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Physico-chemical Properties Evaluation and Characteristics of Instant Cereal from Coconut Cake

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Authors' contributions

This work was carried out in collaboration among all authors. Author KHK conducted the sensory analysis. Authors NMFCMN and MFH analyzed the samples and help in samples preparation. Author FH conducting the experimental design in preliminary studies. All authors read and approved the final manuscript.

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ABSTRACT

The instant coconut cereal was developed using a mixture design and ten formulations of cereal were produced using coconut cake, corn flour and brown rice flour. The characteristics and functional properties of instant cereal from coconut cake on dietary fiber, physical and nutritional analysis were studied. Based on the simplex-centroid design, coconut cake had an improving effect significantly on the total dietary fiber (TDF), insoluble dietary fiber, and soluble dietary fiber but, not significantly in colour. The best mixture giving optimal total dietary fiber, insoluble dietary fiber, soluble dietary fiber was that containing 100% coconut cake flour. The result for TDF showed that the top three with the highest fibre content were cereal 3, 15.25%; followed by cereal 7, 11.75% and cereal 5, 10.05%. The addition of brown rice flour showed the highest water absorption index compared to whole corn flour and coconut flour. On the other hand, addition of coconut cake

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significantly increased the water solubility index compare to whole corn flour. The bulk density of the drum-dried instant cereal ranged between 0.32 and 0.36 g/cm3. The moisture content of ten formulations of cereal in the study was within the recommended range. The protein content of the cereal (g/100 g of dry matter) was the lowest in cereal 8 (6.96) and the highest in cereal 3 (8.83). It also shows that the ten formulations of coconut cereal has an array of nutritional properties that varied according to flour proportion.

Keywords: Coconut cake; drum drier; fiber; instant cereal; physical and chemical analysis.

1. INTRODUCTION

Cereal-based food is an essential and indispensable component of a daily diet. Cereals refer to the dry seeds of various grass family members such as corn, rice, wheat, oats, and others, which are cultivated for their grains. Instant cereals, on the other hand, are considered ready-to-eat foods that undergo different processes like roasting, grinding, rolling or flaking, shredding, or puffing to attain various forms using any type of cereal. However, instant cereals often lack sufficient nutritional value. To address this issue, the nutritional value of instant cereals can be improved by incorporating additional healthful ingredients.

Coconut is a tropical fruit and mostly grown in Asia, Africa, and South America. The coconut industry includes the production of coconut flour, water, milk, sugar, and virgin coconut oil. Coconut cake is a by-product of the virgin coconut oil. Virgin coconut oil (VCO) is in high demand worldwide due to its health advantages. The fresh coconut kernel is processed in both cold and hot methods to extract VCO [1]. The two main co-products of VCO manufacture are VCO cake and coconut milk residue, and both are processed into a meal that is used in animal feed. High dietary fibre content in coconut cakes have a lot of positive health effects on people, including lowering the risk of diabetes, colon cancer, and coronary heart disease [2].

Recent studies on the nutritional benefits of coconut cake have shown that it contains fibre, protein, fat, vitamins, minerals, and has a low glycemic index. Besides that, the most incredible health benefit in coconut is the unique type of saturated fats. The fatty acids in coconut are short chain fatty acids (SCFAs) and medium chain fatty acids (MCFAs), whereas the fatty acids in other common edible oils are typically long chain fatty acids (LCFAs). MCFAs, also known as medium chain triglycerides (MCTs), are special saturated fats and oils that the body can digest and absorb more quickly due to their smaller molecules and shorter chains than other saturated fats and oils [3,4]. Additionally, it has been demonstrated that coconut cake contains soluble and insoluble dietary fibre, which reduces total low-density lipoprotein (LDL) cholesterol levels in human. It can be used as a fibre food for diabetic patients as well as to help prevent constipation. Numerous studies have been done on coconut-based foods, including those that partially replace wheat or maize flour in the production of high-quality functional foods such noodles, spaghetti, cookies, and energy bars. This is due to the nutritional benefits of coconut [5]. Various levels of coconut substitution in various food products can allow the consumers to vary their meal while still receiving the nutritional benefits of coconut. Instant cereals have been recognized as the main source of carbohydrates for breakfast [6] and it can also be consumed as Ready-to-eat (RTE) foods, convenience and it is easily consumed by almost all age groups.

