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Fiber content and storage stability of antioxidant activity of nutraceutical mango products and gluten-free cookies

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***Abstract*— This study provides new data on the total dietary fiber (TDF) contents and storage stability of antioxidant activity of nutraceutical mango products and gluten-free cookies, which play an important role in health benefits. The main objective of this research is to recycle fruit by-products as they represent the bulk of food waste and create into promising products such as nutraceutical foods. Mango peels were used to produce nutraceutical food products such as mango puree and gluten-free mango cookie. Mango peel and gluten-free plain cookie were used as controls to compare the TDF contents and antioxidant activities of mango puree and gluten-free mango cookie after Day 28. TDF contents of mango peel exhibited the highest while mango puree exhibited the lowest. Oxygen radical absorbance capacity (ORAC) assay was used to determine storage stability of antioxidant activity over 28 days. The ORAC values of the mango puree were 1770 units on Day 1 and 1210 units after Day 28, respectively; gluten-free mango cookie was 645 units on Day 1 and 623 units after Day 28, respectively; and gluten-free plain cookie was 480 ORAC units on Day 1 and 270 units after Day 28, respectively. Gluten-free mango cookie which exhibited the least decrease of antioxidant activity was highlighted as the potential of nutraceutical food product. Although the results obtained had shown that antioxidant level was present in the products after 28 days of storage, further research could be conducted to determine the types of antioxidants present in these products, thus enhancing health benefits to consumers.**

Keywords- total dietary fiber; fruit by-products; nutraceutical foods; antioxidants.

I. INTRODUCTION

Fruit by-products such as peels pose a serious disposal problem as they represent the bulk of food waste. Studies on peels were limited and their use for food production was hardly conducted. Fruit peels can be used as a good source of natural antioxidants and dietary fibre [1]. Hence, they can be utilised to create nutraceutical foods.

Nutraceutical foods provide medical or health benefits, including the prevention and treatment of diseases [2]. By utilising fruit by-products to produce nutraceutical food products, the amount of fruit wastes was also reduced. At the same time, fruit peels with natural antioxidants were also present in these products, hence promoting health benefits to the consumers and public.

Dietary fibre and antioxidants can be found in nutraceutical food products. Dietary fiber is beneficial to health as it prevents constipation, coronary heart diseases and diabetics [3]. Antioxidants can prevent cancer and disease as they have the ability to scavenge free radicals in human system [4].

Researches had shown that the mango peel extract and fraction contained higher antioxidant activity than the pulp fraction [5-6]. The high level of antioxidant is attributed to the optimal mix of antioxidants such as vitamin C, polyphenols, carotenoids and complex carbohydrates. The mango that was used in this research study was *Mangifera indica L* Honey Thai. The antioxidant activity of each food sample was determined using oxygen radical absorbance capacity (ORAC). ORAC assay is a universal tool used for measuring the antioxidant capacity of biomolecules from a variety of samples. ORAC assay determined antioxidant activity using peroxyl radicals [7].

Besides having dietary fibre and antioxidants in foods, gluten-free product is also a growing trend of nutritional quality in the market [8]. Gluten-free means no gluten (special type of protein) present in the food product. Gluten promotes elasticity of bread, providing the chewy texture when consumed. Gluten provides important qualities to bread such as keeping the released gases during fermentation in the dough so the bread will rise and has an absorbent quality [9]. Despite gluten being an important bread ingredient, it also provides consumers, who are suffering from celiac disease. Celiac disease, which impedes the digestion of gluten, can cause weight loss, bloating, diarrhoea, abdominal cramps and/or vitamin and mineral deficiencies. This may be fatal if not treated properly [10].

The objective of this study was to obtain TDF and ORAC values of the newly created nutraceutical food products. The storage stability of nutraceutical mango products and gluten-free cookies in terms of decreased ORAC values after 28 days was also determined.

