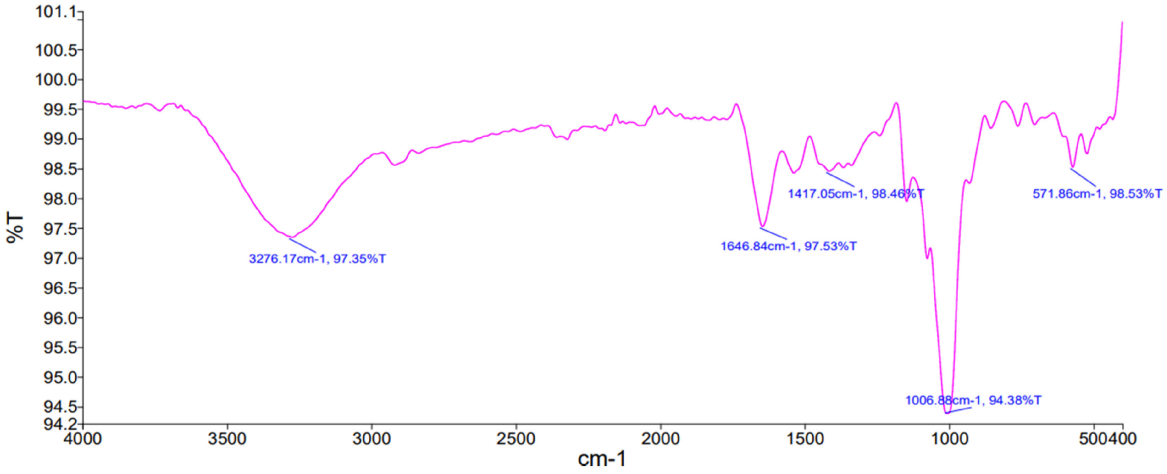
(e) BB-20



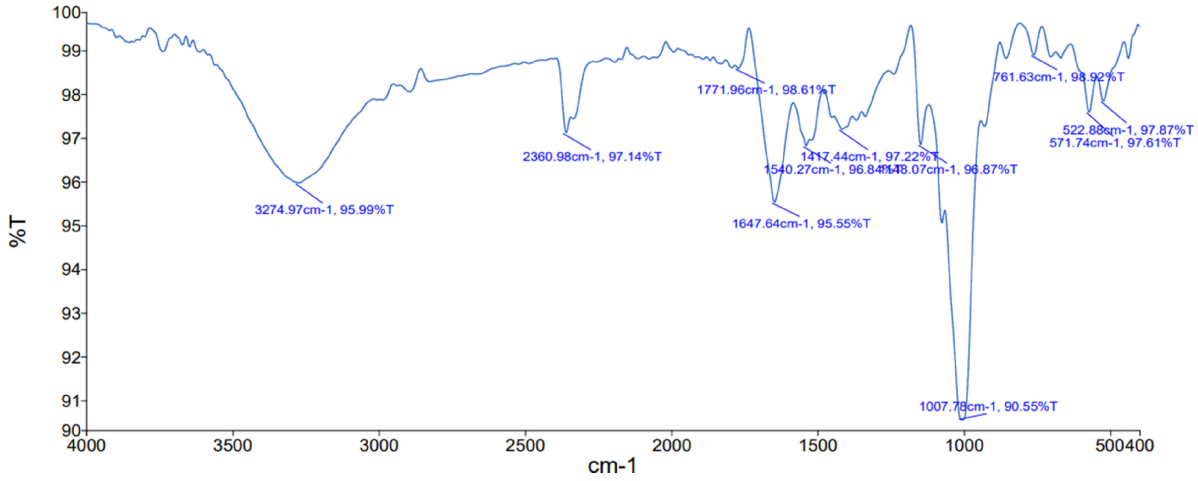
(f) BW-05



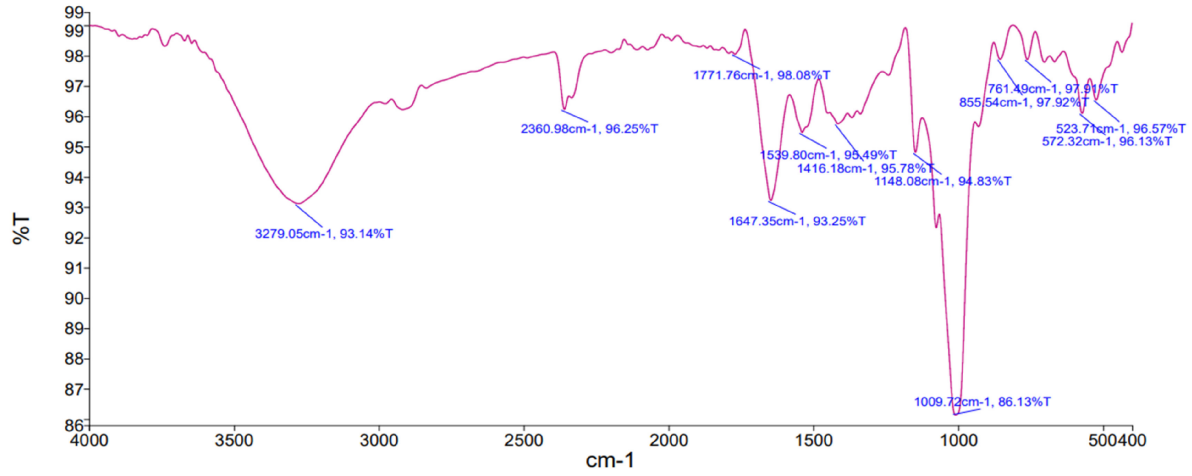
(g) BW-10



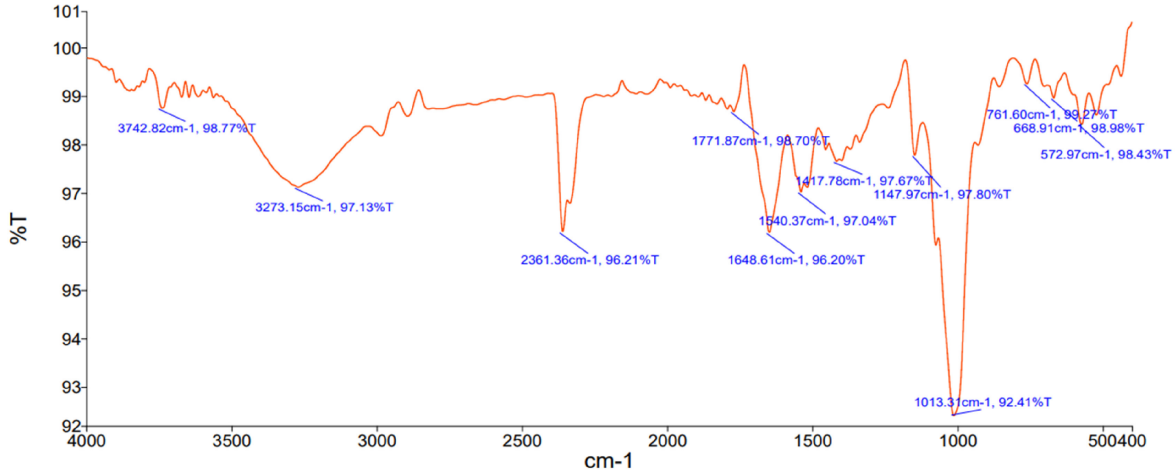
(h) BW-15



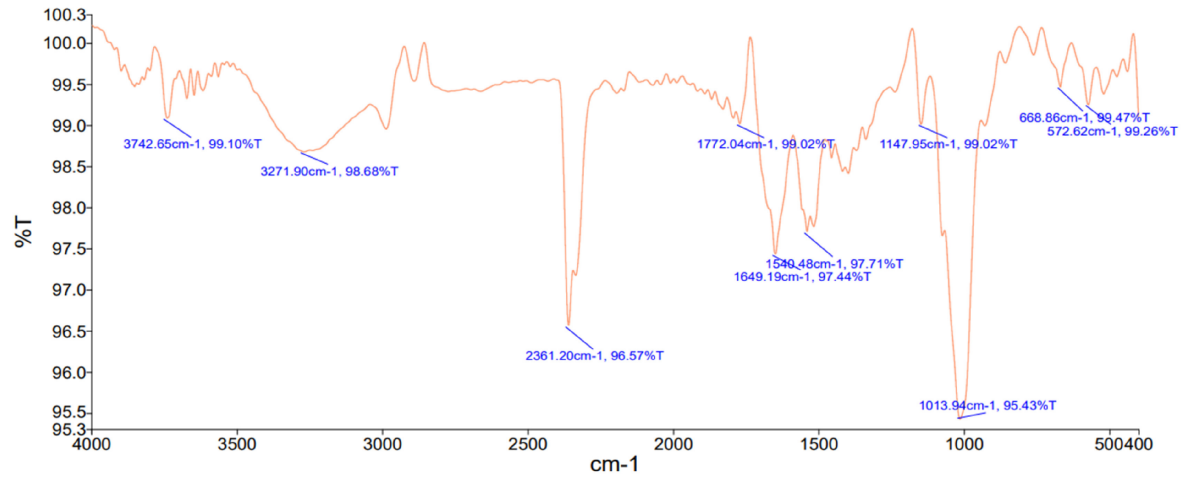
(i) BW-20



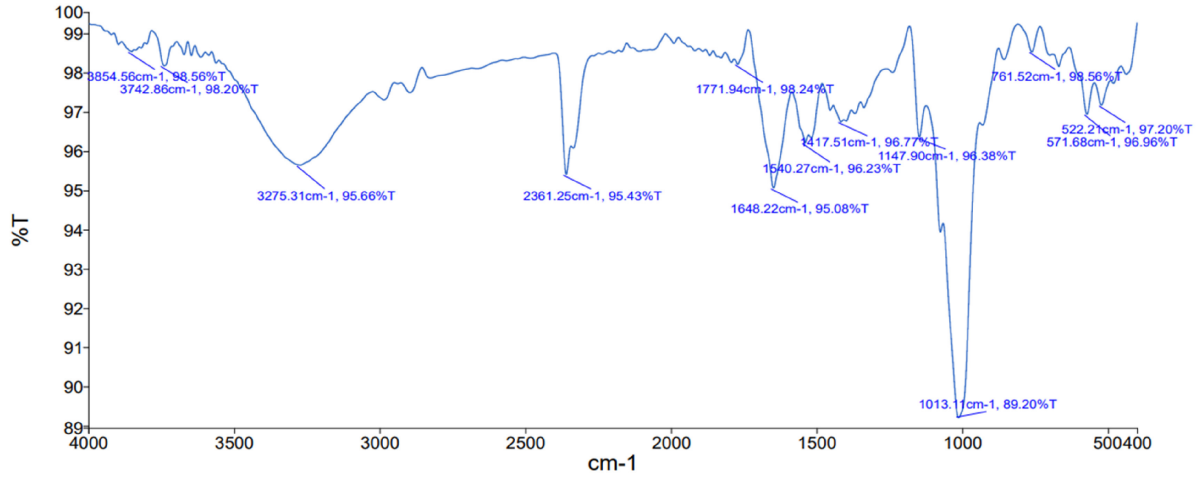
(i) BR-05



