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Research Article

Formulation and Nutritional Characterization of Mustard and Sesame Oilseed Cake Extract-Based Functional Drinks

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The current investigation was carried out to develop polyphenol-enriched functional drinks from oil industry waste. Purposely, polyphenols were extracted from the mustard and sesame oilseed cakes through ultrasound-aided extraction alongside conventional extraction mode for comparison purposes. Among the oilseed cake extracts, sesame with methanol and ultrasonic extraction exhibited best results for TPC, DPPH, FRAP, ABTS, and β-carotene as 39 ± 0.04 g GAE/100 g, 35 ± 0.02 g TE/100 g, 20 ± 0.02 g TE/100 g, 18 ± 0.03 g TE/100 g, and 35 ± 0.05 g TE/100 g, respectively, and mustard showed 31 ± 0.04 g GAE/100 g, 20 ± 0.01 g TE/100 g, 16 ± 0.02 g TE/100 g, 12 ± 0.01 g TE/100 g, and 30 ± 0.05 g TE/100 g, respectively. In case of conventional extraction and methanol as solvent, sesame revealed outcomes for TPC, DPPH, FRAP, ABTS, and β-carotene as 13 ± 0.02 g GAE/100 g, 17 ± 0.03 g TE/100 g, 10 ± 0.01 g TE/100 g, 21 ± 0.04 g TE/100 g, and 15 ± 0.03 g TE/100 g, respectively, compared to mustard which showed for TPC, DPPH, FRAP, ABTS, and β-carotene as 11 ± 0.02, 12 ± 0.01, 08 ± 0.01, 17 ± 0.03, and 10 ± 0.01, respectively. Likewise, for mustard oilseed cake extract with conventional extraction technique and water as solvent, minimum findings were observed for TPC, DPPH, FRAP, ABTS, and β-carotene as07 ± 0.01,09 ± 0.02,06 ± 0.01,14 ± 0.03, and07 ± 0.01, respectively. T0 without extracts, T1 (sesame oilseed cake extract based Functional drink) , and T2 (mustard oilseed cake extract based Functional drink). The recorded values for total phenols, total flavonoids, total carotenoids, and vitamin C in T_0, T_1, and T_2 were 29.79 ± 6.05, 32.53 ± 7.05, and 30.5 ± 5.05; 26.33 ± 5.05, 30.60 ± 7.05, and 29.75 ± 5.05; 2.11 ± 0.05, 2.12 ± 0.05, and 2.08 ± 0.01; and 31.7 ± 7.05, 30.5 ± 5.05, and 29.6 ± 6.05, respectively. Likewise, sensory evaluation for color, flavor, sweetness, sourness, and overall acceptability during 2 months of storage depicted acceptable scores. The inclusive best outcomes for phytochemical analysis were achieved with sesame oilseed cake extracts by applying ultrasonic extraction technique and methanol as solvent. In the same way, among the developed functional drinks, T_1 (sesame oilseed cake extract-based functional drink) exhibited best physiochemical as well as storage characteristics.

1. Introduction

Agroindustrial waste disposal is considered the biggest challenge to developing economies by reason of their deleterious effect on the environment. Meanwhile, they hold an array of phytochemicals that can modulate various health discrepancies. Recently, agroindustrial waste-based bioactive compounds are in limelight owing to their potential health benefits. This fact enhanced the attention of researchers to formulate various functional products by waste valorization. A growing number of research are being conducted on the role of secondary metabolites from plants in food and their

potential effects on human health [1]. Food scientists have long attempted to preserve it with little quality loss by utilizing and researching novel preservation procedures. The food industry has always sought environmentally friendly and long-term solutions to food safety issues [2]. In this milieu, oilseed cakes are loaded with bioactive polyphenols and other antioxidants which play their role in the prevention and treatment of diseases [3]. Numerous previous scientific explorations elucidated that oilseed cakes contain compounds such as tannins, flavonoids, saponins, alkaloids, cardiac glycosides, steroids, anthocyanins, and allantoins that play a pivotal role in disease prevention and cure [4]. Oilseeds are generally known as the most common source of ingredients used for functional food. Oilseeds are loaded with phytochemicals, for example, phenolic compounds, tocopherols, flavonoids, tocotrienols, and lignans. Oil meals or oil cakes are products that remain after the extraction of oil from oil seeds. There are two types of oil cakes: edible oil cakes and nonedible oil cakes [5]. The nutritional value of edible oil cakes is higher compared to nonedible oil cakes. The protein content of edible oil cakes varies from 15% to 50% (http://www.seaoWndia.com). Based on different conditions, mainly depending upon growing conditions and variety, their composition varies. Mustard has been utilized for the treatment of various ailments such as arthritis and rheumatism, for aching feet as a foot bath, and in plaster a form to cure pneumonia and bronchitis on the chest and back [6]. The extracts of mustard (Brassicaceae seed metals) have tremendous antioxidant activity resulting from the phenolic compounds present in them.

