ORIGINAL ARTICLE

Production of Highly Functional BISCUITS Using Dried KOMBU (*Laminaria japonica*) Powder as the Supplement

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ABSTRACT

Background: Biscuits have been increasingly paid attention due to their attributes such as high palatable, dense nutrients as well as quickly released energy and available in variously convenient forms. Nutritionally advantage, biscuits formation can easily be modified to meet nutritional demands of targeting consumers. **Purpose:** The purpose of this study is to investigate the substitutional portion of the dried Kombu powder (DKP) for wheat flour in the production of high-functional biscuits with improved nutritional values. **Materials and Methods:** The collected samples of dried Kombu were milled into powder using the laboratory grinder and passed through 70-mesh sieve to obtain uniform-sized powder. The powder was then packed in airtight container and stored at ambient temperature until further used. **Results:** Nutritional analysis, the biscuits produced from wheat-DKP composites were significantly higher than that of 100% wheat biscuits in terms of all sensory attributes. **Conclusions:** The study demonstrates that the high potential supplement of the wheat flour by DKP in biscuits to improve nutritional values and the development of new formulation for making highly functional biscuits were successfully obtained.

Key words: Dried Kombu biscuits, dried Kombu powder, functional foods, nutritional values, physicochemical analysis, sensory evaluation

INTRODUCTION

Laminaria japonica is a flat dark-green marine algae, a type of kelp or seaweed, that is extensively cultivated in the seas of Japan and Korea. *L. japonica* is widely eaten in the East Asia. It is known as Kombu in Japan, Dasima in Korea, and Haidai in China. In cuisine, Kombu is used to make broth, pickled in soy sauce, eaten raw as a sea vegetable, and also used to make kelp tea.[1]

Kombu is particularly rich in the all vital minerals, especially calcium, potassium, magnesium, and iron, as well as the trace elements such as manganese, zinc, chrome, and copper. As it contains more potassium than sodium, Kombu makes a suitable substitute for table salt.

Dried Kombu blades are marinated in rice vinegar, semi-dried, and then cut into paper-thin shavings with a Razor Sharp Knife. It can be wrapped around rice or other ingredients and can easily be used as a condiment for a fish dish or simply eaten on its own as a snack.[2] It is, especially, worth noting that the Kombu is frequently used in cooking for making sweets and flavors to foods and used as a medical drug in Southern China and as a source of iodine in Russia. Kombu is usually sold in dried forms and found in the health food stores and groceries.[3] Similar to most Southeast Asian countries, the Vietnamese people historically valued marine macroalgae as an important natural resource. The history of seaweed use in Vietnam is not as clearly documented compared to, for example, neighboring China, but it can be traced back to the 10th–13th century. Several sources mention the use of

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seaweeds as traditional medicine, material to make sweet soups and cakes, and eventually as a vegetable resource.[4] Kombu contains fucoidan which can inhibit the development of the arthritis-causing inflamed cells in the human body. Dried Kombu powder (DKP) is one of the new ingredients which has been used as common soup stock and has been used for many cuisines as an inevitable seasoning worldwide and is often incorporated into soups, salads, and cooked dishes; in the granulated form, Kombu can be sprinkled on food or used as a food additive in many different dishes. Dried Kombu can also be deep-fried in oil to make chips or sautéed and marinated. Kombu lends itself to being cooked with dried beans and other legumes as it seems to shorten the cooking time and leave the finished cooked products softer and more digestible;[5] however, there is no information about how to prepare and improve the quality of the biscuits made from DKP. Theoretically, DKP could be added into wheat flour biscuits to improve the fiber and other nutrients content and give a special flavor for the biscuits as well as enhance the potential of DKP in food industry. Consumers request various kinds of high-quality processed foods which are nutritionally convenient, tasty, and natural feelings. Besides, the biscuit products supplemented with DKP can supply essential sources of minerals, vitamins (especially, B-6 and possibly B-12), and dietary fiber. It is hence, scientifically and economically, important to know whether the DKP can give the high-quality biscuits with improved nutritional values or not. In summary, this study has been conducted to investigate the physicochemical and nutritional characteristics of DKP to maximize the commercial potential of the dried Kombu in processed food products. In addition, the effects of various proportions of DKP and wheat flour also need determining to make good sensorial quality cookies.