Rice and rice products becoming more popular in value-added consumer products. Brown rice is less processed than white rice. The bran layers are what make the rice brown. Brown rice is more nutritious than white rice due to the presence of vitamins, minerals, and oils in the bran. It also has more fiber than white rice. Brown rice has a glycemic index of 55, which places it about on par with long-grain white rice and qualifies as having a lower glycemic load. In addition to that, it supplies sufficient levels of vitamins, minerals, and amino acids. [7]. For most families, ready-to-eat meals are more convenient during hectic times because quick and simple meals are frequently preferred. Therefore, the production of instant cereals using brown rice could potentially provide a more nutritional raw material.

The whole corn flour are made up of three parts of the grain. The grain is divided into three parts: the fiber-rich outer layer, the lipid- and micronutrient-rich germ, and the starchy endosperm. The nutritional benefits of whole grain have been discussed in terms of

physiological processes such immune system stimulation, cell signalling and/or gene regulation, antioxidants, and anti-inflammatory agents, as well as potential defence mechanisms (e.g., diabetes, cancers, cardiovascular diseases)[8]. The bran and germ of the grain contain the largest concentrations of various substances, including fibre, vitamins, minerals, and other phytochemicals. The major bioactive compounds in whole grain are vitamins, minerals, and phytochemicals including phenolics, carotenoids, vitamin E, lignans, β-glucans, inulin, resistant starch, sterols, and phytates [9].

Foods that are nourishing, healthful, and convenient are increasingly gaining acceptance among consumers and gradually displacing unhealthy diets such as oily food, food with a high fat content, food based on carbohydrates, food from animals, and many others. As a result, instant cereal made from whole corn, brown rice, and coconut flour is a highly sophisticated ready-to-eat food that is convenient, nutritious and healthy. The objective of the study was to investigate the characteristics and functional properties of instant cereal made from coconut cake.

2. MATERIALS AND METHODS

2.1 Raw Materials and Samples Preparation

Coconut cake flour was supplied by Coconut Industrial waste. Brown rice flour (Brand: Radiant, Natural gluten free), organic whole corn flour (Brand: Health Paradise) and banana (Brand: BRAS Pro, Extra Natural) were bought from Shopee Malaysia (https://shopee.com.my). Banana flavour was bought from bakery shop.

The coconut cake flour, brown rice flour and whole corn were weighed according to mixture experimental design as referring to Table 1 and 2 (Minitab). Banana ground together with banana flavour using a waring blender. After that, the mixture samples have been dried flaked into a coarse flaked by using a double drum dryer (R. Simon Ltd. Nip Feed Test Machine, Model 4766, Nottingham, UK) [10]. Then, the dried flakes were stored in the aluminium pack at room temperature until further analyses.

2.2 Design of Experiment

Response surface methodology (RSM) was employed to optimize the three factors of instant cereal formulation {(A) coconut cake, (B) brown rice flour, and (C) whole corn flour} by using mixture design. Mixtures mean the sum of all the ingredients is 1. Three factors of raw material were used as variables as they may have an effect on the responses in dietary fiber, soluble fiber, insoluble dietary fiber, moisture, colour, bulk density, Water Absorption Index (WAI) and Water solubility Index (WSI). The remaining ingredients was left constant [11].

The ten independent variables were studied and a set of 10 experiments were carried out. The Design Expert 7.0 statistical software package was used to analyze the experimental data.

Table 1. Parameters studied in physical optimization of coconut instant cereals

Parameter	Low level	High level
Coconut cake	0	1
Brown rice flour	0	1
Whole corn flour	0	1

Table 2. Mixture composition in coconut cereal formulated with coconut cake, brown rice and whole corn flour

Formulation (F)	Ingredient proportion		
	Coconut cake, X1	Brown Rice, X2	Whole corn,X3
1	0.1667	0.1667	0.6667
2	0.0000	0.5	0.5
3	1.0000	0	0
4	0	0	1
5	0.6667	0.1667	0.1667
6	0.3333	0.3333	0.3333
7	0.5	0.5	0
8	0	1.0	0.0
9	0.5	0	0.5
10	0.1667	0.6667	0.1667

2.3 Determination of Insoluble (IDF), Soluble (SDF), and Total Dietary Fiber (TDF)

TDF, IDF and SDF instant cereals were determined using AOAC Official Method of Analysis enzymatic gravimetric method 985.29 (45.4.07) (AOAC, 2012).