Sesame seeds are vital oilseed crops. Sesame oil generation ranks 8th in the world's oilseed market. Sesame seeds can be utilized separately as well as incorporated into various food products as key ingredients [7]. The antioxidants from sesame oilseeds have been extracted by applying conventional extraction techniques, but contrary to this [8], these techniques have many drawbacks which include a large volume of solvent utilization, longer processing time, and solvent residue removal which are frequently inhibited by food regulation laws. The extraction methods also affect the nutritional values of oil seed cakes. Recently, ecofriendly technologies such as ultrasound, microwave-assisted method, pulse electric field, supercritical fluid extraction, high-pressure processing, and negative pressure cavitation are being used [9]. Various techniques have been optimized for extraction of bioactive compounds from oilseed cakes, and the extracts have been compared for phenolic contents, total lignans, and antioxidant activity. Ultrasound is one of the advanced technologies, based on the mechanism of sound frequency ranging between 18 and 100 kHz [3]. The antioxidant is efficiently extracted from mustard and oilseed cakes by using conventional and ecoinnovative technologies, which can be used to prepare a variety of functional drinks, nutraceutical beverages, bakery products, extruded products, energy bars, and indigenous products [10] [11]. In light of the foregoing, the primary goal of the current study was to optimize the extraction efficiency of mustard oilseed cake and sesame oilseed cake-based bioactive compounds using green extraction technologies, as well as to measure their antioxidant activity, before developing functional drinks using mango juice in combination with mustard oilseed cake extract and sesame oilseed cake extract separately. The drinks were further evaluated for their antioxidant, sensorial, and physiochemical profiles.

2. Material and Methods

The current research project was conducted in the Food Science Department of Government College University, Faisalabad, Pakistan. The project was divided into 3 modules. In the 1st module, phytochemical analysis of mustard and sesame oilseed cake extracts was done by conventional and ultrasonic extraction. In the 2nd module, mustard and sesame oilseed cake-based functional drinks were prepared separately. In the last module, phytochemical and sensory analyses of the developed functional drinks were done.

2.1. Procurement of Raw Materials and Preparation of Extract. Mustard and sesame oilseed cakes were purchased from a local oil processing industry in Faisalabad. Fresh mangoes (Chaunsa) were purchased from the local market of Faisalabad, and other ingredients like yellow color, vanilla flavor, and preservative potassium sorbate E number-202 which were of high quality as well as of research grade were purchased from a scientific store in Faisalabad.

2.2. Conventional Extraction. The extraction method for mustard oilseed cake and sesame oilseed cake was carried out individually, with necessary adjustments reproted by Rodriguez-Saona et al. [12]. The constant temperature of $60 \pm 2 \circ$ C along with a time duration of 30, 60, and 90 minutes was kept. The samples of mustard oilseed cake and sesame oilseed cake (25 g) were added separately in 125 mL solvent (methanol 80% and distilled water). After this, filtration of the extracts was done by Whatman filter paper 40 (Whatman, United Kingdom). For maintaining safe or allowed limits of methanol, the extracts were passed through rotavapor to eliminate methanol residues before drying of extracts. The obtained extracts were stored in airtight bottles, in the Functional Food and Nutraceutical Laboratory of the Food Science Department, Government Collage University, Faisalabad, at 4°C to prevent fungal attacks.

2.3. Ultrasonic Extraction. The extraction process for mustard oilseed cake and sesame oilseed cake was done separately by following Rusak et al. [13] with required modifications. At a constant temperature of 60°C, 600 rpm, and time intervals of 5, 10, and 15 minutes, along with ultrasonic frequency 25 kHz and ultrasonic power 50-150 W, 25 g samples (mustard oilseed cake and sesame oilseed cake) were added separately in 125 mL solvent (methanol 80% and distilled water). Sonication of the samples was done by ultrasonic equipment (VCX 750, Newtown). After this, mixture filtration was done by utilizing the Whatman filter paper (Whatman, UK). Hence, the final extracts were gained.

