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PRODUCTION, QUALITY ASSESSMENT AND SHELF LIFE EVALUATION OF PROTEIN – RICH BISCUITS MADE FROM BLENDS OF WHEAT AND DEFATTED COCONUT FLOURS

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Abstract

Defatted coconut flour obtained from the whitish kernel residue left after the extraction of virgin coconut oil has potential application in high protein-fiber enriched food products. Therefore, a study was conducted to utilize coconut flour, a by-product of the Virgin Coconut Oil (VCO) industry for the partial substitution of wheat flour. In this study, wheat flour was substituted with defatted coconut flour in varying proportions of 0, 10, 20, 30, 40 and 50% w/w to prepare a series of blends for biscuit and the possibility of using coconut flour for the production of biscuits was investigate. Prepared biscuits were subjected to nutritional, physical, textural and organoleptic analysis to evaluate the suitability of biscuits for consumption. Nutritional analysis of coconut flour revealed that it contains 12.6% protein, 13.0% fiber, 9.2% fat, 13.7% sugar, 8.2% ash and 4.2% moisture. Protein, fiber and fat value of defatted coconut flour fortified biscuits increased with progressive increase in proportion of defatted coconut flour and 40% coconut flour added biscuits obtained values of 10.73%, 11.30% and 22.72% respectively, while the lowest values of 4.98%, 8.26% and 16.86% recorded for the wheat flour biscuits. The moisture and ash were increased with corresponding increase in the percentage of defatted coconut flour while showing the decrease in carbohydrate content. Defatted coconut flour incorporated cookies were found to be lesser harder than control cookies when tested for hardness with texture analyzer. 40% defatted coconut flour added biscuits scored the highest overall acceptable rating compared to other tested combinations and could be stored up to 5 months in aluminum package without significant changes in keeping quality.

Keywords: biscuit, defatted coconut flour, nutritional profile, sensory evaluation

Introduction

Utilisation of food by – products and wastes receive more attention in the food industry. These wastes would be minimized through the utilisation of available resources into various types of food products. Therefore, an effective effort was needed to solve those problems by developing high nutritional and industrial potential of by – products, wastes and utilised directly for human consumption.

Various attempts had been made for researching for the use of food by – products such as pomace of apple, citrus fruits, grape skin and seed, guava, mango and pineapple with a view to explore the potential applications and physiological activities of that particular food by – products. The demand for by – products from fruits and vegetables increased due to their high content in nutritional quality, low in caloric content, strong in antioxidant capacity and high water retention capacity.

Virgin coconut oil is a recently emerging high demand product in the world. Defatted coconut flour is one of the major by – product generated from the virgin coconut oil industry. However, the defatted coconut flour is often discarded. The whitish residue remained after extracting virgin coconut oil can be milled into flour. The coconut flour can provide not only value added income to the country, but also a nutritious and

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healthy source of dietary fiber (Trinidad *et al*., 2003). Coconut flour plays a role in controlling cholesterol and sugar levels in blood and prevention of colon cancer. Studies revealed that consumption of high fiber coconut flour increases faecal bulk (Arancon, 2009).

Biscuits, among the bakery products are the most significant snack foods in the world. These are an important food product used as snacks by children and adults (Hussain *et al*., 2010). Biscuits differ from other baked products like bread and cakes because of their low moisture content, which ensures that they are free from microbial spoilage and confer a long shelf life on the product. Good eating quality makes the biscuits more attractive for fortification and other nutritional improvement.

The production of biscuits incorporated with defatted coconut flour led to the innovation of new product by utilising the by – products from coconut. Nowadays, people were aware about the consumption of healthier food in their daily life. The innovation was in coherent with consumers demand for a healthier choice of food product. Therefore, the present study was aimed to develop nutritionally enriched biscuits and to assess the nutritional, physical, microbial and organoleptic qualities in the formulated biscuits.