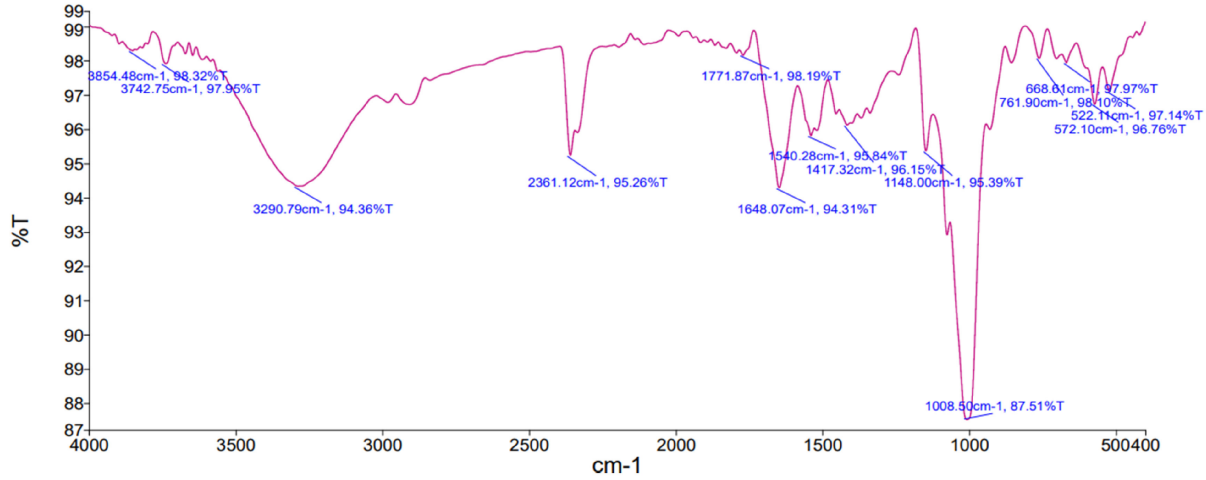
(k) BR-10



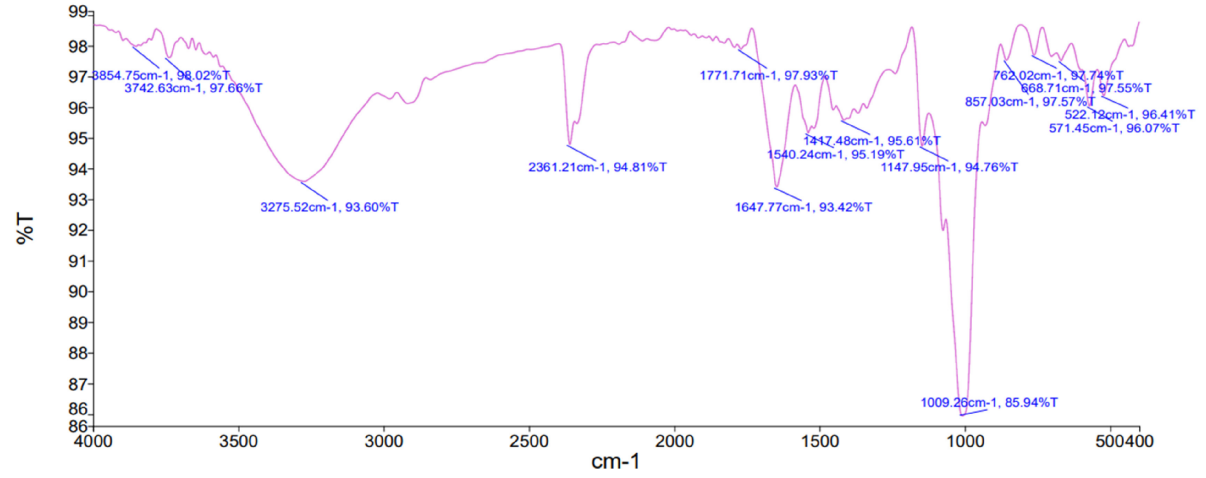
(l) BR-15



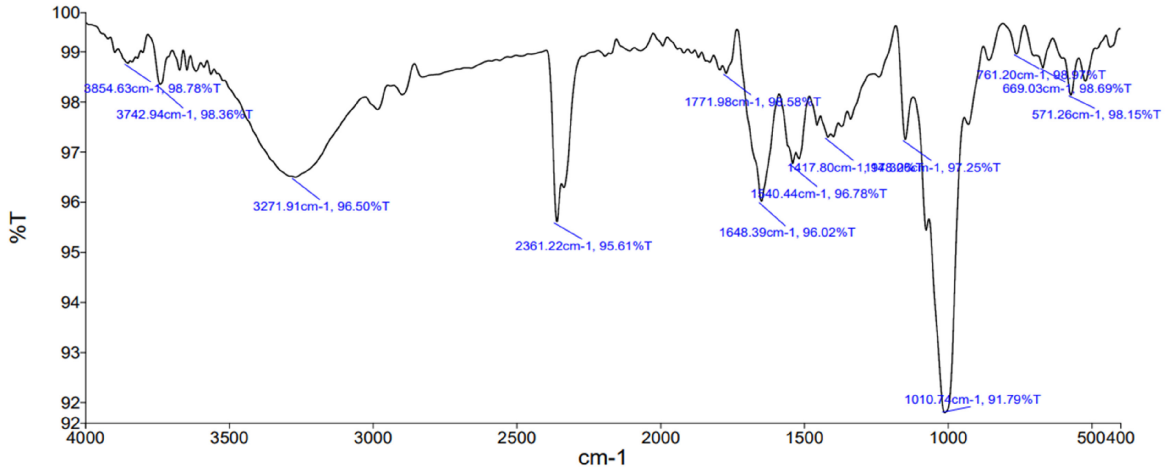
(m) BR-20



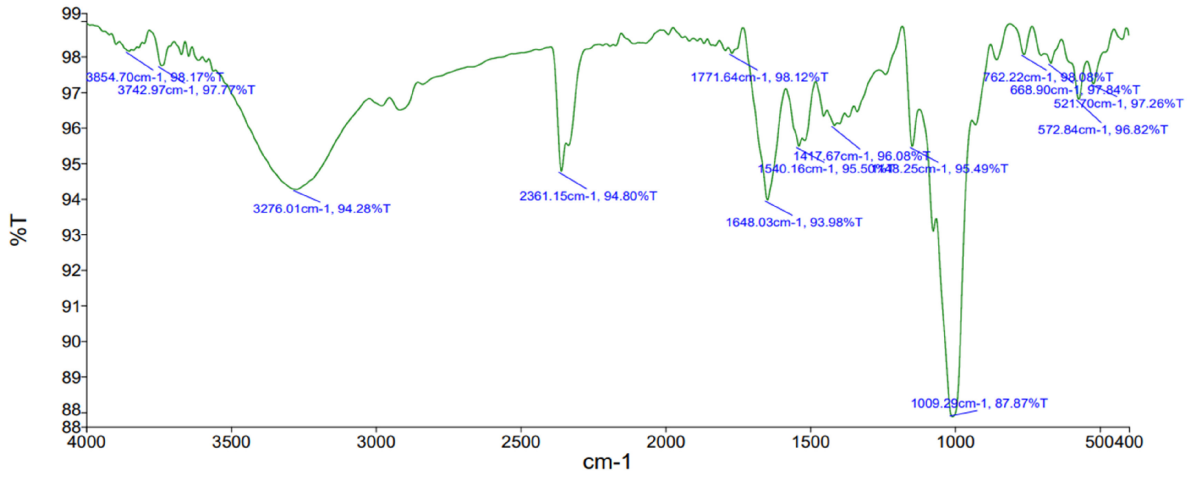
(n) BM-05



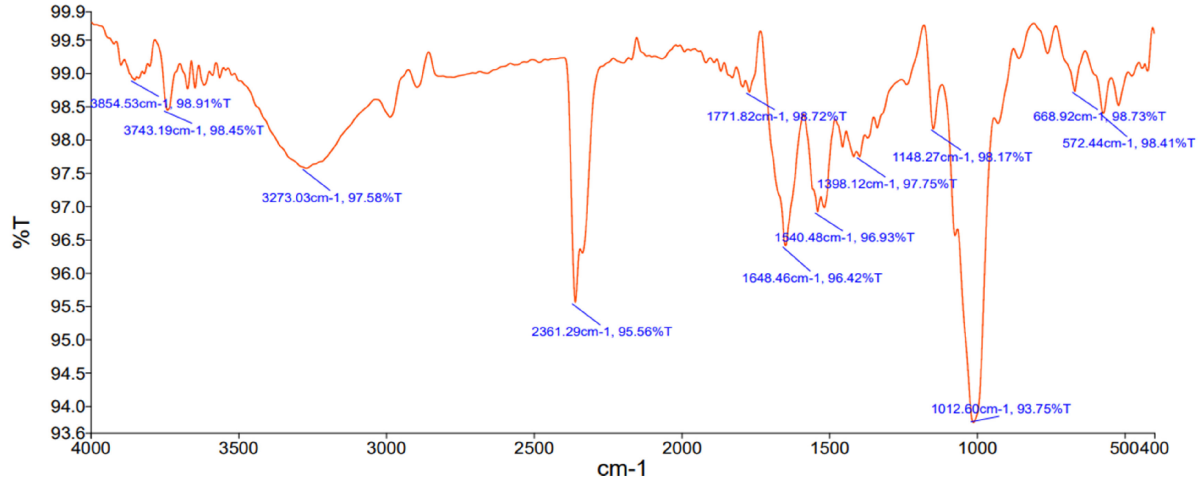
(o) BM-10



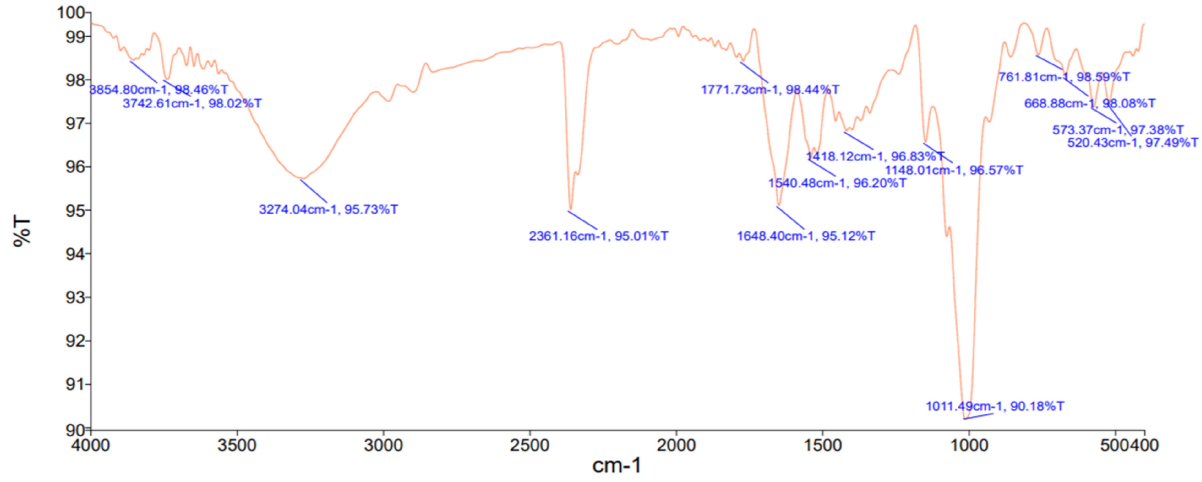
(p) BM-15



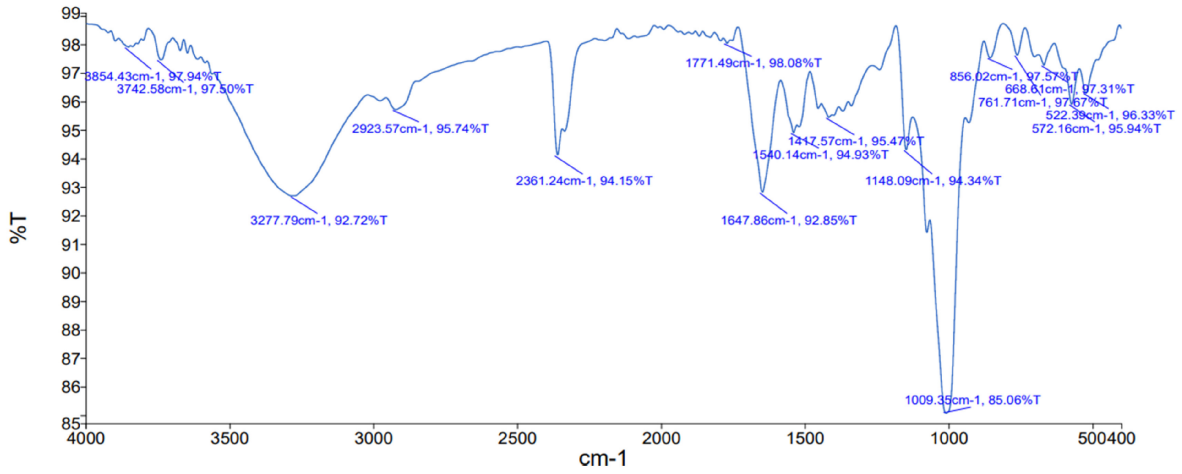