2.4. Antioxidant Activity

2.4.1. Inhibition of β-Carotene Bleaching. The antioxidant potential of the obtained extracts was examined by test described by Heimler et al. [14] depending on the oxidation of β-carotene. In 400 mg Tween 20, 20 mg of β-carotene was dissolved along with 20 mL of chloroform and 40 mL of linoleic acid. 3 mL of the synthesized emulsion was added to 10 mL of the testing sample. The water bath heating removed chloroform (as chloroform dissolves in water from where it can evaporate to air). Lastly, oxidation of β-carotene was observed at 470 nm spectrophotometrically. The following formula was utilized to calculate antioxidant activity:

$$\text{AA} = \frac{\text{Degradation rate of control} - \text{degradation rate of sample}}{\text{Degradation rate of control}} \times 100. \quad (1)$$

2.4.2. Free Radical Scavenging Activity (DPPH Assay). According to Heimler et al. [14], free radical scavenging activity was examined. Purposely, 1 mL of DPPH (2,2-diphenyl-1-picrylhydrazyl; Sigma-Aldrich, Missouri, USA) was synthesized in ethanol (0.025 g DPPH and 100 mL ethanol). Then, mixing of it with 2 mL of the extract present in a test tube was carried out for approximately 30 minutes and at ambient temperature; sequentially, the tube was incubated. The absorbance at 517 nm was noted at every 30 minutes for 60 minutes. The inhibition percentage was calculated according to the following formula:

$$\text{FRSR\%} = 100\frac{\text{AB-AA}}{\text{AB}}, \quad (2)$$

where AB is the blank sample absorbance ($t = 0$ minutes) and AA is the absorbance of extract solution under test.

2.4.3. Total Polyphenol Contents (TPC). The gallic acid solution at varying concentrations was added to methanol (20, 40, 60, 80, and 100 μg/mL). A standard curve was prepared and 20 μL of extract in a test tube stayed for 5 minutes. Then, in the test tube, 1.5 mL of 6% sodium carbonate was added and kept in a dark place for 60 to 90 ± 2 minutes at 22°C. At 765 nm (Spectrophotometer SPECORD 200 plus UV visible, Analytik Jena, Yokohama, Kanagawa), the total phenolic components of the extracts were determined by the following:

$$C + C1^{*}\frac{V}{m}, \quad (3)$$

C is the GAE (gallic acid equivalent), $C1$ is the gallic acid concentration (mg/ml) (established from the calibration curve), V is the extract volume (mL), and m is the extract weight (g).

2.4.4. Flavonoid Determination. Flavonoid calculation were performed using the Calabro et al.'s [15] technique, with a purposeful dilution of one mL extract in 100 mL methanol. The chromogen reagent (1.00 g of p-dimethylaminocinnamaldehyde (PDAC) (Sigma-Aldrich, Portland, Oregon, USA) was dissolved in a 750 mL methanol and 250 mL concreted HCl mixture that had been previously chilled. Finally, we added 100 mL methanol to 1 mL of the extract and stayed for 10 minutes against the blank (water) at 640 nm. The appearance of yellow color was an indication of flavonoid contents' presence. The calibration curve was built via 5 to 100 mg/L of the quercetin ≥ 95% as standard. The total flavonoid contents were measured by the following equation depending upon the calibration curve:

$$Y = 0.0122 + 0.0018 \times y, \quad (4)$$

where y is the rate of absorbance.

2.5. Development of Product

2.5.1. Preparation of Functional Drink. The part of an HPLC system that converts a chemical or physical characteristic into a quantitative signal related to concentration or identity is called the detector. Early HPLC detection procedures frequently involved collecting fractions for offline analysis. The first online monitors for HPLC were not released till the 1940s and 1950s [16]. Depending upon the extraction efficiency, HPLC, and antioxidant characterization, the best treatments were selected for the development of mustard oilseed cake extract-based and sesame oilseed cake extract-based functional drinks. In the product development step, fresh mangoes were purchased from a local market in Faisalabad, and mangoes were washed with tap water to remove dust or dirt. After this, the fruits were dried with a paper towel. The peel from the mango is removed and the edible portion is cut into suitable size pieces; mango juice was obtained by utilizing an electric juice extractor, pasteurized, and cooled. After this, filtration was done with a double-layered sterilized muslin cloth, and all coarse particles as well as impurities were removed by filtration. After vortex mixing, the juice was in three parts. Three different treatments of innovative functional drinks were synthesized by utilizing mustard oilseed cake and sesame oilseed cake in different ratios and water. For flavor development, vanilla essence (0.5 mL per liter) was used. In addition to this, color (0.005 g per liter) is added to make drinks acceptable for consumers. The functional drink preparation was done in hygienic conditions to prevent contamination. Labeling of treatments was done. T_0 is labeled for control treatment which was used for comparison with other treatments. T_1 treatment sample was synthesized by using 250 ppm mustard oilseed cake extract. T_2 treatment sample was synthesized by 250 ppm sesame oilseed cake extract along with a constant amount of mango juice 1000 ppm in both.