Materials and Methods

Raw materials

Refined wheat flour was purchased from Prima company (Pvt) Ltd, Trincomalee. Coconut gratings were defatted and powdered using 2 mm sieve. Wheat flour was mixed with defatted coconut flour and biscuits were prepared according to the following treatments using the recipe described below:

Treatments:

T_1 - 100% wheat flour (Control)

T_2 - 90% wheat flour + 10% de-fatted coconut flour

T_3 - 80% wheat flour + 20% de-fatted coconut flour

T_4 - 70% wheat flour + 30% de-fatted coconut flour

T_5 - 60% wheat flour + 40% de-fatted coconut flour

T_6 - 50% wheat flour + 50% de-fatted coconut flour

Development of nutritionally enriched biscuits

The biscuits were prepared by using a Creamery method. Biscuits were made at the incorporation of defatted coconut flour with the replacement of refined wheat flour at the level of 10, 20, 30, 40 and 50% in the standardized formulations. 50 g low fat margarine and 50 g powdered sugar were creamed together by electric beater. All purpose wheat flour (250 g) and baking powder (5 g) were sieved twice together. The sieved flour was added to the creamed paste. As per the treatment, firm dough was prepared from all mixture. The dough was rolled out to 2.5 mm thickness in a baking tray and cut into round shape having 5 cm diameter with a biscuit cutter. The biscuits were placed in greased aluminium trays and baked in a pre – heated oven at 185 ºC for 15 minutes. These biscuits were assessed for nutritional, physical, microbial and organoleptic qualities.

Nutritional analysis

The moisture, ash, protein, fiber and fat of the biscuits were determined according to the standard AOAC (2000) methods. The carbohydrate content was determined by calculating the difference. Data were analysed by Analysis of Variance (ANOVA) and the difference between means was compared using Duncan's Multiple Range Test (DMRT), through Statistical Analysis System (SAS) software statistical package.

Physical property

Biscuits were cooled for one hour for the determination of spread ratio as per the method described in AACC (2000). Six biscuits were taken randomly and placed them edge to edge and stacking for the estimation of diameter and thickness and finally by the subtraction of their average value spread ratios were obtained.

Textural Property

Texture attributes of biscuits like hardness and breaking strength were taken as quality parameters to check the textural properties of biscuits by using TAHDI Texture analyser. Hardness and breaking strength were determined as mentioned by Singh (2003). The probe was calibrated and then a test was run by placing sample on the platform of the texture analyser. Hardness was measured using texture analyser as maximum peak force (N) required to break the sample. Breaking strength was also measured by using the same texture analyser.

Sensory analysis

The sensory attributes including taste, texture, colour, flavour and overall acceptability were evaluate by a trained 30 – member panel. The evaluation was held either 10 am for the morning session and at 3 pm for the afternoon session. The Seven – point hedonic scale was used to evaluate the degree of liking (7) and disliking (1) for preference of the biscuits. The mean scores were analysed using analysis of variance (ANOVA) method and difference separated using Fredmann Test.

Microbial analysis

The aerobic plate count was carried out using the method of Fawole and Oso, (1998). 10 g of each sample was taken aseptically and homogenized in 90 ml sterile distilled water using a blender (Philips Type HR 2815i) for 2 min. Serial dilutions (using 1 ml of homogenates) were made in 9 ml sterile distilled water, dispensed in test tubes. One millilitre of each dilution was pour plated in sterile Petri dishes, using the plate count agar (PCA, oxoid), incubated at 37°C for 24 - 36 h. Counts of visible colonies were made and expressed as log CFU/g sample.

Results and Discussion

Composition of defatted coconut flour

The nutritional composition of the coconut flour were moisture 4.2%, fat 9.2%, protein 12.6%, total sugar 13.7%, ash 8.2%, fiber 13.0% and soluble carbohydrate 39.1%. The values are in accordance with Marquez (1999). Composition of coconut flour depends on the retention components after the extraction of coconut oil from scraped coconut.