MATERIALS AND METHODS

Preparation of DKP

The raw and dried seaweed leaves were milled into powder using the laboratory grinder and passed through 70-mesh sieve to obtain uniform-sized powder. The powder was then packed in airtight container and stored at ambient temperature until further used.

Preparation of Wheat-Kombu Biscuits

The Wheat-Kombu composites were prepared at different ratios (of 100:0; 95:5; 90:10; 85:15; and 80:20) with other ingredients were weighed accurately as the formulations shown in Table 1. Butter and sugar were creamed in a mixer before the homogenized mixture of dried ingredients was added. The smooth dough was formed and rolled until 3–5 mm thick with the help of a rolling pin. A round cutter of 4 cm diameter was used to create a uniform shape for all biscuits. Then, they were transferred to a lightly greased baking tray and baked at 160°C for 15 min in a preheated oven. After baking, all biscuits were allowed to be completely cool (about 30 min) and stored in airtight containers for 12 h before further analysis.

Table 1: Ingredients used in the preparation of biscuits

Ingredients	Samples (g)				
	A	B	C	D	E
Wheat flour	100	95	90	85	80
DKP	0	5	10	15	20
Powdered sugar	15	15	15	15	15
Butter	40	40	40	40	40
Baking powder	0.4	0.4	0.4	0.4	0.4
Ammonium bicarbonate	1	1	1	1	1
Salt	0.5	0.5	0.5	0.5	0.5

DKP: Dried Kombu powder

As shown in the all well-prepared tables, A is symbol marked biscuits produced from 100% wheat flour. Similarly, B is marked biscuits produced from 95% wheat and 5% DKP, C is marked biscuits produced from 90% wheat and 10% DKP, D is marked biscuits produced from 85% wheat and 15% DKP, and E is marked biscuits produced from 80% wheat and 20% DKP.

- A = 100:0 ratio of wheat-DKP in biscuits.
- B = 95:5 ratio of wheat-DKP in biscuits.
- C = 90:10 ratio of wheat-DKP in biscuits.
- D = 85:15 ratio of wheat-DKP in biscuits.
- E = 80:20 ratio of wheat-DKP in biscuits.

Proximate Analysis of DKP

The proximate analysis of the composite flours and developed biscuits moisture, protein, ash, crude fiber, fat content, and energy values was determined using the methods described by AOAC.[6]

Total Carbohydrate Content

Total carbohydrate was determined by the difference.[6]

% Carbohydrate = 100 – % (protein+ fat + ash+ fiber + moisture).

Determination of Mineral Composition in the Made Composite

The mineral composition of the made biscuits was determined using the method of Passos *et al*.[7]

Functional property analysis of the flour samples

Bulk density

Bulk density was determined following the method described by Eleazu and Ironua and Onabanjo and Dickson (2014). A 10 ml graduated cylinder, previously tarred, was gently filled with 5 g of sample. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was to a constant. The bulk density of the sample (g/ml) was calculated as weight of the sample per unit volume of sample.

Water absorption capacity (WAC)

The WAC of the sample was determined using the method as described by Eleazu and Ironua[8] and Onabanjo and Dickson[9] with minor modification. A measured quantity (1 g) of the sample was dispersed in 10 ml of distilled water in a conical graduated centrifuge tube. The sample was thoroughly mixed for 30 s and allowed to stand at room temperature for 30 min before being centrifuged at 4000 rpm for another 20 min. The volume of the supernatant was measured directly from the graduated centrifuge tube. The amount of the absorbed water was multiplied by the density of water (1 g/ml), and results were expressed as g/g.

