

Evaluation of Nutritional Composition of Defatted Coconut Flour Incorporated Biscuits

H.P.D.T. Hewa Pathirana¹, W.M.K. Lakdusinghe¹, L.L.W.C. Yalegama¹, C.A.T.D. Chandrapeli¹ and J.A.D Madusanka¹

Abstract

Defatted coconut kernel is the major by-product of the dry method of virgin coconut oil (VCO) processing which includes high fiber content. It is ground into a fine powder, has a high potential to use as a composite matrix for baked food items with wheat flour. The aim of this research is to compare nutritional characteristics of defatted coconut flour incorporated biscuits (CF), desiccated coconut incorporated commercial biscuits (DC) and wheat flour-based commercial biscuits (WF) using white bread (WB) as a reference. Proximate composition (moisture, ash, crude fat, crude protein, crude fiber and carbohydrate), Hydrolysis Index (HI) and Predicted Glycemic Index (PGI) of samples were performed through standard in-vitro analysis methods. Results of the proximate analysis revealed that moisture (36.67 ± 0.16 %) and protein (13.35 ± 1.17 %) content of bread were significantly ($p < 0.05$) higher while fat, fiber and ash content of CF incorporated biscuits were significantly ($p < 0.05$) higher with the values of 26.67 ± 1.87 %, 3.53 ± 0.10 % and 4.70 ± 2.61 % respectively. Free sugar glucose content (FSG) of WF was observed the highest significant ($p < 0.05$) value of 5.88 ± 1.03 % while the highest amount of rapidly available glucose (RAG) (81.45 ± 5.27 %), slowly available glucose (SAG) (59.81 ± 7.58 %), total glucose (TG) (99.16 ± 5.56 %) were observed in reference food of bread. The PGI of three biscuit types belonging to the medium glycemic food with the values of 60.84, 64.53 and 62.90 respectively for CF, DC and WF treatments.

Key words: Biscuits, defatted coconut flour, glycemic index, in-vitro digestion

Introduction

Coconut (*Cocos nucifera*) is a widely used raw material in food preparation especially in tropical countries. It is rich in nutrients such as fiber, saturated fat, protein, carbohydrates and minerals such as sodium, potassium, calcium and magnesium. Virgin coconut oil is one of the most valuable products which is extracted from fresh coconut meat without brown testa (paring) with low temperature (dry extraction cold-press process) or without the use of heat (wet extraction process) (Thaiphanit and Anprung, 2016). Consumption of medium-chain fatty acid (MCFAs) such as VCO reduces the risk factor of cardiovascular diseases (Oh K *et al.*, 2005), lowers the blood pressure (Nurul-Iman *et al.*, 2013) and blood sugar (Babayana, 1987). The MCFAs present in the VCO can be acted as an energy source for the brain through metabolizing it into the ketone bodies which are converted to acetyl Co-A to produce ATP and it acts as precursors for acetylcholine in neurons (John *et al.*, 2020). Moreover, pure coconut scent is preserved in VCO with a high level of antioxidants and vitamins to improve the anti-carcinogenic activity of the human body (Nevin and Rajamohan, 2004). During virgin coconut oil production defatted edible solid by-product is removed and which is called defatted coconut residue or oil cake ("poonac, Punnakku") can be milled into flour. The coconut flour can provide a nutritious and healthy source of dietary fiber. Trinidad *et al.* (2003) reported that coconut flour plays a role in controlling cholesterol and sugar levels in the blood and in prevention of colon cancer.

Consumption of food with high fiber is very essential for safeguarding from prevalent non-communicable diseases such as elevated cholesterol, diabetic and cancer. Therefore, people more concern about the ingredients in their diet especially low sugar and high fiber. However, fast-moving lifestyle accelerates fast food consumption such as biscuits, cake and other bakery products. The demands of these types of products are increased because of less perishability, durability, and easy handling than high perishable foods.