Nutritional composition of wheat – defatted coconut flour biscuits

The nutritional analysis of prepared biscuits indicated that all the samples contained favourable proportions of protein, fiber and fat.

Protein content

In this study, the partial substitution of wheat flour by defatted coconut flour increased the protein content of biscuits. The protein increased from 4.98 to 11.96% with the increase in the percentage of defatted coconut flour from 0 to 50%. Figure .1 shows the changes in protein and fiber content of developed biscuits.

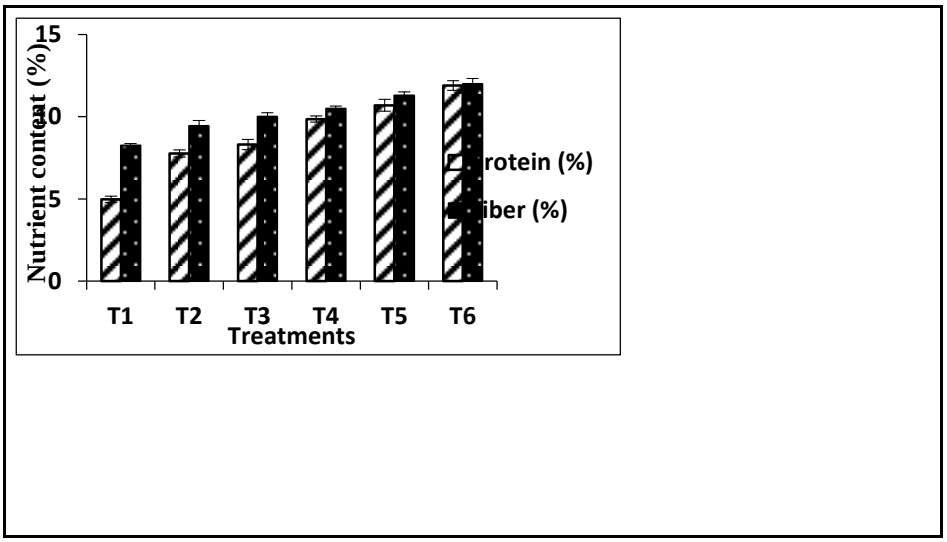

Figure.1: Changes in Protein and Fiber Content of Freshly Made Wheat- Defatted Coconut Flour Biscuits

The values are means of triplicates. The vertical bars indicate the standard errors

According to Bressani and Wilson (2012), cereal protein, including wheat, is limited in the essential amino acid lysine content and they also recommended that the biological value of wheat flour can be significantly improved by the addition of lysine. Coconut flour when incorporated into wheat flour increases the amino acid content, especially lysine. Therefore, incorporation of coconut flour into wheat flour improves the protein content of composite flour and thus improves the nutritional status of the biscuits.

According to DMRT, control biscuits made from 100% wheat flour has the lowest protein content of 4.98% whereas 50% defatted coconut flour added biscuits has the highest protein content of 11.96%.

Fiber content

Fiber content of biscuits ranged from 8.26 to 12.0% when the defatted coconut flour was incorporated from 0 to 50%. The increment in fiber content could be due to the increase in the proportion of defatted coconut flour in the composite flour blend. Figure 4.1 shows the changes in fiber content of the developed biscuits. Fibers in biscuits is mainly contributed by coconut fiber and wheat flour contains only 2.7% dietary fiber (Leelavathi and Rao, 1993). As fiber absorbs large amount of water, it gives a sensation of fullness (having an appetite completely satisfied). Therefore, coconut fiber supplemented biscuits can be prepared with high fiber content.

According to DMRT, T_6 which was containing 50% defatted coconut flour has the highest fiber content of 12.0% and control biscuit made from 100% wheat flour has the lowest fiber content of 8.26%. There was no significant different between 20% and 30% defatted coconut flour added biscuits.