(q) BM-20



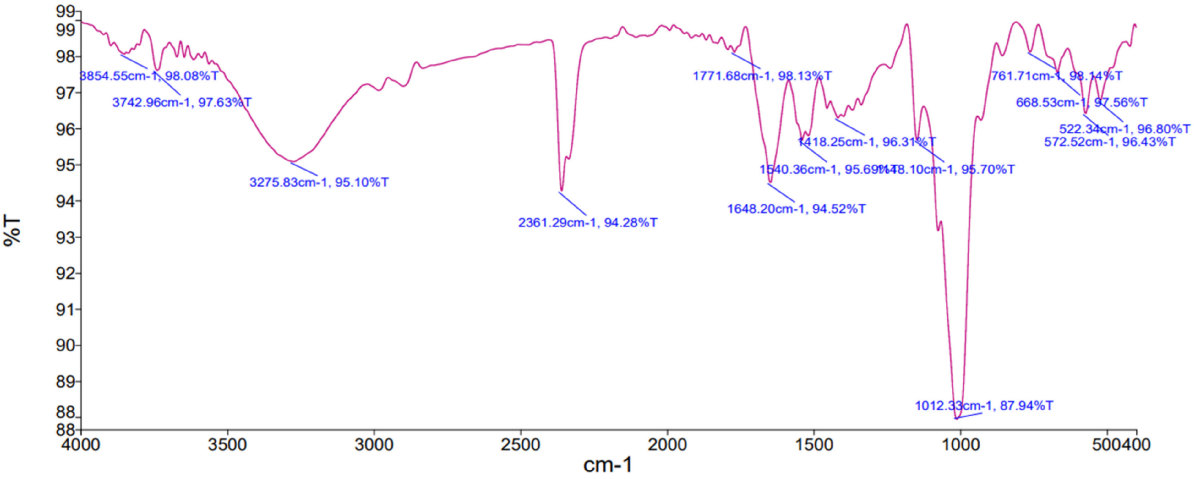
(r) BF-05



(s) BF-10



(t) BF-15



(u) BF-20

1011.48 cm^{-1}, 1009.57 cm^{-1}, 1006.88 cm^{-1}, 1007.78 cm^{-1} at 5%, 10%, 15% and 20% concentration of BW noodles showed strong stretching in C–O vibration bond. Peak 762.09 cm^{-1}, 761.65 cm^{-1}, and 761.63 cm^{-1} at 5%, 10%, and 20% concentrations of BW noodles showed strong stretching in C–Cl vibrational bond. Strong stretching in vibration bonds of C–Br showed at peaks 572.96 cm^{-1}, 572.23 cm^{-1}, 571.86 cm^{-1} and 571.74 cm^{-1} at 5%, 10%, 15% and 20%; 523.01 cm^{-1}, 522.88 cm^{-1} at 10% and 20% concentration of BW noodles.