2.5.2. Physiochemical Analysis of Functional Drinks. Total phenolic content and carotenoids were estimated according to the method given by Abid et al. [17] with a slight adjustment. Vitamin C was determined by AACC [18] [19]. Total flavonoids were measured as the method described by Calabro et al. [15] with required modifications. By utilizing hand refractometer, the total soluble solids (TSS) of the developed functional drinks were assessed (TAMCO, Model

N. 90021, Japan). Moreover, functional drinks' pH was evaluated with a pH meter, which was calibrated (InoLab 720, Germany). After that, the acidity (g/L citric acid) of the functional drinks was evaluated by sample titration with sodium hydroxide (NaOH) (0.1 N solution) AACC [18] as described by Imran et al. [20].

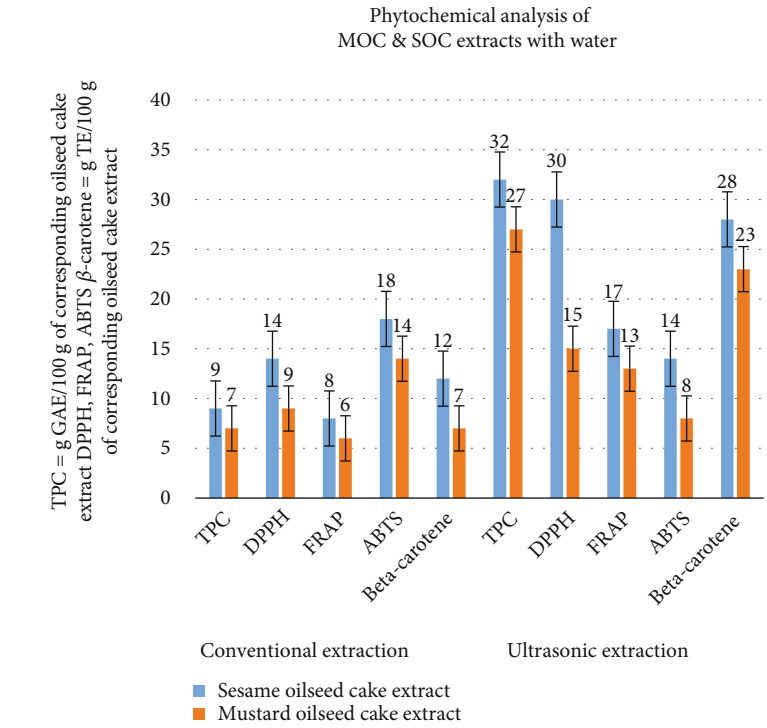
2.5.3. Sensory Evaluation. Sensory estimation of the developed functional drinks was done according to the guidelines [20]. Nine hedonic scales were chosen for rating, ranging from strongly like to severely dislike. Sensory evaluation was done on the basis of various attributes such as color, flavor, aroma, taste, mouth feel, taste, and overall acceptability. Sensory evaluation of the developed functional drinks was done in a sensory laboratory located at the Government College University, Faisalabad. The panelist might be seated in various cabins with fluorescent lights. Serving of functional drinks was done in clean transparent covered glasses which were labeled or coded randomly. After trials, the panelists were given natural water to neutralize their mouths. Panelists were given a form to fill out according to the attributes of the functional drinks.

2.6. Statistical Analysis. For the level of significance evaluation, the collected data was expressed to the statistical analysis, following Montgomery (D.C. [21]) with required alterations. On all examined factors, two-way analysis of variance (ANOVA) was applied for comparison of oilseed cake extracts (mustard and sesame) to calculate the significance level at $p < 0.05$ by means of Minitab.