Fat content

The fat content of biscuits increased with an increase in the substitution level of defatted coconut flour. The fat content of biscuits increased from 16.8 to 24.5% with increase in the percentage (0-50%) of defatted coconut flour as shown in Figure.2 The refined wheat flour was having lower fat content whereas there was a slight increase in fat content with increase in defatted coconut flour incorporation. This may be due to the fat found in defatted coconut flour. Yalegama *et al*. (2013) reported that, fat, which is attached to the fibers, remains with cell wall components resulting in high fat content in coconut flour.

According to DMRT, biscuits made from 100% wheat flour has the lowest fat content of 16.8% and 50% defatted coconut flour added biscuits has the highest fat content of 24.5%. There is no significant difference between T_3 (20% defatted coconut flour added biscuit) and T_4 (30% defatted coconut flour added biscuit) at 5% significant level.

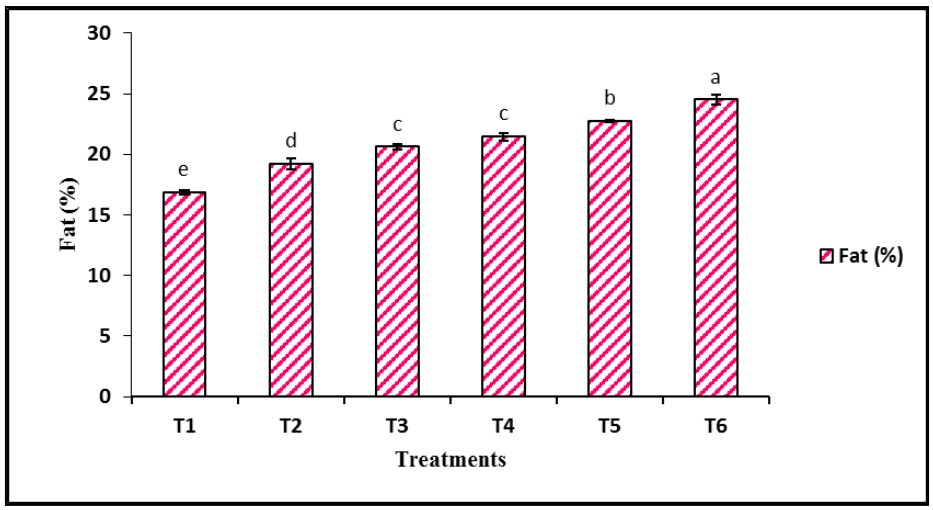

Figure.2: Changes in Fat Content of Freshly Made Wheat-Defatted Coconut Flour Biscuits

The values are means of triplicates. The vertical bars indicate the standard errors

Moisture content

The moisture content of biscuits gradually increased from 4.33 to 5.92% with the incremental addition of defatted coconut flour from 0 to 50%. Changes in moisture, ash and total soluble carbohydrate content of freshly made wheat-defatted coconut flour biscuits are shown in Table.1

Table.1: Moisture, Ash and Total Soluble Carbohydrate Content of Freshly Made Wheat- Defatted Coconut Flour Biscuits

Treatment	Moisture (%)	Ash (%)	Total Soluble Carbohydrates (%)
T_1	4.33 ± 0.012^{e}	0.35 ± 0.08^{d}	65.71 ± 0.43^{a}
T_2	4.39 ± 0.013^{d}	0.51 ± 0.014^{c}	59.29 ± 0.16^{b}
T_3	4.48 ± 0.003^{c}	0.78 ± 0.04^{c}	56.30 ± 0.27^{b}
T_4	5.49 ± 0.020^{b}	1.08 ± 0.012^{b}	52.37 ± 0.33^{c}
T_5	5.79 ± 0.017^{b}	1.28 ± 0.023^{b}	48.96 ± 0.48^{d}
T_6	5.92 ± 0.04^{a}	1.48 ± 0.032^{a}	44.71 ± 0.29^{e}

The values are means of triplicates ± SE.