The 5% concentration of BR revealed 11 peaks detected at 3279.05 cm^{-1}, 2360.98 cm^{-1}, 1771.76 cm^{-1}, 1647.35 cm^{-1}, 1539.80 cm^{-1}, 1416.18 cm^{-1}, 1148.08 cm^{-1}, 1009.72 cm^{-1}, 761.49 cm^{-1}, 572.32 cm^{-1} and 523.71 cm^{-1}. The 10% concentration of BR revealed 12 peaks detected at 3742.82 cm^{-1}, 3273.15 cm^{-1}, 2361.36 cm^{-1}, 1771.87 cm^{-1}, 1648.61 cm^{-1}, 1540.37 cm^{-1}, 1417.78 cm^{-1}, 1147.97 cm^{-1}, cm^{-1}, 1013.31 cm^{-1}, 761.60 cm^{-1}, 668.91 cm^{-1} and 572.97 cm^{-1}. The 15% concentration of BR revealed 10 peaks detected at 3742.65 cm^{-1}, 3271.90 cm^{-1}, 2361.20 cm^{-1}, 1772.04 cm^{-1}, 1649.19 cm^{-1}, 1540.48 cm^{-1}, 1147.95 cm^{-1}, 1013.94 cm^{-1}, 668.86 cm^{-1} and 572.62 cm^{-1}. The 20% concentration of BR revealed 13 peaks detected at 3854.56 cm^{-1}, 3742.86 cm^{-1}, 3275.31 cm^{-1}, 2361.31 cm^{-1}, 1771.94 cm^{-1}, 1648.22 cm^{-1}, 1540.27 cm^{-1}, 1417.51 cm^{-1}, 1147.90 cm^{-1}, 1013.11 cm^{-1}, 761.52 cm^{-1}, 571.68 cm^{-1} and 522.21 cm^{-1}. Peak 3854.56 cm^{-1} at 20%; peaks 3742.82 cm^{-1}, 3742.65 cm^{-1} and 3742.86 cm^{-1} at 10%, 15% and 20%; peaks 3279.05 cm^{-1}, 3273.15 cm^{-1}, 3271.90 cm^{-1}, 3275.31 cm^{-1} at 5%, 10%, 15% and 20% concentration of BR noodles showed stretching of the O–H vibrational bond (Wahyono *et al.*, 2019; Hassan *et al.*, 2020; Tabugon *et al.*, 2021). Peaks 2360.98 cm^{-1}, 2361.36 cm^{-1}, 2361.20 cm^{-1} and 2361.31 cm^{-1} showed the N^{+}-H stretching of vibrational bond in 5%, 10%, 15% and 20% concentration of BR noodles (Raharja *et al.*, 2017). Strong stretching of the C=O vibrational bond occur at peaks 1771.76 cm^{-1}, 1771.87 cm^{-1}, 1772.04 cm^{-1} and 1771.94 cm^{-1} in 5%, 10%, 15% and 20% concentrations of BR noodles. Peaks 1647.35 cm^{-1}, 1648.61 cm^{-1}, 1649.19 cm^{-1}, 1648.22 cm^{-1}; 1539.80 cm^{-1}, 1540.37 cm^{-1}, 1540.48 cm^{-1} and 1540.27 cm^{-1} showed C=C stretching of alkene in 5%, 10%, 15% and 20% concentrations of BR noodles (Bui *et al.*, 2015; Chavan & Gaikwad, 2021). Peaks 1647.35 cm^{-1}, 1648.61 cm^{-1}, 1649.19 cm^{-1} and 1648.22 cm^{-1} showed the random secondary structure of a protein (Arunkumar *et al.*, 2019). Bending of N–H of amines showed by 1416.18 cm^{-1}, 1417.78 cm^{-1} and 1417.51 cm^{-1} at 5%, 10% and 20% concentrations of BR noodles (Brice *et al.*, 2021). Peaks 1148.08 cm^{-1}, 1147.97 cm^{-1}, 1147.95 cm^{-1} and 1147.90 cm^{-1}; peaks 1009.72 cm^{-1}, 1013.31 cm^{-1}, 1013.94 cm^{-1} and 1013.11 cm^{-1} at 5%, 10%, 15% and 20% concentration of BR noodles showed strong stretching in C–O vibration bond. Peaks 761.49 cm^{-1}, 761.60 cm^{-1} and 761.52 cm^{-1} at 5%, 10% and 20%; peaks 668.91 cm^{-1}, 668.86 cm^{-1} at 10% and 15% concentration of BR noodles showed strong stretching in C–Cl vibrational bond. Strong stretching in vibration bonds of C–Br showed at peaks 572.32 cm^{-1}, 572.97 cm^{-1}, 572.62 cm^{-1} and 571.68 cm^{-1} at 5%, 10%, 15% and 20%; 523.71 cm^{-1} and 522.21 cm^{-1} at 5% and 20% concentration of BR noodles.

The 5% concentration of BM revealed 14 peaks detected at 3854.48 cm^{-1}, 3742.75 cm^{-1}, 3290.75 cm^{-1}, 2361.12 cm^{-1}, 1771.87 cm^{-1}, 1648.07 cm^{-1}, 1540.28 cm^{-1}, 1417.32 cm^{-1}, 1148.00 cm^{-1}, 1008.50 cm^{-1}, 761.90 cm^{-1}, 668.60 cm^{-1}, 572.10 cm^{-1} and 522.11 cm^{-1}. The 10% concentration of BM revealed 15 peaks detected at 3854.75 cm^{-1}, 3742.63 cm^{-1}, 3275.83 cm^{-1}, 2361.21 cm^{-1}, 1771.71 cm^{-1}, 1647.77 cm^{-1}, 1540.24 cm^{-1}, 1417.48 cm^{-1}, 1147.95 cm^{-1}, 1009.26 cm^{-1}, 857.03 cm^{-1}, 762.02 cm^{-1}, 668.71 cm^{-1}, 571.45 cm^{-1} and 522.12 cm^{-1}. The 15% concentration of BM revealed 12 peaks detected at3854.63 cm^{-1}, 3742.94 cm^{-1}, 3271.91 cm^{-1}, 2361.22 cm^{-1}, 1771.98 cm^{-1}, 1648.39 cm^{-1}, 1540.44 cm^{-1}, 1417.80 cm^{-1}, 1010.24 cm^{-1}, 761.20 cm^{-1}, 669.03 cm^{-1} and 571.26 cm^{-1}. The 20% concentration of BM revealed 13 peaks detected at 3854.70 cm^{-1}, 3742.97 cm^{-1}, 3276.01 cm^{-1}, 2361.15 cm^{-1}, 1771.64 cm^{-1}, 1648.03 cm^{-1}, 1540.16 cm^{-1}, 1417.67 cm^{-1}, 1148.25 cm^{-1}, 1009.29 cm^{-1}, 762.22 cm^{-1}, 572.84 cm^{-1} and 521.70 cm^{-1}. Peaks 3854.48 cm^{-1}, 3854.75 cm^{-1}, 3854.63 cm^{-1} and 3854.70 cm^{-1}; peaks 3742.75 cm^{-1}, 3742.63 cm^{-1}, 3742.94 cm^{-1} and 3742.95 cm^{-1}; peaks 3290.75 cm^{-1}, 3275.83 cm^{-1}, 3271.91 cm^{-1} and 3276.01 cm^{-1} in 5%, 10%, 15% and 20% concentration of BM noodles showed stretching of O–H vibrational bond (Wahyono *et al.*, 2019; Hassan *et al.*, 2020; Tabugon *et al.*, 2021). Peaks 2361.12 cm^{-1}, 2361.21 cm^{-1}, 2361.22 cm^{-1} and 2361.15 cm^{-1} showed the N^{+}-H stretching of vibrational bond in 5%, 10%, 15% and 20% concentrations of BM noodles (Raharja *et al.*, 2017). Strong stretching of the C=O vibrational bond occurs at peaks 1771.87 cm^{-1}, 1771.71 cm^{-1}, 1771.98 cm^{-1} and 1771.64 cm^{-1} in 5%, 10%, 15% and 20% concentrations of BM noodles. Peaks 1648.07 cm^{-1}, 1647.77 cm^{-1}, 1648.39 cm^{-1} and 1648.03 cm^{-1}1; peaks 1540.28 cm^{-1}, 1540.24 cm^{-1}, 1540.44 cm^{-1} and 1540.16 cm^{-1} in 5%, 10%, 15% and 20% concentrations of BM noodles showed C=C stretching of alkene (Bui *et al.*, 2015; Chavan & Gaikwad, 2021). Peaks 1648.07 cm^{-1}, 1647.77 cm^{-1}, 1648.39 cm^{-1} and 1648.03 cm^{-1} showed the random secondary structure of a protein (Arunkumar *et al.*, 2019). Bending of N–H of amines showed by 1417.32 cm^{-1}, 1417.48 cm^{-1}, 1417.80 cm^{-1} and 1417.67 cm^{-1} in 5%, 10%, 15%