¹ Coconut Processing Research Division, Coconut Research Institute, Sri Lanka

Most of the fast foods are made of wheat (*Triticum aestivum L.*) flour. Wheat flour contains 78.10 % carbohydrates, 2.10 % fat, 2.10 % minerals, 14.7 % protein. The quality of wheat flour-based food is high due to the presence of wheat protein gluten (Okpala and Egwu, 2015). Ingredients that are added to the biscuit and processing method can alter the nutritional composition of the final biscuit. Defatted coconut flour is a fiber-rich ingredient and it can alter the nutritional composition of the product compared to the traditional wheat flour-based product. Therefore, Glycemic Index food which is an important characteristic can be altered by the substitution of wheat flour with defatted coconut flour.

Glycemic Index (GI) is defined as the incremental area under the β -glucose response curve (IAUC) of a tested meal containing 50 g of digestible carbohydrates and the incremental area under the β -glucose response curve of the standard food (50 g pure glucose) (IAUCS) (Rudolf *et al.*, 2004). Diet with high GI causes elevated blood glucose level and such food has been associated with the risk of chronic heart diseases. Therefore, the identification of the glycemic index of a food is very crucial for diet management. Generally, the GI of food is determined by in-vivo clinical studies even though it is a time and money-consuming method. However, to predict the GI of a food product through in-vitro digestion that occurs in the upper gastrointestinal tract of humans is used as a promising alternative for clinical GI measurement (Woolnough *et al.*, 2008). The aim of this research is to determine nutritional composition and prediction of the glycemic index (PGI) of defatted coconut flour incorporated biscuits the same as to desiccated coconut incorporated commercial biscuits and wheat flour-based commercial biscuits with reference to white bread through in-vitro analysis.

Materials and Methods

Materials

Defatted coconut flour added biscuits (CF) were prepared in Coconut Processing Research Division at Coconut Research Institute, Sri Lanka. The desiccated coconut added biscuit (DC), wheat flour added biscuit (WF) and white bread (BR) as a reference were purchased from the Cargill Food City supermarket at Dankotuwa, Sri Lanka. The enzyme of pepsin, amyloglucosidase, invertase and pancreatin were purchased from sigma. The poly

propylene tubes (50 ml), Fan forced Oven (JEIO TECH (OF - 22G), Analytical balance (OHAUS), Randall hot extraction apparatus (Behr E 6), FIWE extraction unit, Shaking water bath (SWBR17-2), Spectrophotometer (UV-1800 Shimadzu) were used.

Methods

Preparation of defatted coconut flour-based biscuit

A dough of biscuits was prepared by mixing 300 g defatted coconut flour and 700 g wheat flour as the main matrix for biscuits development. Other ingredients: baking powder (20 g), margarine (600 g), sugar (500 g), egg (50 g) and salt (5 g) was measured and mixed well in a bowl in a machine of dough mixture (model- Sherry 8p-800) in 20 min. Then the dough was leveled by a roller and was cut using a mold of circular shape (diameter 2 cm) and placed on an oil paper in a stainless-steel tray. The biscuits were baked for 15 minutes at 160 oC in a pre-heated oven and were allowed for cooling and were packed in triple laminated aluminum pouches.

Proximate composition

The proximate composition (moisture, ash, crude fat, crude protein, crude fiber and carbohydrate) of four samples was determined (AOAC, 2005) with four replicates.

In-vitro measurement of different sugar fractions

Free sugar glucose (FSG) contents of each biscuit were determined by Nani *et al.* (2017) method. Biscuit samples with 0.5 g carbohydrate were placed in a polypropylene tubes and 5 ml of 0.5 M sodium acetate buffer (pH 5.2) were added. The contents were shaken well. The samples were incubated at 100 oC in a boiling water bath for 30 minutes and cooled to room temperature. The glucose contents of the samples were measured by using a glucose determination kit (GOD PAP, France). GI of three biscuit samples with reference to white bread were determined according to Englyst's protocol with modifications (Englyst *et al.*, 1995). Minced biscuit with 0.5 g carbohydrate was placed in polypropylene tubes and were subjected to a mixture of enzymatic digestion with mechanical disruption by small glass balls. Then, samples were incubated at 37 °C in a shaking water bath to continue the hydrolysis and 1 ml of samples