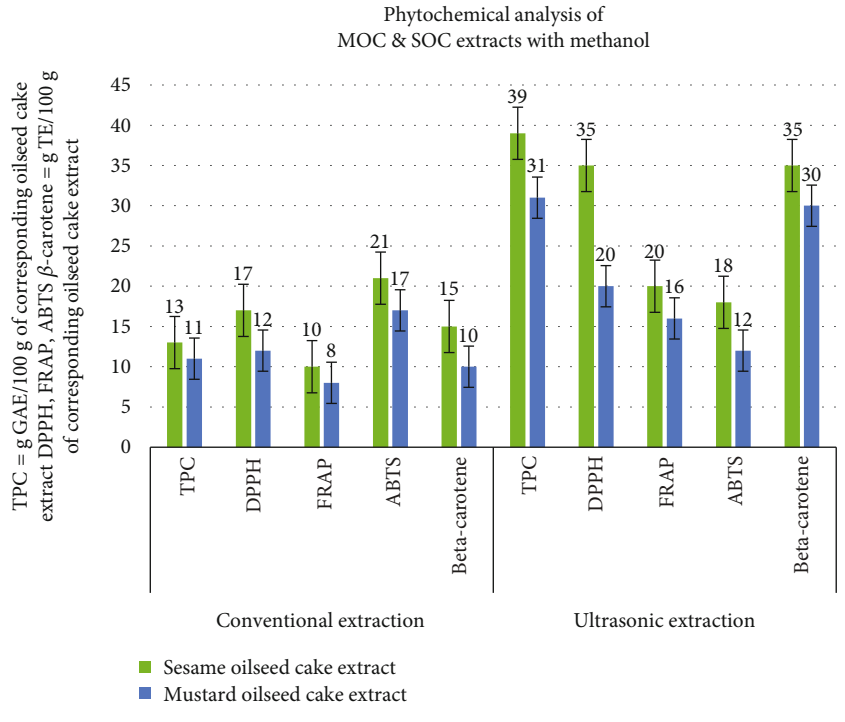
3. Results and Discussion

Results indicated that the polyphenol extraction was affected significantly through extraction techniques. In this context, ultrasound extraction performed better than that of conventional extraction. In the same way, among solvents, methanol showed better results. Likewise, among oilseed cakes, sesame with methanol and ultrasonic extraction exhibited the highest antioxidant activity for TPC, DPPH, FRAP, ABTS, and β-carotene as 39 ± 0.04 g GAE/100 g, 35 ± 0.02 g TE/100 g, 20 ± 0.02 g TE/100 g, 18 ± 0.03 g TE/100 g, and 35 ± 0.05 g TE/100 g, respectively, compared to mustard which showed 31 ± 0.04 g GAE/100 g, 20 ± 0.01 g TE/100 g, 16 ± 0.02 g TE/100 g, 12 ± 0.01 g Trolox/100 g, and 30 ± 0.05 g TE/100 g, respectively. Similar with water and ultrasonic extraction, sesame oilseed cake extracts presented superior results for TPC, DPPH, FRAP, ABTS, and β-carotene as 32 ± 0.03, 30 ± 0.02, 17 ± 0.01, 14 ± 0.02, and 28 ± 0.04), respectively, compared to mustard which showed 27 ± 0.04, 15 ± 0.02, 13 ± 0.01, 08 ± 0.01, and 23 ± 0.01, respectively. In case of conventional extraction and methanol as solvent, sesame oilseed cake extracts revealed outcomes for TPC, DPPH, FRAP, ABTS, and β-carotene as 13 ± 0.02 g GAE/100 g, 17 ± 0.03 g TE/100 g, 10 ± 0.01 g TE/100 g, 21 ± 0.04 g TE/100 g, and 15 ± 0.03 g TE/100 g, respectively, compared to mustard which showed 11 ± 0.02, 12 ± 0.01, 08 ± 0.01, 17 ± 0.03, and 10 ± 0.01, respectively. Similar with water and conventional extraction, sesame oilseed cake extracts exhibited improved results for TPC, DPPH, FRAP, ABTS, and β-carotene as 09 ± 0.01, 14 ± 0.02, 08 ± 0.01, 18 ± 0.02, and 12 ± 0.03, respectively, compared to mustard which showed minimum results (07 ± 0.01, 09 ± 0.02, 06 ± 0.01, 14 ± 0.03, and 07 ± 0.01, respectively). However, in another study Esmaeilzadeh Kenari et al. [22] reported that the Folin-Ciocalteu technique is used to determine the total phenolic concentration, and the antioxidant properties of every extract are assessed using the DPPH (2,2-diphenyl-1-picrylhydrazyl), β-carotene bleaching, and FRAP (ferric reducing/antioxidant power) procedures. With a level of 88.89 mg/g gallic acid equivalent, the ethanol-ultrasonic extraction had the maximum concentration of total phenolic components. The proportion of 88.475% in methanol-ultrasonic extract shows the best performance in scavenging DPPH free radicals. The ethanol-ultrasonic extract has the maximum inhibition percent of 45.64 in the β-carotene-linoleic acid system. The maximum antioxidant action in the FRAP testing is indicated by the ethanol/water (50 : 50)-maceration and ethanol/water (50 : 50)-ultrasonic extracts with absorbance of 1.132 and 1.0745 nm, respectively. A by-product of the sesame oil business is sesame cake.