and 20% concentrations of BM noodles (Brice *et al.*, 2021). Peaks 1148.00 cm^{-1}, 1147.95 cm^{-1} 1148.25 cm^{-1} in 5%, 10% and 20%; peaks 1008.50 cm^{-1}, 1009.26 cm^{-1}, 1010.24 cm^{-1} and 1009.29 cm^{-1} in 5%, 10%, 15% and 20% concentrations of BM noodles showed strong stretching in C–O vibration bond. Strong bending in = C–H occurred at a peak of 857.03 cm^{-1} in a 10% concentration of BM noodles. Peaks 761.90 cm^{-1}, 762.02 cm^{-1}, 761.20 cm^{-1} and 762.22 cm^{-1} at 5%, 10%, 15% and 20%; peaks 668.60 cm^{-1}, 668.71 cm^{-1} and 669.03 cm^{-1} in 5%, 10% and 15% concentration of BM noodles showed strong stretching in C–Cl vibrational bond. Strong stretching in vibration bonds of C–Br showed at peaks 572.10 cm^{-1}, 571.45 cm^{-1}, 571.26 cm^{-1} and 572.84 cm^{-1} in 5%, 10%, 15% and 20%; peaks 522.11 cm^{-1}, 522.12 cm^{-1} and 521.70 cm^{-1} in 5%, 10% and 20% concentrations of BM noodles.

The 5% concentration of BF revealed 12 peaks detected at 3854.53 cm^{-1}, 3743.19 cm^{-1}, 3273.03 cm^{-1}, 2361.29 cm^{-1}, 1771.82 cm^{-1}, 1648.46 cm^{-1}, 1540.48 cm^{-1}, 1398.12 cm^{-1}, 1148.27 cm^{-1}, 1012.60 cm^{-1}, 668.92 cm^{-1} and 572.44 cm^{-1}. The 10% concentration of BF revealed 14 peaks detected at 3854.80 cm^{-1}, 3742.61 cm^{-1}, 3274.04 cm^{-1}, 2361.16 cm^{-1}, 1771.73 cm^{-1}, 1648.40 cm^{-1}, 1540.48 cm^{-1}, 1418.12 cm^{-1}, 1148.01 cm^{-1}, 1011.49 cm^{-1}, 761.81 cm^{-1}, 668.88 cm^{-1}, 573.37 cm^{-1} and 520.43 cm^{-1}. The 15% concentration of BF revealed 16 peaks detected at 3854.43 cm^{-1}, 3742.58 cm^{-1}, 3277.79 cm^{-1}, 2923.57 cm^{-1}, 2361.24 cm^{-1}, 1771.49 cm^{-1}, 1647.86 cm^{-1}, 1540.17 cm^{-1}, 1417.57 cm^{-1}, 1148.09 cm^{-1}, 1009.35 cm^{-1}, 856.02 cm^{-1}, 761.71 cm^{-1}, 668.61 cm^{-1}, 572.16 cm^{-1} and 522.39 cm^{-1}. The 20% concentration of BF revealed 14 peaks detected at 3854.55 cm^{-1}, 3742.96 cm^{-1}, 3275.83 cm^{-1}, 2361.29 cm^{-1}, 1771.68 cm^{-1}, 1648.20 cm^{-1}, 1540.36 cm^{-1}, 1418.25 cm^{-1}, 1148.10 cm^{-1}, 1012.33 cm^{-1}, 761.71 cm^{-1}, 668.53 cm^{-1}, 572.52 cm^{-1} and 522.34 cm^{-1}. Peaks 3854.53 cm^{-1}, 3854.80 cm^{-1}, 3854.43 cm^{-1}, 3854.55 cm^{-1}; peaks 3743.19 cm^{-1}, 3742.61 cm^{-1}, 3742.58 cm^{-1} and 3742.96 cm^{-1}; peaks 3273.03 cm^{-1}, 3274.04 cm^{-1}, 3277.79 cm^{-1} and 3275.83 cm^{-1} in 5%, 10%, 15% and 20% concentrations of BF noodles showed stretching of O–H vibrational bond (Wahyono *et al.*, 2019; Hassan *et al.*, 2020; Tabugon *et al.*, 2021). Peak 2923.57 cm^{-1} in 15% concentration of BF noodles showed symmetrical stretching in the CH_3 bond (Durazzo *et al.*, 2018). Peaks 2361.29 cm^{-1}, 2361.16 cm^{-1}, 2361.24 cm^{-1} and 2361.29 cm^{-1} showed the N^+-H stretching of vibrational bond in 5%, 10%, 15% and 20% concentrations of BF noodles (Raharja *et al.*, 2017). Strong stretching of the C=O vibrational bond occurs at peaks 1771.82 cm^{-1}, 1771.73 cm^{-1}, 1771.49 cm^{-1} and 1771.68 cm^{-1} in 5%, 10%, 15% and 20% concentrations of BF noodles. Peaks 1648.46 cm^{-1}, 1648.40 cm^{-1}, 1647.86 cm^{-1} and 1648.20 cm^{-1}; peaks 1540.48 cm^{-1}, 1540.48 cm^{-1}, 1540.17 cm^{-1} and 1540.36 cm^{-1} in 5%, 10%, 15% and 20% concentration of BF noodles showed C=C stretching of alkene (Bui *et al.*, 2015; Chavan & Gaikwad, 2021). Peaks 1648.46 cm^{-1}, 1648.40 cm^{-1}, 1647.86 cm^{-1} and 1648.20 cm^{-1} showed the random secondary structure of a protein (Arunkumar *et al.*, 2019). Bending of N–H of amines showed by 1418.12 cm^{-1}, 1417.57 cm^{-1} and 1418.25 cm^{-1} in 10%, 15% and 20% concentrations of BF noodles (Brice *et al.*, 2021). Peak 1398.12 cm^{-1} in 5% concentration of BF noodles showed variable bending in the CH bond. Peaks 1148.27 cm^{-1}, 1148.01 cm^{-1}, 1148.09 cm^{-1} and 1148.10 cm^{-1}; peaks 1012.60 cm^{-1}, 1011.49 cm^{-1}, 1009.35 cm^{-1} and 1012.33 cm^{-1} in 5%, 10%, 15% and 20% concentrations of BF noodles showed strong stretching in C–O vibration bond. Strong bending in = C–H occurred at a peak of 856.02 cm^{-1} in a 15% concentration of BF noodles. Peaks 761.81 cm^{-1}, 762.71 cm^{-1} and 761.71 cm^{-1} in 10%, 15% and 20%; peaks 668.92 cm^{-1}, 668.88 cm^{-1}, 668.61 cm^{-1} and 668.53 cm^{-1} in 5%, 10%, 15% and 20% concentration of BF noodles showed strong stretching in C–Cl vibrational bond. Strong stretching in vibration bonds of C–Br showed at peaks 572.44 cm^{-1}, 573.37 cm^{-1}, 572.16 cm^{-1} and 572.52 cm^{-1} in 5%, 10%, 15% and 20%; peaks 520.43 cm^{-1}, 522.39 cm^{-1} and 522.34 cm^{-1} in 10%, 5% and 20% concentrations of BF noodles.