| Treatments | Moisture (%) | Protein (%) | Crude Fat (%) | Ash (%) | Crude Fiber (%) | Carbohydrate (%) |
|------------|--------------|-------------|---------------|------------|-----------------|------------------|
| BR | 36.67±0.16a | 13.35±1.17a | 2.60±0.11d | 2.43±0.12b | 0.28±0.09c | 44.67±1.34d |
| CF | 3.04±0.08b | 3.67±0.21c | 25.67±1.87a | 3.53±0.10a | 4.70±2.61a | 59.40±3.75c |
| DC | 0.89±0.08d | 4.76±0.42b | 18.21±0.15b | 1.65±0.20d | 3.08±0.22ab | 71.42±0.86b |
| WF | 2.28±0.11c | 4.71±0.38b | 11.24±1.44c | 2.04±0.20c | 1.46±0.57bc | 78.28±0.92a |

Table 1. Proximate composition of resulted biscuits, commercial biscuits and white bread

Values are Means ± standard deviations and different superscripts in the same column are significantly different ($p < 0.05$), BR: White bread, CF: Defatted coconut flour-based biscuits, DC: Desiccated coconut added biscuits, WF: Wheat flour-based biscuits.

were taken from each treatment at certain time intervals (0, 20, 30, 60, 90 and 120 minutes) to determine the glucose content. The glucose content of sample after 20 min was measured as G20 – Rapidly Available Glucose (RAG) and glucose content of the sample after 120 min of digestion was designated as G120 – Slowly Available Glucose (SAG). After 120 min, the remaining samples were treated with additional enzymes and the temperature was increased to 100 °C to complete the hydrolysis followed by centrifuging at 1500 xg for 2 min to obtain a clear supernatant and thus, Total Glucose Content (TGC) of the samples were determined. To measure the glucose content at each time for specific digestion, an aliquot of (200 µl) of the sample was mixed with 4 ml of absolute ethanol to stop the hydrolysis. Glucose content of the sample was determined using a glucose determination kit (GOD PAP, France) based on the procedure given by the GOD, PAP, France and the absorbance was measured at 505 nm using a spectrophotometer (UV-1800 Shimadzu).

Calculations and statistics

RAG, SAG and various starch fractions were calculated by using the following equations.

$$1\text{-Rapidly Available Glucose (RAG)} = G20$$

$$2\text{-Slowly Available Glucose (SAG)} = G120 - G20$$

$$3\text{- Free Sugar Glucose (FSG)} = G30$$

The results were converted to starch by multiplying the percentage glucose concentration by a factor (0.9). Then percentages of starch hydrolysis were built for each sample and reference food over the incubation time. The area below the hydrolysis curve (AHC) was estimated by integrating the hydrolysis curves.

The Hydrolysis Index (HI) was calculated as the ratio between the AHC of each sample and the AHC of glucose and expressed as a percentage. The GI of the samples were estimated according to the equation of $GI = 39.71 + 0.549 HI$ (Goni *et al.*, 1997). Statistical analysis (ANOVA) was performed using the MINI TAB system (Version 16.0). Tukey's tests were used for comparison of means at $p < 0.05$.

Results and Discussion

The results of proximate composition show significant differences for moisture, protein, crude fat, ash, crude fibre and carbohydrates contents of biscuits (Table 1).

Moisture

The moisture content of food indicates the water activity which is responsible for the shelf-life stability of processed food. Adding more water into the dough of bread increases the water content of bread to increase the bread yield and profit (Miller *et al.*, 2008). That's why bread has significantly ($p < 0.05$) higher moisture content (36.67±0.16 %) compared to the three types of biscuits (Table 1). Results showed that CF has significantly ($p < 0.05$) higher moisture content (3.04±0.08 %) than DC (0.89±0.08 %) and WF (2.28±0.11 %) biscuits samples. The reason may be due to the high water absorption ability of coconut flour.