2.4 Colour Determination of Instant Cereals

Colorimetric determination of instant cereals were performed by using Minolta CR-400 colorimeter (Konica Minolta Sensing Inc., Japan), according to L*, a*, b* system. The L* (lightness), a* (red intensity) and b* (yellow color intensity) values were measured at six different points for each sample. The L value states the positions on the white/black axis, the a value the position on the red/green axis and the b value the position on the yellow/blue axis.

2.5 Physical Anlaysis

The bulk density of the flour samples was determined using the methods outlined by Mohd Hanim et al. [12]. A 50 mL measuring cylinder was filled with ten grams of the flour sample. The cylinder was then tapped gently on the bench top from a height of 5 cm to pack the sample. The volume of the packed sample was recorded, and the bulk density was calculated in g/cm^3.

$$\text{Bulk density} = \frac{\text{Weight of sample (g/cm}^3\text{)}}{\text{Volume of sample after tapping}}$$

The water absorption index (WAI) and water solubility index (WSI) were determined according to the procedure outlined by Hanim et al. [12]. Each flour sample weighing 4.5 g was mixed with 30 mL of water in a tared 60 mL centrifuge tube. The slurry was shaken with a glass rod for 1 minute at room temperature and then centrifuged at 3000 × g for 10 minutes. The supernatant was carefully transferred into a tared evaporating dish and evaporated overnight at 110°C.

$$\text{Water Absorption Index (WAI)} = \frac{\text{wet sediment weight}}{\text{dry sample weight}}$$

$$\text{Water Solubility Index (WSI, \%)} = \frac{\text{dry supernatant weight}}{\text{dry sample weight}} \times 100$$

2.6 Proximate Composition

By using the approved methods 925.10, 923.03, 920.85, and 920.87 of the Association of Official Analytical Chemists, the flours were analysed, in triplicates, for moisture, crude protein (N x 6.25), crude fat, and ash [13]. Carbohydrate was calculated by subtracting the sum of the moisture, crude protein, total fat and ash from 100%. Gross energy or calories percent of the samples were calculated from the data obtained on proximate analysis by multiplying the percentage of crude protein and carbohydrate with 4.0 and crude fat with 9.0, respectively.

3. RESULTS AND DISCUSSION

3.1 Optimization of Instant Cereals Using Experimental Design

The mixture design was used to optimize the proportions of the three ingredients: coconut cake, brown rice and whole corn flour. Component proportions were expressed as fractions of the mixture with a sum (X1 + X2 + X3) equal to one (Table 2). All the components had the same range between 0 and 1. The ten points were three single ingredient treatments, three two-ingredient mixtures and four three-ingredient mixtures. Optimization of coconut cereals was carried out with optimum total dietary fiber, soluble dietary fiber and insoluble dietary fiber. Instant cereal also contains banana paste, malted extract, sweet whey, banana concentrate, and banana flavour.

In the optimization technique, coconut cake, brown rice and whole corn flour were chosen to be the variables toward the responses: total dietary fiber, insoluble dietary fiber, soluble dietary fiber, water absorption index, water solubility index and bulk density. Tables 3 shows that there are 10 formulations and the effect of variables on responses was analyzed using statistical analysis from Design Expert software. According to statistical design, coconut cake had improving effect significantly on the total dietary fiber, insoluble dietary fiber and soluble dietary fiber. By using the mixture design approach, it was possible to optimize each studied parameter to obtain high fiber cereal. The best mixture giving optimal total dietary fiber, insoluble dietary fiber, soluble dietary fiber was that containing 100% coconut cake flour. The result for total dietary fibre content indicated that there was significant difference between cereal C3 and other samples. The result for TDF showed that

the top three of highest fibre content were cereal C3, 15.25%; follow by cereal C7, 11.75% and cereal C5, 10.05%. Preliminary studies of C3, C5 and C7 for sensory acceptance showed that, most panelist were preferred C5 coconut cereal. The increase in fibre content could be attributed to the increase in the addition of coconut flour. According to dietary guidelines, breakfast cereals, particularly those that are whole grain or contain high cereal fiber, are acknowledged for their significant nutrient density, making them a valuable contributor of essential nutrients [14]. Apart from being a rich source of vitamins and minerals, breakfast cereals also have the potential to serve as significant sources of antioxidants [15,16]. Dietary fibre may help reduce the risk of colon cancer by increasing stool bulk, diluting faecal carcinogens, and decreasing transit time. [17].