Total plate count of noodles

The total plate counts of the samples are given in Table 6. The total plate count of the control noodles was 1.4 CFU mL^{-1}. The 5%, 10%, 15% and 20% concentrations of noodles prepared from BB, BR, BM and BF showed significant difference ($P < 0.05$) with each other, whereas 10% and 15% concentrations of BW noodles showed non-significant difference ($P > 0.05$) with each other. The 10% concentration of BW (2.0 CFU mL^{-1}) and BF (1.9 CFU mL^{-1}) noodles showed non-significant difference ($P > 0.05$) with each other. The 15% concentration of BW (1.9 CFU mL^{-1}) and BR (2.0 CFU mL^{-1}) noodles showed non-significant differences ($P > 0.05$) with each other. The 20% concentration of BB (1.2 CFU mL^{-1}) and BF (1.2 CFU mL^{-1}), BW (1.5 CFU mL^{-1}) and BM (1.6 CFU mL^{-1}) noodles showed non-significant differences ($P > 0.05$) with each other. The highest and lowest plate count shown by the sample was 15% concentration of BM (2.9 CFU mL^{-1}) and 5% concentration of BR (1.1 CFU mL^{-1}) noodles respectively. Akhigbemidu *et al.* (2015) found a range of standard plate counts of 17.8×10^3 to 43.8×10^5 CFU g^{-1} in noodles. The

Table 6 Total plate count and total fungal count of different samples of noodles

Sample code	Total plate count (CFU mL^{-1}) at 10^{-6} dilution	Total fungal count (CFU mL^{-1}) at 10^{-6} dilution
Control	1.4 ± 0.04^{b}	1.8 ± 0.04^{d}
BB-05	2.0 ± 0.08^{e}	1.2 ± 0.07^{a}
BB-10	2.3 ± 0.06^{g}	1.6 ± 0.03^{c}
BB-15	1.6 ± 0.12^{c}	2.6 ± 0.09^{g}
BB-20	1.2 ± 0.06^{a}	2.0 ± 0.03^{e}
BW-05	2.4 ± 0.09^{g}	1.3 ± 0.07^{b}
BW-10	2.0 ± 0.07^{e}	2.8 ± 0.13^{h}
BW-15	1.9 ± 0.03^{e}	1.7 ± 0.12^{d}
BW-20	1.5 ± 0.07^{c}	1.9 ± 0.04^{e}
BR-05	1.1 ± 0.10^{a}	1.2 ± 0.08^{a}
BR-10	2.7 ± 0.14^{h}	2.5 ± 0.14^{g}
BR-15	2.0 ± 0.06^{e}	1.1 ± 0.12^{a}
BR-20	1.3 ± 0.08^{b}	1.6 ± 0.07^{c}
BM-05	1.4 ± 0.11^{b}	1.3 ± 0.10^{b}
BM-10	1.7 ± 0.04^{d}	1.4 ± 0.05^{b}
BM-15	2.9 ± 0.06^{i}	1.9 ± 0.09^{e}
BM-20	1.6 ± 0.12^{c}	1.5 ± 0.11^{c}
BF-05	2.1 ± 0.10^{f}	1.2 ± 0.04^{a}
BF-10	1.9 ± 0.05^{e}	1.4 ± 0.06^{b}
BF-15	1.4 ± 0.06^{b}	2.7 ± 0.15^{h}
BF-20	1.2 ± 0.03^{a}	2.3 ± 0.11^{f}

Data are presented as mean ± SD; [a–h]Means with the same superscript in a row do not vary significantly ($P < 0.05$) from each other.

total plate count of noodles was 6.7 to 3.65 CFU g^{-1} (Zula *et al.*, 2021). The total bacterial count in cucumber pomace-enriched noodles lies between 1.9 and 6.4 log CFU (Saad *et al.*, 2021). The specific reason behind the effect of the process on the total plate count was the growth condition and its optimisation, bacterial cell state, role of media and the preservatives used (Jongenburger *et al.*, 2010). In our investigation, total bacterial concentration was detected and confirmed that prepared noodles from the BSG were safe for human consumption.

Total fungal count of noodles

The total fungal counts of the samples are also given in Table 6. The total fungal count of control noodles was 1.8 CFU mL^{-1}. The 5%, 10%, 15% and 20% concentrations of noodles prepared from BB, BW2 and BF showed significant difference ($P < 0.05$) with each other. The 5% (1.2 CFU mL^{-1}) and 15% (1.1 CFU mL^{-1}) concentration of BR noodles showed non-significant difference ($P > 0.05$) with each other. The 5% (1.3 CFU mL^{-1}) and 10% (1.4 CFU mL^{-1}) concentration of BM noodles showed non-significant difference ($P > 0.05$) with each other. The 5% concentration of BB (1.2 CFU mL^{-1}), BR (1.2 CFU mL^{-1}) and BF (1.2 CFU mL^{-1}), BW (1.3 CFU mL^{-1}) and BM (1.3 CFU mL^{-1}) noodles showed non-significant difference ($P > 0.05$) with each other. The 10% concentration of BM (1.4 CFU mL^{-1}) and BF (1.4 CFU mL^{-1}) noodles showed non-significant differences ($P > 0.05$) with each other. The 20% concentration of BB (2.0 CFU mL^{-1}), BF (1.9 CFU mL^{-1}), BR (1.6 CFU mL^{-1}) and BM (1.5 CFU mL^{-1}) noodles showed non-significant differences ($P > 0.05$) with each other. The highest plate count was shown by the 10% concentration of BW (2.8 CFU mL^{-1}) and the lowest plate count was shown by the 5% concentration of BB (1.2 CFU mL^{-1}), BR (1.2 CFU mL^{-1}) and BF (1.2 CFU mL^{-1}) noodles. Akhigbemidu *et al.* (2015) found a range of standard fungal counts of 30–56×10^{1} CFU g^{-1} in noodles. The total fungal count of noodles lies in the range of 5.9 to 2.6 CFU g^{-1} (Zula *et al.*, 2021). The total fungal count in cucumber pomace-enriched noodles lies between 0.9 and 3.0 log CFU (Saad *et al.*, 2021). The effect of process on the total fungal count was occurred on the growth of fungal due to the temperature, moisture level and oxygen content. It also delays the stain, growth and development (Maximiano *et al.*, 2022). In our research, it confirmed the prepared noodles from the different BSG were safe for human consumption on the basis of fungal growth detection on the prepared sample.