WAC measures the ability of flour to absorb water and swell for improved consistency in food. It is a property desirable in food systems to improve yield and consistency and give body to the food.[8] The increase in the WAC has always been associated with increase in the amylose leaching and solubility, and loss of starch crystalline structure.[10]

Oil absorption capacity (OAC)

OAC of the flour was determined using the method as described by Adepeju *et al*.[11] and Eleazu and Ironua.[8] 1 g of sample was mixed with 10 ml of pure canola oil for 60 s. The mixture was set to stand for 10 min at room temperature and centrifuged at 4000 rpm for 30 min, and the oil that separated was carefully decanted. The tubes were allowed to drain at an angle of 45° for 10 min and then weighed. Oil absorption was expressed as a percentage increase of the sample weight.

Proximate analysis of developed biscuits

Moisture, fiber, ash, crude fiber, protein, mineral composition, and fat content of prepared biscuits were determined by the same methods used for DKP analysis.

Physical property measurements of biscuits

The width was measured by placing 6 biscuits edge-to-edge to get the average value in millimeters. The thickness was measured by stacking 6 biscuits on top of each other to get the average value in millimeters. Width divided by the thickness gave the spread factor. Digital weighing scale was used to determine the weight (in grams) of biscuits. Volume of biscuits was defined as the area multiplied by thickness. After calculating volume, density was obtained by the ratio of weight of volume.[12,13] The expansion coefficient was determined using the method of millet seeds dislocation,[14] and it was calculated as:

$$E_C = \frac{V_2 - V_1}{V_1} \times 100\%$$

Sensory evaluation

The consumer acceptance of four different samples of biscuits was evaluated using a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely).[15]

Statistical Analysis

Data were subjected to analysis of variance using the "Statistical Package for the Social Sciences" version 20.0. Results were presented as means±standard deviations of triplicate experiments. A significant difference was established at $P \leq 0.05$.

RESULTS

Proximate Analysis of DKP

The results of analysis proximate attributes of DKP are presented in Table 2.

Functional Properties of Composite Flour

The important functional properties that are usually assayed include WAC, bulk density, OAC, viscosity, and foam stability.[8] The results of functional properties of DKP and the composite flour samples are presented in Tables 3 and 4.

Table 2: Proximate values of DKP

Components (%)	Value*
Moisture (WB)	5.49±0.017
Ash	26.9±0.2
Fat	0.09±0.02
Protein	25.33±0.208
Crude fiber	2.3±0.01
Total carbohydrate	38.96±0.08
Iron	2.88±0.015 (mg/100g)
Iodine	49.67±1.53 (mg/100g)

*Values in the table represent the means±standard deviations (*n*=3 replicates), WB=Wet basis, DKP: Dried Kombu powder

Table 3: Effect of incorporating DKP on the functional properties of the composite flours

Sample	Bulk density (g/cm^3)	WAC (g/g)	OAC (g/g)
A	0.69±0.01^a	2.23±0.01^a	1.76±0.02^a
B	0.67±0.01^{ab}	2.25±0.01^{ab}	1.79±0.01^{ab}
C	0.65±0.01^{bc}	2.27±0.01^{bc}	1.81±0.02^b
D	0.64±0.01^{cd}	2.28±0.01^c	1.85±0.01^c
E	0.62±0.02^d	2.29±0.01^c	1.88±0.01^c

*Values in the table represent the means±standard deviations (*n*=3 replicates). The values denoted by different letters in the same column are significantly different ($P \leq 0.05$), DKP: Dried Kombu powder, OAC: Oil absorption capacity, WAC: Water absorption capacity

Physical Properties of Developed Biscuits

The results obtained from the physical measurements of biscuits made from wheat flour and composite flour with varying levels of DKP are shown in Table 5 and Figure 1.

Proximate Values of Developed Biscuits

Table 6 and Figure 2 present the nutritional composition of biscuits prepared from the composite flour of wheat flour substituted with DKP at different ratios compared to the control sample.

Mineral Compositions of Developed Biscuits

The estimated values of iodine and iron in the studied biscuits are given in Table 7.