Mean values with the same superscript letters within the same column do not differ significantly at 5% level

These values were within the range reported to have no adverse effect on the quality attributes of the product (Kaur *et al.*, 1996). The increase in moisture content can be attributed to the increased protein content that

also increase the water binding capacity of biscuits with high levels of defatted coconut flour. Singthong *et al*. (2011) observed similar increase in moisture content with increasing levels of coconut flour.

According to DMRT, 50% defatted coconut flour added biscuits has the highest moisture content of 5.92% and 100% wheat flour added biscuit (control) has the lowest moisture content of 4.33%.

Ash content

The ash content of a food material could be used as an index of mineral constituents of the food (Sidorova *et al*., 2007). The ash content of biscuits increased from 0.35 to 1.48% with increase in the percentage of defatted coconut flour from 0 to 50%. Changes in ash content of freshly made wheat-defatted coconut flour biscuits are shown in Table.1

The increasing trend observed in ash content might be due to the fact that defatted coconut flour contained higher amounts of materials compared to wheat flour. Srivastava *et al*. (2010) also reported that an increase in moisture and ash values with increasing percentages of defatted coconut flour substitution in wheat flour biscuits. According to the DMRT, T_6 which was containing 50% defatted coconut flour has the highest ash content.

Total soluble carbohydrate

The results showed that soluble carbohydrate content decreased from 65.7 to 44.7% with increase in the percentage (0-50%) of defatted coconut flour as sown in Table.1 The variations in soluble carbohydrate among the biscuit samples may results from the difference in the level of protein, fat, ash and moisture content of wheat flour and defatted coconut flour.

According to DMRT, the control treatment (T_1) has the highest total soluble carbohydrate of 65.7% and biscuit which contain 50% defatted coconut flour has the lowest soluble carbohydrate content of 44.7%.According to DMRT, the control treatment (T_1) has the highest total soluble carbohydrate of 65.7% and biscuit which contain 50% defatted coconut flour has the lowest soluble carbohydrate content of 44.7%.

Physical Analysis

An increase in diameter was observed after baking of biscuits. The increase in diameter can also be attributed to the fat content since the defatted coconut flour also has a certain amount of fat that contributes to the total fat content of biscuits. As the fat increases an increase in expansion of biscuits was observed that increase in diameter. Thickness of the biscuits showed gradual decrease as the level of defatted coconut flour replacement. The reduction in thickness as the level of coconut flour increased which may be contributed to enhanced hydration capacity of flour after fortification. Figure.3 shows the changes in thickness and diameter of different biscuit samples with different treatments.