Sensory analysis

Table 7 illustrates the sensory evaluation of the noodles prepared from different concentrations of different samples of spent grains. The sensory analysis was done with the consideration of important organoleptic factors such as colour, appearance, taste, aroma, body and texture. The results show that the change in concentration of BSG can affect the organoleptic qualities of the candy. The overall acceptability of the control sample is 7.6 based on hedonic scale-based sensory evaluation. On the basis of the sensory evaluation table, it is obvious that the noodles prepared from 10% concentration of BM spent grains showed higher overall acceptability of 8.47.

On the basis of cooking properties, noodles prepared from BM and BF spent grains showed good results, from which BM-10 shows the highest cooking yield and lowest cooking loss. The highest protein content and crude fibre content were shown by BM noodles. High nutritional content (total phenolic and total flavonoid content) BM and BF noodles. The BM noodles showed high percentage inhibition of DPPH•, percentage inhibition of amylase and lipase. Further, on the basis of sensory evaluation, noodles prepared from 10% concentration of BM noodles showed highest overall acceptability.

Table 7 Sensory Evaluation of different samples of noodles

Sample code	Colour and appearance	Taste	Aroma	Body and texture	Overall acceptability
Control	7.45 ± 0.30^{c}	7.52 ± 0.28^{d}	7.68 ± 0.23^{d}	7.89 ± 0.39^{e}	7.60 ± 0.25^{d}
BB-05	7.06 ± 0.42^{b}	6.50 ± 0.35^{b}	7.00 ± 0.14^{b}	7.10 ± 0.26^{d}	6.92 ± 0.50^{b}
BB-10	7.10 ± 0.28^{b}	6.45 ± 0.20^{b}	7.25 ± 0.26^{c}	7.32 ± 0.43^{d}	7.03 ± 0.18^{b}
BB-15	7.20 ± 0.34^{b}	6.15 ± 0.45^{a}	6.74 ± 0.58^{b}	5.68 ± 0.22^{b}	6.45 ± 0.30^{a}
BB-20	7.28 ± 0.26^{b}	6.25 ± 0.24^{a}	6.51 ± 0.20^{a}	5.12 ± 0.36^{a}	6.29 ± 0.25^{a}
BW-05	7.20 ± 0.30^{b}	7.00 ± 0.45^{c}	7.22 ± 0.18^{c}	7.01 ± 0.43^{d}	7.11 ± 0.38^{b}
BW-10	7.38 ± 0.29^{b}	7.25 ± 0.19^{c}	7.50 ± 0.43^{c}	7.54 ± 0.21^{e}	7.42 ± 0.20^{c}
BW-15	7.45 ± 0.35^{c}	7.00 ± 0.32^{c}	7.40 ± 0.36^{c}	6.18 ± 0.36^{c}	7.01 ± 0.21^{b}
BW-20	7.56 ± 0.34^{c}	6.50 ± 0.15^{b}	7.38 ± 0.48^{c}	5.57 ± 0.48^{b}	6.75 ± 0.33^{b}
BR-05	7.04 ± 0.27^{b}	7.10 ± 0.22^{c}	7.30 ± 0.28^{c}	6.20 ± 0.24^{c}	6.91 ± 0.29^{b}
BR-10	7.39 ± 0.29^{b}	7.26 ± 0.14^{c}	7.25 ± 0.16^{c}	7.06 ± 0.36^{d}	7.24 ± 0.31^{c}
BR-15	7.43 ± 0.55^{b}	7.48 ± 0.42^{d}	7.42 ± 0.37^{c}	5.72 ± 0.28^{b}	7.02 ± 0.27^{b}
BR-20	7.28 ± 0.35^{b}	6.72 ± 0.25^{b}	7.00 ± 0.48^{b}	5.35 ± 0.42^{a}	6.59 ± 0.34^{a}
BM-05	8.02 ± 0.36^{d}	7.51 ± 0.26^{d}	7.00 ± 0.22^{b}	7.51 ± 0.38^{e}	7.51 ± 0.35^{c}
BM-10	8.53 ± 0.25^{e}	8.50 ± 0.25^{e}	8.25 ± 0.35^{e}	8.60 ± 0.30^{f}	8.47 ± 0.50^{e}
BM-15	7.12 ± 0.35^{b}	7.65 ± 0.50^{d}	7.40 ± 0.25^{c}	6.37 ± 0.43^{c}	7.14 ± 0.43^{c}
BM-20	7.04 ± 0.22^{b}	7.08 ± 0.38^{c}	7.31 ± 0.52^{c}	5.79 ± 0.45^{b}	6.81 ± 0.28^{b}
BF-05	6.10 ± 0.25^{a}	6.25 ± 0.40^{a}	7.56 ± 0.26^{c}	7.15 ± 0.25^{d}	6.77 ± 0.23^{b}
BF-10	6.48 ± 0.52^{a}	6.48 ± 0.55^{b}	7.21 ± 0.38^{c}	7.34 ± 0.46^{d}	6.88 ± 0.25^{b}
BF-15	6.29 ± 0.29^{a}	6.10 ± 0.30^{a}	7.60 ± 0.45^{c}	5.70 ± 0.34^{b}	6.42 ± 0.50^{a}
BF-20	6.25 ± 0.15^{a}	6.00 ± 0.45^{a}	6.42 ± 0.20^{a}	6.28 ± 0.26^{c}	6.23 ± 0.30^{a}

Data are presented as mean ± SD; $^{a-f}$Means with the same superscript in a row do not vary significantly ($P < 0.05$) from each other.

Conclusion

The noodles were prepared at different concentrations from different spent grains samples. The noodles prepared from barley and maize spent grains were found to have high nutritional value as compared to others. On the basis of sensory evaluation, the noodles prepared from 10% concentration of barley and maize spent grains were selected as it has good texture, colour and appearance. It was comparatively good in taste and aroma from other samples. Production of noodles from spent grains can increase the nutritional value of noodles and it can be used as a value-added product.

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Author contributions

Anisha Anisha: Resources (equal); writing – original draft (equal). **Mukul Kumar:** Writing – review and editing (equal); Data curation (equal). **Deepika Kaushik:** Writing – original draft (equal). **Ashwani Kumar:** Data curation (equal). **Tuba Esatbeyoglu:** Writing – review and editing (equal). **Charalampos Proestos:** Writing – review and editing (equal). **Mohammad Rizwan Khan:** Writing – review and editing (equal). **Tahra Elobeid:** Writing – review and editing (equal). **Jasjit Kaur:** Resources (equal).

Conflicts of interest

The authors have declared no conflicts of interest.

Ethical approval

Ethics approval was not required for this research.

Peer review

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Data availability statement

The data that support the findings of this study are available from the authors upon reasonable request.

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