Sensory Evaluation

Sensory evaluation of the product was conducted based on 9-point hedonic scale for appearance, color, flavor, texture, and overall acceptability. A semi-trained panel of 70 members was randomly selected to evaluate the sensory properties of the developed biscuits. The sensory evaluation was performed in laboratory with clean sensory cabinets containing fresh water. The panelists were instructed to evaluate the mentioned attributes of the samples and to rate each attribute. A 9-point hedonic scale with 1 (dislike extremely) and 9 (like extremely) was used. The mean scores of five samples in five sensory attributes are presented in Table 8.

DISCUSSION

Proximate Analysis of DKP

As shown in Table 2, moisture content of the powder (wet basis) was 5.49 ± 0.017%. Reportedly, the moisture content of DKP is considered as a quality characteristic where storage is concerned since high moisture content in the processed powder can accelerate chemical or microbiological deterioration. Data collected from numerous researches on dried seaweed powder have shown that the moisture content of the powder is in the range of 3.66–6.74% wet basis.[16]

Table 4: Functional properties of DKP

Physical property	Value*
Bulk density (g/cm^3)	0.525±0.002
WAC (g/g)	3.547±0.032
OAC (g/g)	2.323±0.068

*Values in the table represent the means±standard deviations (*n*=3 replicates). The values denoted by different letters in the same column are significantly different, DKP: Dried Kombu powder, OAC: Oil absorption capacity, WAC: Water absorption capacity

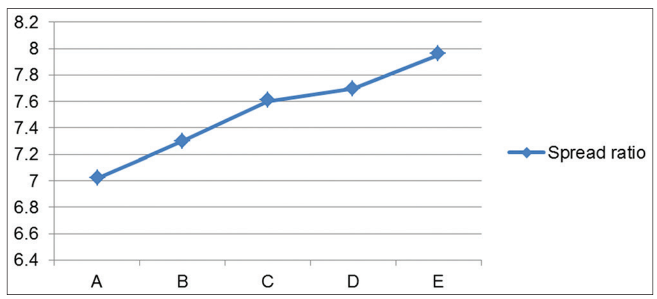

Figure 1: Effect of incorporating different levels of dried Kombu powder on the spread ratio of biscuits

Table 5: Physical properties of developed biscuits

Sample	Diameter (cm)	Thickness (cm)	Spread ratio	Weight (g)	Volume (cm^3)	Density (g/cm^3)
A	4.07±0.03^a	0.58±0.01^a	7.02±0.12^a	6.61±0.02^a	7.54±0.18^a	0.88±0.02^a
B	4.09±0.04^a	0.56±0.01^{ab}	7.30±0.1^{ab}	6.45±0.01^b	7.36±0.25^{ab}	0.88±0.02^a
C	4.08±0.03^a	0.54±0.01^{bc}	7.6±0.13^{bc}	6.31±0.1^b	7.01±0.02^{bc}	0.9±0.02^a
D	4.1±0.02^a	0.53±0.01^{bc}	7.7±0.1^{bc}	6.13±0.02^c	7.04±0.1^{bc}	0.87±0.02^a
E	4.1±0.04^a	0.52±0.02^c	7.95±0.24^c	6.12±0.01^c	6.84±0.24^c	0.9±0.03^a

*Values in the table represent the means±standard deviations (*n*=3 replicates). The values denoted by different letters in the same column are significantly different ($P \leq 0.05$)

Table 6: Proximate values of developed biscuits

Sample	Moisture (%)	Fat (%)	Ash (%)	Fiber (%)	Protein (%)
A	6.5±0.01^a	26.5±0.09^a	0.97±0.01^a	0.34±0.01^a	7.8±0.04^a
B	7.01±0.01^b	25.34±0.06^b	1.02±0.01^b	0.67±0.03^b	8.65±0.05^b
C	7.44±0.01^c	24.01±0.01^c	1.11±0.00^c	0.94±0.01^c	9.44±0.06^c
D	7.94±0.01^d	22.53±0.01^d	1.17±0.01^d	1.33±0.01^d	10.35±0.06^d
E	8.53±0.01^e	21.12±0.07^e	1.22±0.02^e	1.65±0.06^e	11.27±0.03^e