3.1. Physiochemical. The mean squares regarding storage and treatment on total phenols, flavonoids, ascorbic acid, and carotenoids are in Figures 1(b) and 1(c). While TSS, acidity, and pH (Table 1) for matching oilseed cake extract-based functional beverages demonstrated a significant impact of treatments, TSS was shown to have a nonsignificant influence on their interactive action. The acidity of functional drinks varied significantly due to the effect of treatments T_0, T_1, and T_2 which were noted as 1.05 ± 0.01, 1.04 ± 0.01, and 1.03 ± 0.03, respectively. During storage, the increase of acidity was observed as 1.01 ± 0.02 to 1.07 ± 0.03 from 0 to 60 days (Table 2(a)). Similarly, treatment T_0 had the least significant influence on pH (5.04 ± 0.01) than T_2, T_1 and T_2 (5.03 ± 0.01) respectively. However, pH was decreased during 2 months of storage from 5.07 ± 0.02 to 4.97 ± 0.02, respectively. The total soluble solids (TSS) of three functional drinks T_0, T_1, and T_2 were reported as 48 ± 4.05, 47.3 ± 2.05, and 46.5 ± 3.05, respectively. The highest value of TSS was recorded at T_0 as 50 ± 3.05 at 60 days (Table 1).In addition to the physicochemical properties of the oil fraction, Elleuch et al. [23]; determined the chemical composition of raw sesame seed (RS), sesame coat 1 (SC_1), and sesame coat 2 (SC_2), which were produced as byproducts after the dehulling and roasting mechanisms during the synthesis of sesame paste (tehineh) for the manufacturing of Halaweh (sweetened tehineh). SC_1 and SC_2 had lower levels of oil and protein and greater levels of dietary fibre, ash, and polyphenol when compared to RS. In comparison to RS oil, oil from SC_1 and SC_2 included more chlorophyll, free fatty acids, polyphenols, and sesamol. More color intensity, UV-B, UV-A, and UV-C absorption, as well as a noticeably greater viscosity ($p < 0.05$), were all displayed by SC_2 oil. Elleuch et al. [24] found 9.9 mg/g of seed coat dry matter in the polyphenol concentration of sesame testa. In comparison to aqueous extracts (52.7 mg/g of



(a)



(b)

Figure 1: Continued.

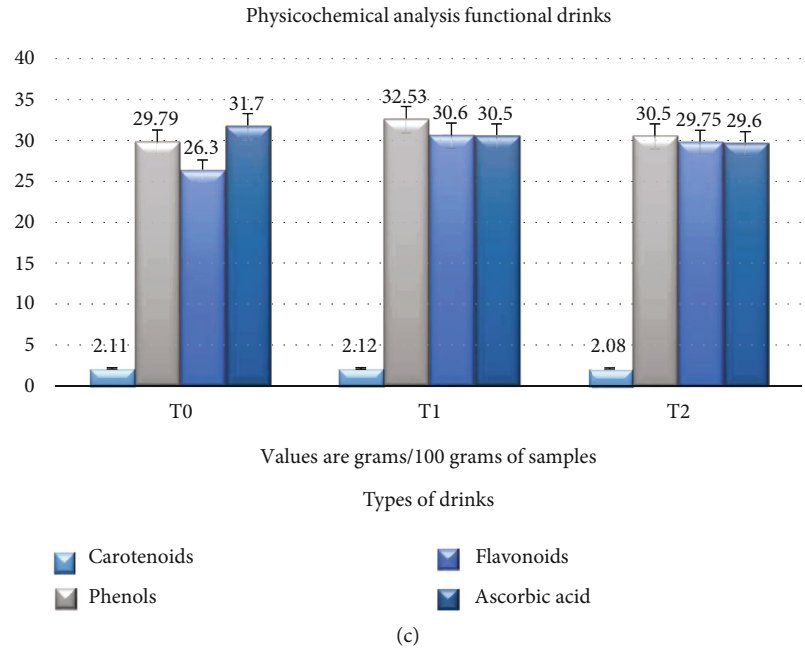


Figure 1: (a) Comparison on extraction techniques during phytochemical analysis of mustard oilseed cake and sesame oilseed cake with water. (b) Comparison on extraction techniques during phytochemical analysis of mustard oilseed cake and sesame oilseed cake with methanol. (c) Physicochemical analysis of functional drinks. T_0: control drink (pure mango juice); T_1: best drink (mango juice 50% and sesame oilseed cake extract 10%); T_2: best drink (mango juice 50% and mustard oilseed cake extract 10%).

extract), ethanol, aqueous methanol, and acetone extracts of seed coatings produced polyphenol levels that were comparable (75 mg/g of extract). Compared to water extracts, aqueous or organic solvent extracts have stronger antioxidant capacity. According to our findings, sesame seed coatings may be used to prepare dishes that are high in fibre, low in calories, and rich in antioxidants.