WSI reflects the solubilization of starch when excess water is added [18,19]. This affects digestibility and reflects the extent of molecular damage. WAI and WSI were greatly affected by type of flour. The interaction between coconut cake flour and brown rice flour revealed an interesting contrast in which a combination of high coconut flour resulted in high WSI. Addition of coconut cake significantly increased the WSI compare to whole corn flour. WSI in drum-dried products is ascribed to the destruction of starch granules and reduction in crystallinity. When coconut cake flour increases, WSI increases because many more starch granules are available for degradation by heat and shear between starch granules and drum surface [19]. WSI recorded in this study was generally lower compared to results obtained for low amylose rice by Supprung and Noomhorm [19], rice berry flour by Wiriyawattana et al. [20], purple sweet potato flour [21], and complimentary food [22,23]. In other hand WSI, is an indication of solubility of biomolecules (starches, water soluble fibres, proteins and/or sugars etc.) [24].

The bulk density of the drum-dried instant cereal ranged between 0.32 and 0.36 g/cm3. It showed that the main processing factors did not affect product bulk density. The present study revealed that bulk density depends on the particle size and initial moisture content of flours. Bulk density of composite flour increased with increase in the incorporation of different flours with wheat flour. According to Jittanit et al. 24], the bulk density of certain drum-dried products was influenced by the temperature and speed of the drum drying process. These factors were found to be correlated with the rate of moisture evaporation and the enhancement of porosity. Bulk density of composite flours increased significantly with increase in the incorporation of rice, green gram and potato flour with wheat flour.

Color occupies an effective role in the appearance of the instant cereal and actively influences the consumer's decision to buy the product [25]. The color properties in terms of a* (red (+) / green (−)), L* (black (0) / white (100)), and b* (yellow (+) / blue (−)) values of all instant coconut cereal are indicated in Table 4. Result showed that coconut cereals had a dark yellow color (L* = 20 -33; a* = 4 – 7.9; b* = 12 – 16). The increasing portion of coconut cake flour in instant cereal resulted in a decrease in L*, an increase in a* and a slight increase in b*, i. e. the cereal became darker and reddish. The browning effect of coconut on instant cereal colour was the effect of the high content of saccharides and their reactions during baking (Maillard reaction and caramelization)[26]. Nevertheless, the color of the mixture blends became darker once the banana paste and all the ingredients were homogenized, thus affecting the ten formulations of the instant cereal. In addition, the decrease in L* of instant cereals could be a consequence of the higher content of ash and color properties in the used flours [27]. Even though drying temperature did not significantly affect color, a general decrease in L*-value occurred when temperature was gradually increased from 120 to 130°C. The trends in L*-value may be explained mainly by nonenzymatic browning reactions such as Maillard and dextrinization, which may have been heightened as the product stayed longer on the heated drum or as temperature increased during processing [28,29]. This observation reflects those of Wiriyawattana et al. [30] who also reported product darkening resulting from increased temperature during drum drying. The trends in L*-value were identical for the different levels of solids concentration of the slurry.

3.2 Nutritional Analysis of Instant Cereals

Analysis of the moisture content showed that all the 10 formulation (Table 5) of cereals had less than 5% moisture. Products with lower water content, generally having longer shelf life due to less subject of microorganisms degradation and chemical changes. All the coconut cereal formulations have moisture content ranged from 2 to 3.3%. The moisture content of ten

Table 3. Mixture composition in coconut cereal formulated with coconut cake, brown rice and whole corn flour