*Values in the table represent the means±standard deviations (*n*=3 replicates). The values denoted by different letters in the same column are significantly different ($P \leq 0.05$)

Some red seaweed powders (*Hypnea japonica* and *Hypnea japonica*) have been found to have higher moisture contents, about 9.95–10.9% wet basis.[17]

Furthermore, from Table 2, the ash content of the powder was 26.9 ± 0.2%, of which the collected value in this study was in a similar range when compared to the work done by Jenifer and Kanjana, 2015, and Vijay and Balasundari 2015, B.F.Sc., 2017.[18] Since the ash content of the analyzed food represents the mineral content of the food material, it has been identified to contain iodine, calcium, phosphorus, magnesium, sodium, potassium, iron, zinc, and copper as they are the main mineral constituents in Kombu.[19] Kombu contains the highest level of iodine of all the seaweeds, which is essential for normal growth and development. In the study, iron content in Kombu powder is 2.88 ± 0.015 mg/100 g and iodine content is 49.67 ± 1.53 mg/100 g, extremely high level of trace elements content.

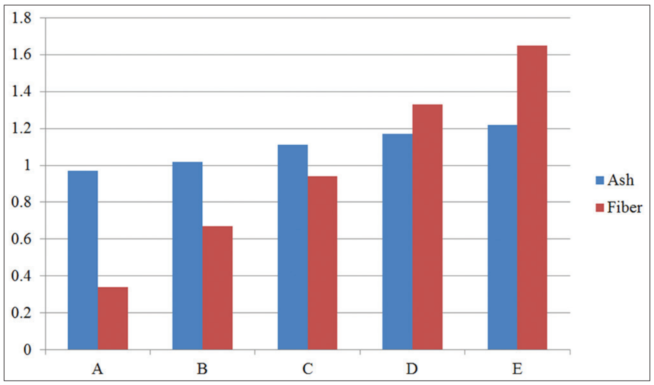

Figure 2: Effect of incorporating different ratio of dried Kombu powder on the ash and fiber content of biscuits

Table 7: Mineral compositions of developed biscuits

Sample	Iron (mg/100g)	Iodine (mg/100g)
A	**ND**	**ND**
B	0.16±0.01^{a}	1.61±0.01^{a}
C	0.38±0.01^{b}	2.79±0.02^{b}
D	0.54±0.01^{c}	4.07±0.08^{c}
E	0.73±0.02^{d}	4.99±0.15^{d}

ND=not detectable, *Values in the table represent the means ±standard deviations (*n*=3 replicates). The values denoted by different letters in the same column are significantly different ($P \leq 0.05$)

Table 8: Sensory evaluation scores of developed biscuits in term of color, taste, flavor, texture, and overall acceptability in 5-point scale

Sample	Color	Taste	Flavor	Texture	Overall acceptance
A	2.74^{a}	3.03^{a}	3.15^{a}	3.07^{a}	2.94^{a}
B	3.44^{b}	3.47^{b}	3.44^{b}	3.58^{b}	3.47^{b}
C	3.66^{c}	3.86^{d}	3.93^{d}	3.52^{b}	3.76^{cd}
D	3.71^{c}	3.64^{c}	3.62^{c}	3.58^{b}	3.63^{c}
E	3.95^{d}	3.83^{d}	3.68^{c}	3.54^{b}	3.80^{d}

*Average of 60 evaluations. The values denoted by different letters in the same column are significantly different ($P \leq 0.05$)

Brown seaweed family is known as low-fat content food.[20] The fat content of the studied DKP was considerably low, valued of 0.09 ± 0.02% which was similar data collected by Burtin, 2003,[21] and Polat and Ozogul[22] when the fat content of Kombu ranged from 1% to 5% of dry weight.