3.2. Sensory Evaluation. The hedonic response is inevitable for acceptance of the product and its marketability. Good sensory response ensures consumer acceptance and confidence in the developed product. The functional and nutraceutical drinks were assessed for various sensory attributes including color, flavor, sweetness, sourness, and overall acceptability. Sensory evaluation is the key factor to judge consumer acceptability for product development. The hedonic evaluation is mandatory by the trained panelist for the assessment of the products; Since sensory qualities such as colour, general attractiveness, soreness, and sweetness are evaluated using 9 hedonic scales. The variance of means illustrated for sensory evaluation is a nonmomentous effect of treatment (T_0, T_1, and T_2) and storage (0-60 days) except for sweetness (Table 2(b)). The means of color of functional drink were observed significantly influenced by treatments T_0, T_2, and T_1, 7.51 ± 0.04, 7.50 ± 0.03, and 7.49 ± 0.02, respectively. The storage stability of functional drinks for 60 days revealed that the color score decreases from 7.74 ± 0.04 to 7.32 ± 0.02, respectively (Table 2(a)). Similarly, the application of flavor assessment exposed the momentous behavior among T_0 (7.60 ± 0.05), T_1 (7.62 ± 0.4), andT_2 (7.65 ± 0.03). However, the decrease was observed 7.73 ± 0.03 to 7.52 ± 0.04 during storage of two months. Sweetness changes by treatments T_0, T_1, and T_2 were 7.29 ± 0.02, 7.35 ± 0.01, and 7.34 ± 0.03, respectively, while during storage, the same trend of decrease was noted from 7.45 ± 0.02 to 7.23 ± 0.02 in sweetness. The score for soreness explored a significant relationship as7.48 ± 0.05 (T_0),7.52 ± 0.02(T_1), and 7.47 ± 0.03 (T_2). There is a significant decrease from 7.64 ± 0.04 to 7.35 ± 0.02 for soreness during the 60 days of storage. The overall acceptability of oilseed cake extract-based functional drinks illustrated the significant effect of treatments T_0, T_1, and T_2, 7.85 ± 0.05, 7.86 ± 0.04, and 7.82 ± 0.04, respectively. During 0 to 60 days of storage, the overall acceptability explored a significant decrease from 7.85 ± 0.05 to 7.81 ± 0.03, respectively (Table 2(b)). The increase in acidity and drop in pH of functional beverages due to citric acid degradation after storage of 0-60 days, s well as the elevation of total soluble solids, may be attributed to their predisposition for polymerization, sedimentation, and defragmentation during storage. The current investigation is following the earlier findings of Imran et al. [20]; they conducted an analysis for a functional drink (ginger-mint functional drink) regarding sensory evaluation, and they narrated that a decline in color, flavor, taste, and overall acceptability was observed during the 3-month storage. Similarly, the present findings are supported by the investigation of Mishra and Sangma [25], who concluded that sensory attributes of functional beverages showed a significant decline during storage. In short, the overall results declared a declining

Table 1: Treatments and storage effects on physicochemical properties of functional drink.

	pH Treatments					Acidity (%) Treatments					TSS (° Brix) Treatments			
Day	T_0	T_1	T_2	Mean	Day	T_0	T_1	T_2	Mean	Day	T_0	T_1	T_2	Mean
0	5.20 ± 0.02	5.07 ± 0.01	5.05 ± 0.01	5.10 ± 0.02A	0	1.01 ± 0.02	1.02 ± 0.01	1.00 ± 0.02	1.01 ± 0.02	0	46 ± 2.05	45.7 ± 4.05	45.5 ± 3.05	45.73 ± 4.04B
30	5.02 ± 0.03	5.03 ± 0.01	5.03 ± 0.02	5.02 ± 0.01A	30	1.05 ± 0.01	1.04 ± 0.01	1.03 ± 0.03	1.04 ± 0.01A	30	48 ± 4.05	47.7 ± 3.05	46.5 ± 2.05	47.40 ± 3.05A
60	4.92 ± 0.01	4.99 ± 0.02	5.01 ± 0.03	4.97 ± 0.02B	60	1.09 ± 0.02	1.06 ± 0.03	1.06 ± 0.02	1.07 ± 0.03B	60	50 ± 3.05	48.7 ± 2.05	47.5 ± 4.05	48.73 ± 4.05A
Means	5.04 ± 0.01A	5.03 ± 0.02AB	5.02 ± 0.01B		Means	1.05 ± 0.02	1.04 ± 0.01	1.03 ± 0.02		Means	48 ± 4.05A	47.3 ± 2.05A	46.5 ± 3.05B	

T_0: control drink (pure mango juice); T_1: best drink (mango juice 50% and sesame oilseed cake extract 10%); T_2: best drink (mango juice 50% and mustard oilseed cake extract 10%).