Protein

Proteins are essential macromolecules for the development of biological organs. Amino acids are monomers of the protein molecules. The BR has significantly higher protein content (13.35±1.17 %) (Table 1). The protein content of DC (4.76±0.42 %) and WF (4.71±0.38 %) is

significantly ($p < 0.05$) the same while CF shows a significantly low protein content (3.67 ± 0.21 %). Thirty percent substitution of wheat flour from defatted coconut flour did not affect the increment of protein percentage in defatted coconut flour added biscuits even defatted flour has a higher protein content of 21.76 % (Yalegama *et al.*, 2013).

Fat

The fat content of food provides energy and essential fatty acids to boost the body function. Source of fat (Animal or plant origin) determine the health aspects of human while creating non-communicable diseases such as elevated cholesterol and heart diseases (Zheng F. M. and Yeong Y.L, 2016). Coconut flour contains significantly high fat content (13.43 %) compared to wheat flour (1.93 %) (Yalegama *et al.*, 2013). The CF has a significantly higher fat content 25.67 ± 1.87 % than DC treatment (Table 1). The raw material of desiccated coconut contains 68 % (SLSI, 98) of fat which is higher than the fat content of coconut flour (13.43 %). Even desiccated coconut added biscuit is expected to have higher fat content. The amount of replacement of wheat flour from desiccated coconut or defatted coconut flour is a critical factor to change the nutritional profile of biscuits.

Ash

Ash content of the food gives an overview of the mineral content. Fortification of mineral substances to the food product is a novel trend to boost the nutrient content of food while acquiring health benefits for human life. Previous studies showed that wheat flour is less in ash with the approximate figures of 0.70 % (Ocheme *et al.*, 2018). In contrast, coconut flour contains five times higher minerals (5.12 %) (Yalegama *et al.*, 2013) than wheat flour (0.7 %) (Ocheme *et al.*, 2018). Therefore, the biscuits substituted with defatted coconut flour have a significantly higher mineral content 3.53 ± 0.10 % (CF) than the wheat flour-based biscuits.

Crude Fiber

Crude fiber is the carbohydrate substances that our bodies cannot digest. Insoluble fiber after the digestion acts like a broom to sweep out the digestive tract while preventing constipation, infections of the gut, hemorrhoids, heart disease and some types of

cancer. Therefore, consumption of fiber-rich food is very vital to boost the healthy life of a human. Defatted coconut flour contents (9.27 %) of crude fiber (Yalegama *et al.*, 2013) are higher than wheat flour (0.84 %) (Ocheme *et al.*, 2018). Therefore, significantly higher crude fiber content was observed in the CF (4.70 ± 2.61 %) and DC (3.08 ± 0.22 %) treatments. As crude fiber does not contribute to energy, it is expected not to contribute to a high glycemic index. So, the biscuit with high fiber content is expected to show a lower GI value.

Carbohydrate

The carbohydrate content of the sample includes the sugar and starch material which are incorporated in the food products. The sugar content of food directly contributes to the Glycemic Index of the food to categorize it as a product of low, medium or high Glycemic. Defatted coconut flour contains 46.73 % (Yalegama *et al.*, 2013) carbohydrate content which is significantly lower compared to the wheat flour having carbohydrate content of 72.73 % (Ocheme *et al.*, 2018). Results revealed that wheat flour added biscuits (WF) have the highest carbohydrate content (78.28 ± 0.92 %) in a fresh sample. Desiccated coconut incorporated biscuit (DC) had 71.42 ± 0.86 % carbohydrate content which is significantly lower than WF. CF has the lowest carbohydrate content (59.40 ± 3.75 %) out of three types of biscuits varieties.

In-vitro measurement of different sugar fractions

The results are shown in Table 2.

Free sugar glucose content of the food product

Dietary carbohydrates are absorbed into small intestine depending on the source, physico- chemical properties and processing aspects of the food product. Free glucose in the food is freely attached to mono and disaccharides and their alcohol substances which undergo the immediate release of glucose molecules into the intestine after the ingestion of food. A significantly higher level of free sugar glucose (sum of free glucose and glucose from sucrose) has in WF (5.88 ± 1.03 %) than others.