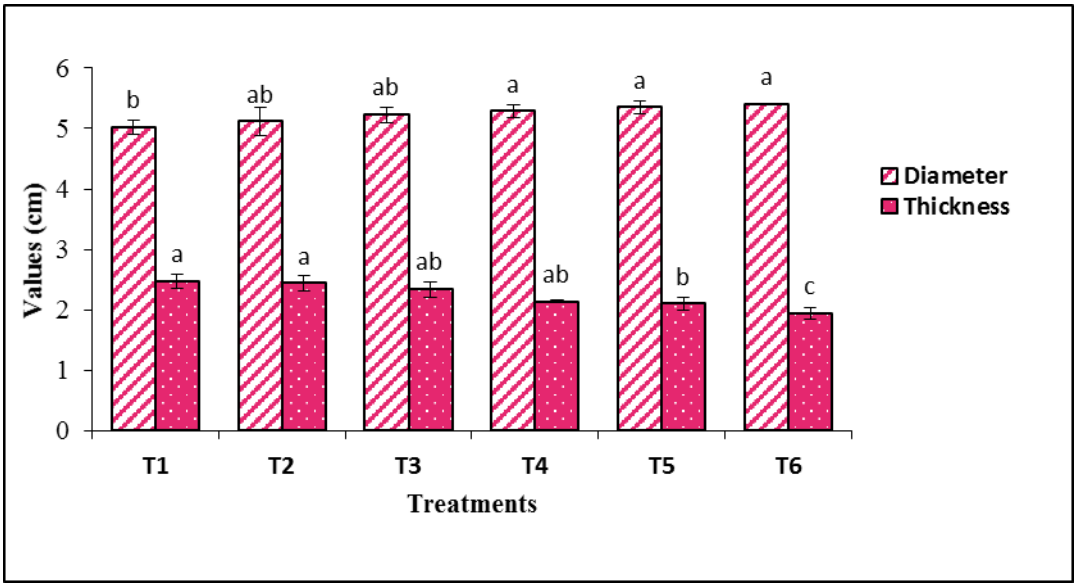

Figure.3: Thickness and Diameter of Biscuits Made with Different levels of Defatted Coconut Flour

The values are means of triplicates. The vertical bars indicate the standard errors

Textural Analysis

Textural characteristics of biscuits containing wheat–defatted coconut flour biscuits is shown in Table.2 Biscuits made up with 100% wheat flour has the highest mean score for hardness (10.9 N) while the 50% defatted coconut flour incorporated biscuits gained the lowest score of 6.22 N. Decreasing trend in hardness on addition of defatted coconut flour was also observed by Srivastava *et al*. (2010).

A declining trend was observed for breaking strength with increase in the level of defatted coconut flour. The values for breaking strength were ranging from 68.89 to 16.54 N. At high fat content, the lubricating function is high, thus less water is required and a softer texture is obtained (Yadav and Subramanyan, 2012).

Table 2: Textural Characteristics of Biscuits Containing Wheat-Defatted Coconut Flour Biscuits

Treatment	Hardness (N)	Breaking strength (N-mm)
T_1	10.90 ± 0.21^{a}	68.89 ± 0.01^{a}
T_2	9.98 ± 0.31^{a}	69.09 ± 0.19^{a}
T_3	9.38 ± 0.17^{a}	63.32 ± 0.17^{b}
T_4	9.49 ± 0.27^{a}	57.77 ± 0.34^{c}
T_5	7.21 ± 0.13^{b}	31.84 ± 0.17^{d}
T_6	6.22 ± 0.23^{b}	16.54 ± 0.27^{e}

Mean values with the same superscript letters within the same column do not differ significantly at 5% significant level. Values are means of triplicates.

Hence the hardness and breaking strength gradually decreased forming a softer biscuits with an increased level of defatted coconut flour biscuits. This shows that incorporation of defatted coconut flour has positive effect on textural properties.

Sensory Analysis

The products developed were assessed for sensory evaluation and was compared with control biscuits. The results proved the worth of study and were found satisfactory with high value of overall acceptability. Data regarding the organoleptic evaluation is presented in figure.4

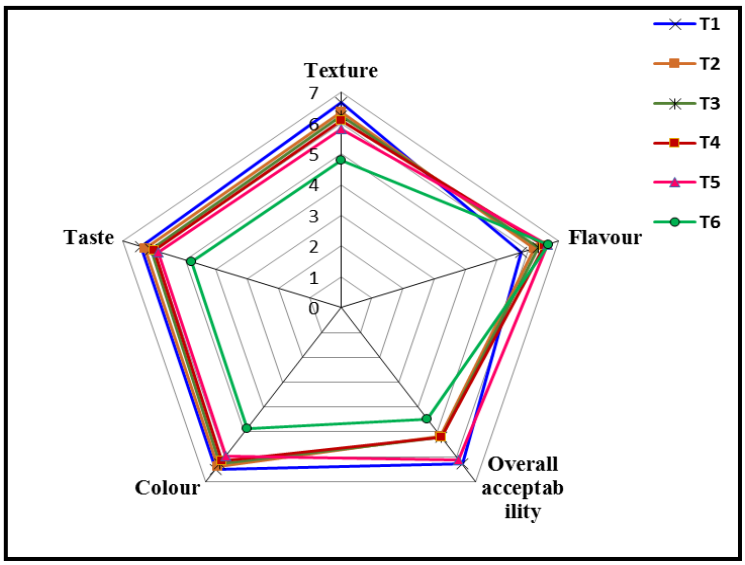

Figure.4: Sensory Properties of Biscuits Incorporated With Defatted Coconut Flour