Cereal	Ingredient proportion			Total Dietary Fiber (TDF)	Soluble Fiber (SF)	Insoluble Dietary Fiber (ISF)			
	Coconut cake	Brown Rice	Whole corn flour				Water Absorption Index (WAI)	Water solubility Index (WSI)	Bulk density
C1	0.1667	0.1667	0.6667	8.35 ± 0.35^{d}	1.9 ± 0.14^{bc}	6.45 ± 0.49^{de}	3.67± 0.17^{c}	30.62 ± 1.39^{c}	0.35 ± 0.01^{ab}
C2	0.0000	0.5	0.5	5.2 ±0.42^{g}	1.35 ± 0.07^{d}	3.85 ± 0.35^{g}	4.03 ± 0.05^{b}	27.30 ± 0.62^{d}	0.34 ± 0.01^{ab}
C3	1.0000	0	0	15.25 ± 0.21^{a}	2.6 ± 0.00^{a}	12.65 ± 0.21^{a}	2.11 ± 0.03^{g}	41.02 ± 0.46^{a}	0.35 ± 0.01^{ab}
C4	0	0	1	7.1± 0.00^{e}	2.25 ±0.07^{b}	4.95 ± 0.21^{fg}	3.69 ± 0.04^{c}	30.7 ± 0.74^{c}	0.32 ± 0.02^{c}
C5	0.6667	0.1667	0.1667	10.05± 0.21^{c}	1.6± 0.14^{cd}	8.45 ± 0.35^{c}	2.71 ± 0.05^{f}	35.36 ± 1.21^{b}	0.35 ± 0.01^{ab}
C6	0.3333	0.3333	0.3333	9.6 ±0.28^{c}	2.25 ± 0.21^{b}	7.35 ± 0.07^{cd}	3.04 ± 0.04^{e}	35.92 ± 0.52^{b}	0.33 ± 0.01^{bc}
C7	0.5	0.5	0	11.75 ± 0.07^{b}	1.4 ± 0.28^{d}	10.35 ± 0.35^{b}	2.98± 0.17^{e}	34.30 ± 2.65^{b}	0.35 ± 0.01^{a}
C8	0	1.0	0.0	3.45 ± 0.21^{h}	0.8 ± 0.14^{e}	2.65 ± 0.35^{h}	5.25 ± 0.22^{a}	17.39 ± 1.24^{e}	0.35 ± 0.01^{a}
C9	0.5	0	0.5	9.6 ± 0.28^{c}	1.9 ± 0.14^{bc}	7.7 ± 0.14^{c}	2.69 ± 0.05^{f}	39.44 ± 0.14^{a}	0.35 ± 0.01^{ab}
C10	0.1667	0.6667	0.1667	6.25± 0.21^{f}	1.6 ± 0.00^{cd}	5.45± 1.34^{ef}	3.45 ± 0.04^{d}	31.13 ± 0.39^{c}	0.36 ± 0.01^{a}

Data was expressed as mean ± SD, each value is a mean of triplicate reading (n=3), means with different lower case letters in the same column are significantly different (p = .05)

Table 4. Colour analysis in coconut cereal formulated with coconut cake, brown rice and whole corn flour

Formulation	Ingredient proportion			Colour		
Cereal	**Coconut cake**	**Brown rice flour**	**Whole corn Flour**	**L**	**a***	**b***
C1	0.1667	0.1667	0.6667	31.42 ± 2.64^{abc}	4.09 ± 0.55^{e}	13.51 ± 2.41^{bc}
C2	0.0000	0.5	0.5	32.17 ± 2.32^{abc}	4.97 ± 0.67^{de}	14.20 ± 2.12^{abc}
C3	1.0000	0	0	30.47 ± 1.70^{c}	7.11 ± 1.16^{ab}	13.46 ± 1.73^{bc}
C4	0	0	1	33.94 ± 0.74^{a}	5.78 ± 1.13^{cd}	16.24 ± 0.85^{a}
C5	0.6667	0.1667	0.1667	30.87 ± 0.99^{bc}	6.69 ± 0.22^{bc}	14.12 ± 1.10^{abc}
C6	0.3333	0.3333	0.3333	30.97 ± 0.78^{bc}	7.94 ± 0.22^{a}	14.12 ± 0.73^{abc}
C7	0.5	0.5	0	32.21 ± 1.36a^{bc}	7.73 ± 0.59^{a}	15.27 ± 1.40^{ab}
C8	0	1.0	0.0	33.18 ± 2.35^{ab}	5.00 ± 0.97^{de}	14.15 ± 1.73^{abc}
C9	0.5	0	0.5	29.96 ± 1.41^{c}	6.68 ± 0.47^{bc}	13.20 ± 1.55^{bc}
C10	0.1667	0.6667	0.1667	29.84 ± 2.17^{c}	6.93 ± 0.53^{ab}	12.21 ± 2.02^{c}

Data was expressed as mean ± SD, each value is a mean of triplicate reading (n=3), means with different lower case letters in the same column are significantly different (p = .05)