Marsham *et al*.[23] found a high level of protein in 11–108 species of algae (6.9–44%). Burtin (2003) reported that the protein content of brown seaweeds was about 5–15% of the dry weight compared with those of red and green seaweeds (10–30% as dry weight); the protein content of the powder was 25.33 ± 0.208%. Though, Kombu is a high source of food protein and its protein has been reported to have good biological value.[24]

The study of Vijay and Balasundari., 2017,[20] revealed that the fiber content of dried kelp powders ranged from 1.13% to 2.54%, and the result obtained from the DKP in this study was within that range of 2.3%. It has been well known that dietary fiber serves as a useful tool in the control of oxidative processes in food products and as functional food ingredient (Eleazu and Ironua 2013). In addition, dietary fiber decreases the absorption of cholesterol from the gut in addition to delay the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes.[25]

Scientifically and practically, it is very necessary to determine and know the carbohydrate content of the studied food materials. As shown in Table 2, data on the total carbohydrate content were of 38.96 ± 0.08%. In DKP, carbohydrates account for the bulk of the powder and hence serve as a good energy source. In a special addition, it is worth mentioning that the carbohydrate contents in dried Kombu have a rather low glycemic index while providing the quick energy to human cells' need without the negative side effects that accompany other energy-dense foods according to a study about the increasing seaweed percentage decrease glycemic index value of pasta of Firdaus *et al*.[26]

Functional Properties of Composite Flour

As shown in Tables 3 and 4, the important functional properties of composite flour needed to be assayed include WAC, bulk density, OAC, viscosity, and foam stability.[8] As these properties are those which determine the applications and use of food material during processing, storage and preparation because they affect the general quality of foods as well as their acceptability.

Bulk Density

Scientifically and economically, bulk density is generally affected by the particle size and density of the flour and so it is a really important approach to determine the packaging requirement, material handling, and application in wet processing in the food industry.[27,28] Hence, the higher the particle size, the lower the bulk density. Consequently, a decrease in bulk density is not really desirable because the high bulk density offers greater packaging advantage, as a greater quantity may be packed within a constant volume.[8] However, the decrease of bulk density was not large enough to lead to a significant effect to the product and the related issues. As presented in Table 4, the value of bulk density for wheat flour (Sample A) was 0.69 g/cm^3, while DKP recorded 0.525 g/cm^3. As shown in Table 4, when more and more DKP was incorporated into wheat flour, the bulk density of composite flour decreased. The values for the samples ranged between 0.62 and 0.69 g/cm^3, with Sample A recorded the highest value and the lowest was Sample E. The values of bulk density among studied samples were reported insignificantly different ($P > 0.05$).

WAC

From Table 4, the WAC for flour composites was increased along with the increase of DKP proportion. The result ranged between 223 to 229% for all samples, with Sample E recorded the highest value and the lowest was sample A. This suggested that when more DKP was added to wheat flour, the WAC of the blended samples was increased. WAC measures the ability of flour to absorb water and swell for improved consistency in food. It is a property desirable in food systems to improve yield and consistency and give body to the food.[8,28]. The increase in the WAC has always been associated with an increase in the amylose leaching and solubility and loss of starch crystalline structure.[29] This leads to the weakened dough and decreases its stability and extensibility. However, wheat-DKP composites displayed acceptable binding properties during preparation, which suggest that the combination of wheat-DKP can be used in making biscuit.[30]

OAC

Data shown in Table 3 indicated that the flour derived from this DKP had considerable OAC (232%). Among all flour samples, the OAC ranged between 176% and 188% in which the highest recorded value was Sample E and the lowest one was Sample A. The OAC of flour composites slightly increased as more and more DKP was incorporated, which indicated holding effect of DKP on OAC of wheat flour. The values of OAC were reported significantly different ($P < 0.05$) between Samples A and E.

The mechanism of fat absorption is attributed mainly to the physical entrapment of oil and the binding of fat to a polar chain of the protein. Non-polar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids.[27,29] Therefore, the high protein content in DKP is the possible reason for the increase in the OAC of composite flours when increasing the level of substitution.