The colour gets darker and when defatted coconut flour is further increased; more darkness takes place, which results in the reduction of quality score for the colour of the biscuits. As amino acids react with reducing sugars during baking and as a result Maillard reaction takes place. This was supported by Dhingra (2000).

More darkness in the colour was observed in the biscuits as the level of the supplementation of defatted coconut flour was increased. This may be due to the browning and caramalization of sugar present in coconut flour during baking. This decreasing trend of quality score for colour of the biscuits may be due to the high level of protein and sugar present in coconut flour.

The score for taste decreased from 6.17 to 4.80 on increasing the level of substitution of defatted coconut flour. The significant decreasing trend of taste may be due to the own taste of coconut flour which dominated when used in high amount (Hussain, 2000). The control biscuits made with 100% wheat flour (T_1) has the highest mean score of 6.17 for taste whereas 50% coconut flour added biscuit (T_6) has the lowest score of 4.80.

The crust texture of biscuits was related to the external appearance of the biscuit top, which is the smoothness or roughness of the crust. Biscuit's texture analysis revealed that there was a significant effect on the texture of the biscuits when coconut flour was added. Decreasing trend was observed in the quality score for texture when the percentage of defatted coconut flour increased. The decreasing trend for texture of the biscuits may be due to the proteins present in coconut flour.

Flavour of biscuits increased from 5.81 to 6.66 with increasing in the substitution level of coconut flour. Quality score of the biscuits revealed that flavour of

biscuits varied significantly among the treatments. The results indicated that the biscuits prepared from T_6 significantly ($p > 0.05$) got the highest score (6.66) for flavour. This is due to the flavour of coconut flour.

Overall acceptability includes many implications, which is the important parameter in sensory estimation. There was significant difference between control treatment (T_1) and 40% coconut flour added biscuits (T_5). Biscuits made with 40% defatted coconut flour added biscuits (T_5) has the highest mean value foe overall acceptability according to DMRT while 50% defatted coconut flour added biscuits (T_6) has the lowest score.

Conclusions

The developed biscuits showed good quality characteristics on all parameters considered. The nutritional analysis of defatted coconut flour revealed that it contains 12.6% protein, 9.2% fat, 13.0% fiber and 4.2% moisture. The addition of defatted coconut flour resulted in significant improvement in protein and fiber in wheat – defatted coconut flour biscuits.

From this study, it can be concluded that biscuits incorporated with 40% addition of defatted coconut flour were nutritionally rich and scored high sensory attributes than the other tested treatments. Biscuits substituted with 40% defatted coconut flour has 10.52% protein, 22.68% fat and 11.01% fiber. Textural property of biscuits clearly showed a decreasing trend in hardness and breaking strength. Hardness and breaking strength of the selected biscuit (40% defatted coconut flout biscuit) were 7.21 N and 31.84 Nmm respectively. Biscuit substituted with 40% defatted coconut flour has the diameter of 5.35 cm whereas its thickness is 2.10 cm.

From the overall acceptance rating, the 40% defatted coconut flour added biscuits has the highest mean value and there is no remarkable changes in organoleptic characters were observed up to 5 months of storage in ambient condition of average temperature 30ºC and the RH of 75 – 80% indicating that the shelf life of 40% defatted coconut flour added biscuits were shelf life stable up to 5 months.

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