Table 5. Nutritional analysis of instant cereals

Samples	Ingredient proportion								
	Coconut cake	Brown Rice	Whole corn	%Moisture	Protein	Fat (g/100g)	Ash (g/ 100g)	Carbohydrate, g/100g	Energy value, kcal/100g
Cereal 1	0.1667	0.1667	0.6667	2.81 ± 0.57^{ab}	7.20 ± 0.04^{cd}	1.51 ± 0.24^{f}	2.60 ± 0.27^{bc}	85.69 ± 0.07^{c}	385.71 ± 4.79^{e}
Cereal 2	0.0000	0.5	0.5	2.93 ± 0.40^{ab}	7.08 ± 0.08^{d}	0.56 ± 0.23^{h}	2.80 ± 0.60^{b}	86.63 ± 1.46^{bc}	378.47 ± 3.07^{f}
Cereal 3	1.0000	0	0	3.33 ± 0.61^{a}	8.83 ± 0.04^{a}	14.15 ± 0.28^{a}	3.14 ± 0.18^{a}	70.22 ± 0.98^{g}	445.01 ± 0.85^{a}
Cereal 4	0	0	1	2.40 ± 0.57^{ab}	6.99 ± 0.06^{d}	1.07 ± 0.10^{g}	2.16 ± 0.20^{de}	87.26 ± 0.78^{abc}	386.79 ± 4.16^{e}
Cereal 5	0.6667	0.1667	0.1667	2.51 ± 0.18^{ab}	8.07 ± 0.04^{b}	7.66 ± 0.23^{b}	2.42 ± 0.12^{cd}	79.26 ± 0.47^{f}	418.26 ± 1.69^{b}
Cereal 6	0.3333	0.3333	0.3333	2.24 ± 0.32^{ab}	7.52 ± 0.06^{c}	2.58 ± 0.33^{e}	1.98 ± 0.09^{e}	85.73 ± 0.36^{c}	396.21 ± 4.67^{d}
Cereal 7	0.5	0.5	0	2.69 ± 0.45^{ab}	8.14 ± 0.43^{b}	5.14 ± 0.08^{c}	2.36 ± 0.13^{cd}	81.62 ± 1.06^{e}	405.09 ± 1.59^{c}
Cereal 8	0	1.0	0.0	2.08 ± 0.42^{b}	6.96 ± 0.02^{d}	0.19 ± 0.01^{i}	1.97 ± 0.23^{e}	89.06 ± 0.35^{a}	385.78 ± 1.30^{e}
Cereal 9	0.5	0	0.5	2.50 ± 0.25^{ab}	7.85 ± 0.01^{b}	3.22 ± 0.13^{d}	2.48 ± 0.24^{cd}	83.72 ± 0.64^{d}	395.38 ± 1.44^{d}
Cereal 10	0.1667	0.6667	0.1667	2.35 ± 0.70^{ab}	7.24 ± 0.01^{cd}	0.45 ± 0.10^{h}	2.16 ± 0.09^{de}	87.75 ± 0.96^{ab}	384.16 ± 2.35^{ef}

Data was expressed as mean ± SD, each value is a mean of triplicate reading (n=3), means with different lower case letters in the same column are significantly different (p = .05)

formulation of cereal in this study was within the recommended range. Moisture content of cereals of cereals should not exceed 12-13%.

The energy content of the instant cereal samples exhibited a significant variation, ranging from 378.47 kcal to 445.01 kcal. Cereal 2 had the lowest energy value, while cereal 3 had the highest energy value. The inclusion of 100% coconut cake flour in cereal 3 contributed to the highest energy value compared to cereal 2, which did not contain coconut flour. The protein content ranged from 6.96% to 8.83%. Cereal 8 had the lowest protein content (6.96 g/100 g of dry matter), whereas cereal 3 had the highest protein content (8.83 g/100 g of dry matter). Cereal 3 had the highest protein and fat content, which can be attributed to the use of coconut flour as the sole ingredient in its formulation. On the other hand, cereal 8 displayed a low protein content due to the absence of coconut flour. Previous studies by other authors have reported relatively high protein percentages in coconut flour, ranging between 15% and 20% [31,32]. The rise in protein and fat levels can be linked to the incorporation of coconut cake flour in the instant cereal formulation. Increasing the quantity of coconut cake in the formulation resulted in an increase in both protein and fat content. Khan et al. [32] conducted a study on the composition of coconut flour derived from coconut meal using a dry processing method. The composition they reported was as follows: moisture content of 6.7%, ash content of 1.55%, protein content of 14.3%, fat content of 54.0%, fiber content of 20.50%, and carbohydrate content of 23.40%.