Table 2: Treatments and storage effects on sensory properties of functional drinks.

(a)

Day	Color Treatments			Mean	Day	Flavor Treatments			Mean	Day	Sweetness Treatments			Mean
	T_0	T_1	T_2			T_0	T_1	T_2			T_0	T_1	T_2	
0	7.74 ± 0.02	7.76 ± 0.03	7.72 ± 0.01	7.74 ± 0.04A	0	7.70 ± 0.03	7.75 ± 0.05	7.74 ± 0.05	7.73 ± 0.03B	0	7.45 ± 0.02	7.48 ± 0.03	7.44 ± 0.01	7.45 ± 0.02B
30	7.49 ± 0.01	7.51 ± 0.01	7.52 ± 0.03	7.54 ± 0.03A	30	7.60 ± 0.05	7.62 ± 0.04	7.66 ± 0.02	7.62 ± 0.04A	30	7.25 ± 0.01	7.30 ± 0.02	7.32 ± 0.02	7.29 ± 0.01A
60	7.24 ± 0.03	7.26 ± 0.02	7.28 ± 0.04	7.32 ± 0.02B	60	7.52 ± 0.04	7.50 ± 0.02	7.55 ± 0.03	7.52 ± 0.04A	60	7.18 ± 0.01	7.25 ± 0.04	7.28 ± 0.03	7.23 ± 0.02A
Mean	7.49 ± 0.02	7.51 ± 0.04	7.50 ± 0.03		Means	7.60 ± 0.05	7.62 ± 0.04	7.65 ± 0.03		Means	7.29 ± 0.02	7.34 ± 0.03	7.35 ± 0.01	

(b)

Days	Sourness Treatments			Means	Days	Overall acceptability Treatments			Means
	T_0	T_1	T_2			T_0	T_1	T_2	
0	7.65 ± 0.02	7.66 ± 0.04	7.62 ± 0.03	7.64 ± 0.04B	0	7.83 ± 0.06	7.88 ± 0.07	7.84 ± 0.05	7.85 ± 0.05B
30	7.45 ± 0.03	7.52 ± 0.02	7.48 ± 0.05	7.48 ± 0.03A	30	7.82 ± 0.04	7.85 ± 0.05	7.82 ± 0.03	7.83 ± 0.04A
60	7.35 ± 0.01	7.38 ± 0.04	7.32 ± 0.04	7.35 ± 0.02A	60	7.81 ± 0.05	7.83 ± 0.06	7.80 ± 0.04	7.81 ± 0.03A
Means	7.48 ± 0.05	7.52 ± 0.02	7.47 ± 0.03		Means	7.86 ± 0.04	7.85 ± 0.05	7.82 ± 0.04	

T_0: control drink (pure mango juice); T_1: best drink (mango juice 50% and sesame oilseed cake extract 10%); T_2: best drink with (mango juice 50% and mustard oilseed cake extract 10%).

trend but within an acceptable range. On day 30, there was a slight change, but on day 60, the decline was more noticeable.

4. Conclusion

Agroindustrial waste is currently perceived as treasure rather than a felonious due to promising application of green extraction technologies. Extraction of natural bioactive compounds from agro-by-products especially oilseeds is an emerging interest of scientists particularly in food sector for therapeutic, nutraceutical, or functional product development. The results from this study ascertained that for maximum polyphenol extraction, the ultrasonic technique is superior than the conventional extraction technique. In terms of solvents, methanol exhibited better results compared to distilled water. Likewise, among the oilseed cake extract-based functional drinks, sesame oilseed cake extract-based functional drinks exhibited better sensory characteristics. Moreover, in the future, more comprehensive studies are suggested which will elucidate better conclusive pieces of evidence in terms of the extraction of bioactive compounds to develop nutraceutical or functional food products.

Abbreviations

FD: Functional drink
MOC: Mustard oilseed cake
SOC: Sesame oilseed cake.

Data Availability

Data are available on request from the authors.

Ethical Approval

This study has no link between human and animal testing.

Conflicts of Interest

The authors declare no conflict of interest.

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