| Treatments | FSG | RAG | SAG | TG | HI | PGI |
|------------|------------|-------------|-------------|--------------|-------|-------|
| BR | 0.45±0.17b | 81.45±5.27a | 59.81±7.58a | 99.16±5.56a | - | - |
| CF | 0.79±0.50b | 35.10±2.96b | 36.18±5.53b | 40.91±1.34c | 38.58 | 60.84 |
| DC | 0.20±0.03b | 21.72±4.65c | 33.97±4.82b | 54.40±8.21b | 45.31 | 64.53 |
| WF | 5.88±1.03a | 38.20±5.10b | 41.11±2.68b | 45.84±5.60bc | 42.35 | 62.91 |

Table 2. Glucose concentrations of four biscuits after in-vitro digestion

Values are Means ±standard deviations and different superscripts in the same column are significantly different (p<0.05), BR: White bread, CF: Defatted coconut flour-based biscuits, DC: Desiccated coconut added biscuits, WF: Wheat flour-based biscuits.

Rapidly available glucose content of the food product

Glucose which is released after 20 min of digestion helps to surge the blood sugar level after food consumption. Glucose is an important source of energy for almost all the cells in the body, especially the brain cells. Therefore, athletes may use glucose as their energy source, thus it rapidly releases the highest concentration of glucose within a shorter period of time. Results of this study revealed that significantly (P<0.05) higher level of rapidly available glucose (81.45±5.27 %) is released by BR within the in-vitro digestion system. Therefore, consumption of food with elevated rapidly available glucose such as white bread is not recommended for diabetic patients.

Slowly available glucose and total glucose content

Slowly releasing glucose-containing food is good for maintaining proper blood sugar status within the human system. White bread had a significantly higher slowly available glucose content of 59.81±7.58 % compared with other biscuit types. However, there were no significant effects of the incorporation of defatted coconut flour into biscuits because all the biscuit samples used for this study had similar slowly available glucose contents. However, the formula can be improved to have the desired effect.

The in-vitro system, complete hydrolysis with an excess amount of enzyme is carried out to release all the glucose to the system. Excess enzymes removed a significantly higher amount of total glucose (99.16±5.56 %) in the BR sample while lower releasing with CF (40.91±1.34 %). Therefore, these values are expected to show a lower GI value.

Hydrolysis index and predicted glycemic index of biscuits

Glycemic Index of food sample provides an overview of glucose absorption into the small intestine. The calculated hydrolysis indexes for CF, DC and WF are 38.58, 45.31 and: 42.35 respectively. When the value of the glycemic index is less than 55, it is considered as a low GI food and the value is between 55 to 70 is considered as medium GI food and more than 70 GI value is considered as a high GI food (Eleazu, 2016). The lowest PGI value has been observed in the CF sample and it has 60.84 whereas can be ranked as medium GI food. Thus, coconut flour has a substantial effect on the digestion of the in-vitro system by delaying glucose releasing to the outer environment from the food. It can be due to the significant proportion of ash and fiber content of the defatted coconut flour incorporated biscuits. The starch releasing ability of three samples and white bread revealed that the starch releasing ability of CF is low while the highest starch releasing ability in WF (Figure 1).

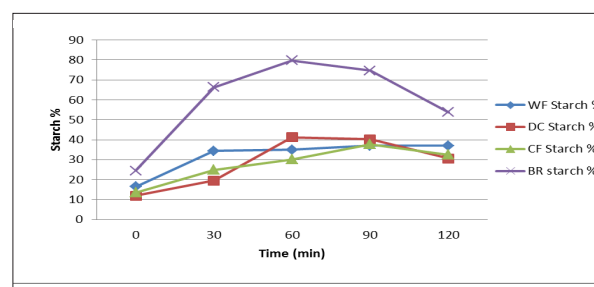


Figure 1. Starch concentration (%) of each sample during in-vitro digestion

Conclusion

Incorporation of defatted coconut flour increased the fiber and ash content of the biscuits while reducing sugar releasing capacity after in-vitro digestion. Therefore, it reduces the Glycemic Index of the product than the wheat flour-based counterparts. The defatted coconut flour-based biscuits (CF), as well as desiccated coconut incorporated (DC) and wheat flour-based biscuits (WF) can be categorized as medium GI food which is a healthy diet for a diabetic person and those who searching for healthy diets.

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