Physical Properties of Developed Biscuits

As clearly shown in Table 5, the spread ratio is considered as one of the most important quality parameters of biscuits because it correlates with texture, grain finesse, bite, and overall mouth feel of the biscuits.[13] Figure 2 shows that the higher level of composite flour significantly increased the spread ratio of the final product ($P < 0.05$). The highest value was of Sample E (7.95), while the lowest value belonged to Sample A (7.02). An increase in DKP content significantly increased the spread ratio of the biscuits, which was directly related to their thickness, whereas the diameter was generally not affected. The significant difference in terms of spread ratio among samples was due to the high water and OAC of the DKP. The study of Aziah, Noor *et al*., 2012,[15] and Miller and Hoseney, 1997,[31] revealed that the amount of protein in the flour affects the formation of continuous gluten web which increases the viscosity and stops the flow of the dough. Despite the high protein content, the flow of the dough still increased due to the extremely high water and OAC - natural features of seaweeds.

The volume of biscuits was ranged from 6.84cm^3 to 7.54 cm^3, with the highest value was seen in Sample A and the lowest value was of Sample E. The higher the replacement of DKP, the lower the volume of the biscuits. This is possibly due to the fibers present in the DKP, which might interfere in the structure of the matrix, diminishing the gas retention capacity in the dough.[32] The volume of dried Kombu biscuits decreased linearly, whereas density increased in the similar manner. However, the differences of two attributes among samples were insignificant ($P < 0.05$). Mean densities of biscuits ranged from 0.88 g/cm^3 to 0.9 g/cm^3, with the highest value was of Sample E and the lowest value was of Sample A. Density was the best index of sensory texture of biscuits. Lower density means greater crispiness and higher textural value.[33] As reported by Manohar and Rao,[34] there was a positive correlation between dough firmness and density.

The weight of the experimental biscuits was between 6.12 g and 6.61 g with the highest value was of Sample A and the lowest was found in Sample E. The results differed significantly among samples ($P < 0.05$). As can be seen, the higher level DKP incorporated, the more the weight loss of the biscuits. The DKP had higher WAC than the wheat flour, and hence, this resulted in the higher initial moisture content of the dough and the higher loss of water during baking of the biscuits.

Proximate Values of Developed Biscuits

As clearly shown in Table 6, it can be seen that there was a significant increase of moisture content of biscuits from Sample A to E (from 6.5% to 8.53%). As shown in the previous part, the WAC of wheat flour was 2.23 g/g lower than that of DKP, namely 3.547 g/g. Therefore, the biscuits contained more DKP had higher affinity for water which was informed by their higher moisture content. The difference in moisture between the control sample A and other treatments was significant ($P < 0.05$).

The concentration of fat in the biscuits ranged between 21.12% and 26.5%, with highest concentration of fat was seen in biscuits A. Although there was a variation in the fat content in different types of biscuits, it was statistically similar ($P > 0.05$). The result shows that fat concentration decreased as the quantity of DKP increased. This was probably due to the higher fat retention ability of DKP comparing with that of wheat flour during baking process. Higher fat retention improves the mouthfeel and retains the flavor of the biscuits (Baljeet, Ritika *et al*. 2010). This obtained result was in agreement with the works of Jenifer *et al*., 2015.[18]

As shown in Figure 2, the ash content of samples was improved when there was a higher level of DKP in biscuit formulation. The clear effect could be seen even when only 10% DKP was used in making biscuits. Hence, the highest ash content was of Sample E (1.22%), followed by Sample D (1.17%), and they were significantly higher ($P < 0.05$) comparing with that of the control Sample A (0.97%). The ash content of food material could be used as an index of mineral constituents of the food because ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of an oxidizing agent.[9]

The value of crude fiber content of biscuits also increased significantly ($P < 0.05$) as more DKP was added to wheat flour in biscuit production. The highest value of crude fiber was found in Sample E (1.65%) having 20% DKP substitution and the lowest was seen in Sample A (0.34%). This suggested that DKP had more crude fiber than wheat flour. People who consume generous amounts of dietary fiber have health-protective effect, compared to those who have minimal fiber intake. Increasing the intake of high fiber foods or fiber supplements improves serum lipoprotein values, lowers blood pressure, improves blood glucose control for diabetic individuals, aids weight loss, and improves regularity.[35] With the mounting evidence of the overall health benefits of fiber, aggressive efforts should be made to incorporate fiber intake goals in nutrition therapy for metabolic conditions as well as in nutrition guidelines for health promotion.[36]

The concentration of protein in the biscuits ranged between 7.8% and 11.27%, with the highest concentration of protein was seen in biscuit E. The result shows that protein concentration increased as the quantity of DKP increased. This was probably due to the extremely high protein content of DKP (25.33 ± 0.208%) comparing with that of wheat flour (7.8% from the present study).