In comparison to brown rice flour and corn flour (as shown in Table 5), coconut cake flour used in the study exhibited a relatively high fat content, which is consistent with the fact that coconuts are classified as oil plants. There was a noticeable disparity in the ash content among the tested flours, with coconut cake flour (3.14%), brown rice flour (1.97%), and corn flour (2.16%). Among the studied formulations, Cereal 8 had the highest carbohydrate content, as indicated in Table 5. The macronutrient composition of coconut cake flour analyzed in this study was similar to the findings reported by other researchers [31,33]. However, some studies indicate significantly lower fat (10.9%) and protein (12.1%) contents [2,31]. These differences can be attributed to variations in production techniques, raw materials used, and the intended application.

4. CONCLUSION

The instant cereal derived from coconut cake, with different proportions, demonstrated a significant improvement in dietary fiber and water solubility index. The increasing portion of coconut cake flour in instant cereal resulted in a decrease in L*, an increase in a* and a slight increase in b*, i. e. the cereal became darker and reddish. A significant difference was also noticed in the bulk density as coconut cake contained 100% in the formulation. Among the ten formulations, the highest moisture, protein, fat, ash and energy value were specified in 100% coconut cake proportion. Therefore, coconut cake waste from the industries can be great ingredients for making nutritionally enhanced foods as well as functional foods.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Arumuganathan T, Madhavan K, Mathew AC, Padmanabhan S. Lipid profile of virgin coconut oil processed by different methods. J. Plantation Crops. 2011;39(1): 247-251.
2. Trinidad TP, Valdez DH, Loyola AS, Mallillin AC, Askali FC, Castillo JC, and Masa DB. Glycemic index of different coconut (Cocosnucifera) flour products in normal and diabetic subjects. British J. Nutrition. 2007;90(3):551-556.
3. Jadhav HB, Annapure US. Triglycerides of medium-chain fatty acids: a concise review. Journal of Food Science and Technology –Mysore. 2023;60(8):2143-2152.
Available:https://doi.org/10.1007/s13197-022-05499-w
4. Che Man YB and Marina AM. Medium chain triacylglycerol, In: F. Shahidi (Ed.), Nutraceutical and specialty lipids and their coproducts, Boca Raton: Taylor and Francis Group. 2006;27- 56.