Mineral Compositions of Developed Biscuits

It is well-known that deficiency or overexposure to various elements has noticeable effects on human health. Edible seaweeds accumulate iodine from seawater and are, therefore, a good dietary source of iodine. An adequate consumption of seaweed can eliminate iodine deficiency disorders. Retail availability and intake or iodine-rich foods are essential for individuals to meet their daily iodine requirements, and iodine is an essential trace element required for normal thyroid performance (NHMRC, 2006). Iodine deficiency affects about two billion people and is the leading preventable cause of intellectual disabilities. Besides iodine, another important trace element presenting in Kombu is iron. Iron is an essential element for almost all living organisms as it participates in a wide variety of metabolic processes, including oxygen transport, deoxyribonucleic acid synthesis, and electron transport.[37] Anemia occurs when the body does not have enough red blood cells or hemoglobin which can be caused by lacking in sufficient supply of iron. Iron-deficiency anemia affects, perhaps, 1–2% of all-American adults (Iron and your health, Harvard Men's Health 2015).

The estimated values of iodine in the studied biscuits as shown in Table 7 demonstrated that the increasing level of DKP substitution in producing biscuits exhibited a significant level of iodine of the products compared to the control samples. In the incorporated dried Kombu biscuits, iodine ranged between 1.61 and 4.99 mg/100 g from Sample B to Sample E, whereas the value of the control sample cannot be detected. These concentrations were statistically different ($P < 0.05$) among the studied samples. It was also similar with iron content when the increasing level of DKP substitution in producing biscuits exhibited a significant level of iron of the products compared to the control samples. In the incorporated dried Kombu biscuits, iron content ranged between 0.16 and 0.73 mg/100 g from Sample B to Sample E.

Sensory Evaluation

Organoleptic tests of the biscuits depend on its first color, crispiness, taste, aroma, and overall acceptability of the sample. From Table 8, mean scores of the samples in five sensory attributes are presented, of which the color of biscuits made from wheat-dried Kombu composite flour was more preferable than that of the control sample. The highest score was of the Sample E (3.95) having 20% of DKP, followed by Sample D (3.71) with 15% DKP substitution, while the score of control sample was the lowest, namely 2.74. With the taste attribute, Sample C with 3.86 point was the most favorable, which was a very close score to Sample E with 3.83 point, followed by the turn are Sample D and Sample B. This pattern happened similarly to the flavor where Sample C had the highest scores (3.93), followed by Sample E with 3.68 points and the lowest points were of Sample A, 3.15, respectively. Though there is a significant difference between the results of texture evaluation of Sample A and the other 4 samples.

Texture point ranged from 3.07 of Sample A to 3.52–3.58 of Samples B, C, D, and E; there was statistical difference ($P > 0.05$). The results of the evaluation also showed that biscuits made from the composite flours of wheat and dried Kombu were more accepted than the control ones. The highest score was of Sample E (3.80), followed by Sample C with the score of 3.76 and the last place was Sample A with the score of 2.94.

CONCLUSIONS

The study demonstrates that the high potential supplement of the wheat flour by DKP in biscuits to improve nutritional values and the development of new formulation for making high quality biscuits. The Kombu powder helps by not only improving nutritional value and health benefits but also highly increasing the acceptance of various ages of consumers.

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How to cite this article: Toan NV, Phuong LA. Production of Highly functional Biscuits Using Dried KOMBU (*Laminaria japonica*) Powder as the Supplement. Clin J Nutr Diet 2018;1(2):1-9.