5. Sykut-Domańska E, Zarzycki P, Sobota A. The potential use of by-products from coconut industry for production of pasta. J Food Process Preserv. 2020;00:14490. Available:https://doi.org/10.1111/jfpp. 14490
6. Marangoni F, Poli A, Agostoni C, Di Pietro P, Cricelli C, Brignoli O, Fatati G, Giovannini M, Riva E, Marelli GA. Consensus document on the role of breakfast in the attainment and maintenance of health and wellness. Acta Biomed. 2009;80:166-171.
7. Liu K, Cao X, Bai Q, Wen H. Relationhips between physical properties of brown rice and degree of milling and loss of selenium. Journal of Food Engineering. 2009; 94:69–74.
8. Fardet A. New hypotheses for the health-protective mechanisms of whole-grain cereals: What is beyond fiber? Nutr. Res. Rev. 2010;23:65–134.
9. Liu RH. Whole grain phytochemicals and health. J. Cereal Sci. 2007;46:207–219.
10. Zuwariah I, Saiful Bahri S, Syahida M, Rodhiah R, Mohd Fakhri H. Serbuk nanas pengeringan drum. Buletin Teknologi Makanan. 2019;17:137-145.
11. AOAC. Official methods of analysis, Association of official analytical chemist 19th edition, Washington DC, USA; 2012.
12. Mohd Hanim AB, Chin NL and Yusof YA. Physico-chemical and flowability characteristics of a new variety of Malaysian sweet potato, Vitato Flour. Imternational Food Research Journal. 2014;21(5):2099-2107.
13. AOAC. Association of official analytical chemists. official methods of analysis. 2000;Vol.II 17th edition) of AOAC International. Washington, DC, USA.
14. National Health and Medical Research Council. Australian dietary guidelines. Canberra (Australia): National Health and Medical Research Council; 2013.
15. Ryan L, Thondre P, Henry C. Oat-based breakfast cereals are a rich source of polyphenols and high in antioxidant potential. Journal of Food Composition and Analysis. 2011;24(7):929-934.
16. Alan J, Baublis, Changrun Lu, Fergus M, Clydesdale and Eric A Decker. Potential of wheat-based breakfast cereals as a source of dietary antioxidants. Journal of the American College of Nutrition. 2000; 19(3);308-311. Available:https://doi.org/10.1080/07315724.2000.10718965
17. Song M, Chan AT, Sun J. Influence of the gut microbiome, diet, and environment on risk of colorectal cancer. Gastroenterology. 2020;158:322–40. Available:https://doi:10.1053/j.gastro.2019.06.048
18. Oikonomou NA, and Krokida MK. Literature data compilation of WAI and WSI of extrudate food products. International Journal of Food Properties. 2011;14(1):199–240. Available:https://doi.org/10.1080/10942910903160422
19. Supprung P and Noomhorm A. Optimization of drum drying parameters for low amylose rice (KDML 105) starch and flour. Drying Technology: An International Journal.2003;21:1781–1795.
20. Wiriyawattana P, Suwonsichon S and Suwonsichon T. Effect of drum drying on physical and antioxidant properties of riceberry flour. Agriculture and Natural Resources. 2018;52:445–450.
21. Soison B, Jangchud K, Jangchud A, Harnsilawat T, Piyachomkwan K, Charunuch C and Prinyawiwatkul W. Physico-functional and antioxidant properties of purple-flesh sweetpotato flours as affected by extrusion and drum drying treatments. International Journal of Food Science and Technology. 2014; 49:2067–2075. Available:https://doi. org/10.1111/ijfs.12515
22. Eshun AAA. Development and evaluation of the functional, nutritional quality and consumer perception and acceptability of a sesame seed and peanut-based complementary food for infants 6 – 24 months. An MPhil thesis submitted to the University of Ghana, Legon; 2019.
23. Matthey FP, and Hanna MA. Physical and functional properties of twin-screw extruded whey protein concentrate-corn starch blends. LWT - Food Science and Technology.1997;30:359–366. Available:https://doi.org/10.1006/fstl.1996.0189
24. Jittanit W, Chantara-In M, Deying T and Ratanavong W. Production of tamarind powder by drum dryer using maltodextrin and Arabic gum as adjuncts. Songklanakarin Journal of Science and Technology. 2011;33(1):33–41.
25. Ghandehari Yazdi AP, Kamali Rousta L, Azizi Tabrizzad MH, Amini M, Tavakoli M,

Yahyavi M. A review: New approach to enrich pasta with fruits and vegetables. Food Science and Technology. 2020; 17(103):129–149
26. Sacchetti G, Pittia P, Mastrocola D, Pinnavaia GG. Stability and quality of traditional and innovative chestnut based products. Acta Hortic. 2005;693:63–70.
27. Teterycz D, Sobota A, Zarzycki P, Latoch A. Legume flour as a natural colouring component in pasta production. Journal of Food Science and Technology. 2020; 57(1):301–309. Available:https://doi.org/10.1007/ s13197-019-04061-5
28. Abonyi BI, Feng H, Tang J, Edwards CG, Mattinson DS and Fellman JK. Quality retention in strawberry and carrot purees dried with Refractance Window® System. Journal of Food Science. 2002;67:1051–1056.
29. Nunes LP, Ferrari CC, Ito D, Souza ECG, Germer SPM. Drum drying process of jaboticaba pulp using corn starch as an additive. Brazilian Journal of Food Technology. 2020;23:2019166.
30. Wiriyawattana P, Suwonsichon S, Suwonsichon T. Effect of drum drying on physical and antioxidant properties of riceberry flour. Agriculture and Natural Resources. 2018;52:445–450.
31. Pejcz E, Mularczyk A, Gil Z. Technological characteristics of wheat and non-cereal flour blends and their applicability in bread making. J. Food Nutr. Res. 2015;54: 69–78.
32. Khan MA, Mahesh C, Semwal AD and Sharma GK. Effect of virgin coconut meal (VCM) on the development of rice based extruded snacks. International Journal of Advance Research. 2015;3(10):717–725.
33. DebMandal M. and Mandal S. Coconut (Cocos nucifera L.: Arecaceae): In health promotion and disease prevention. Asian Pasific Journal of Tropical Medicine. 2011;4(3):241-247.

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