II. MATERIALS AND METHODS

A. Ingredients for processing fresh mango peel

The raw fine sugar and fine grain sugar of SIS brand (Singapore), FairPrice Premium quality fine salt (China), unsalted pure creamery butter of SCS brand (Australia), Vanilla Essence and baking powder of Bake King brand (Singapore), Potato Starch superior of Windmill brand (Holland), Tapioca Flour and finest rice flour of Max's brand (Thailand) and Chew's Fresh eggs (Singapore) and glucose of Phoon Huat brand (Singapore) were used. Mango peel *Mangifera indica L* Honey Thai and the citric acid powder

given by the industry partner (Polar Puffs and Cakes Pte. Ltd.) were used.

*Food samples**

Using the above-mentioned ingredients, nutraceutcal food samples, namely mango puree, gluten-free mango cookies and gluten-free plain cookies were created. Fresh mango peels were processed and blended into puree form. Gluten-free plain cookies and gluten-free mango cookies (with mango puree) were made.

**The full recipe cannot be revealed due to the confidentiality agreement signed between institution and industry partner.*

B. Samples preparation

Five types of samples, namely fresh mango flesh; mango puree; mango peel; gluten-free mango cookie and gluten-free plain cookie were weighed and prepared according to the sample extraction in ORAC kit protocol (Cell Biolabs, USA) and TDF-100 kit protocol (Sigma, USA).

Antioxidant capacity assay

The antioxidant capacity was determined by the ORAC assay. The materials in the ORAC kit used were 96-well Microtiter Plate; Fluoroscein Probe (100 times); Free Radical Initiator; Antioxidant Standard (Trolox™) and Assay Diluent (4 times). Other materials needed were sample extracts; sterile water; 37ºC incubator; pipette controller; serological pipette; 1 µL-10 µL micropipette; 10 µL-100 µL micropipette; 100 µL-1000 µL micropipette with disposable tips; falcon tubes and eppendorf tubes. The ORAC procedure also used an automated plate reader (Tecan Infinite M200).

Total dietary fiber analysis

Fat-free samples were analysed for the TDF contents by enzymatic and gravimetric method of the Association of Official Analytical Chemists (AOAC) [11], using the TDF-100 kit. Along with the test samples, blank and reference samples were also analysed simultaneously in duplicate for comparison. TDF contents of the samples analysed were calculated and expressed on fresh weight basis.

III. Results and Discussion

TABLE I. ORAC VALUES AND TDF CONTENTS OF SAMPLES

Sample No.	Sample Name	ORAC (Day 1)	ORAC (Day 28)	% ORAC decrease	% TDF (w/w) (Day 28)
1	Mango Flesh	499	292	11	-[a]
2	Mango Peel	1770	1210	31.6	8.93
3	Mango Puree	1576	1080	31.5	2.02
4	Mango Cookie[#]	645	623	3.4	4.33
5	Plain Cookie[#]	480	270	43.8	4.17

[a]TDF was not conducted. [#]Gluten-free cookie.

A. Antioxidant activity of samples

Mango peel and gluten-free plain cookie were used as controls to compare the antioxidant activities of mango puree and gluten-free mango cookie after Day 28.

From the results of Day 1 (Table 1), the mango peel had the highest antioxidant activity (ORAC), followed by mango puree, mango cookie, mango flesh and lastly plain cookie. This concluded that the mango peel fraction contained a higher level of antioxidant activity than the pulp fraction, which was the mango flesh. Making use of the mango peel to make puree and incorporating the puree into the cookie will thus increase the antioxidant capacity for the cookie. Overall, the mango peel had a higher antioxidant activity (1770 units on Day 1 and 1210 units after Day 28) than the raw mango, 1002 units [12]. This difference could be due to the differences in methods and mango cultivars.

Both mango peel and mango puree had the greatest yet similar decrease of ORAC units. Hence, their storage stability of antioxidant activity was lower than those of mango fresh and mango cookie.

The lowest antioxidant level was found in the plain cookie when no mango puree was added. Antioxidant such as butylated hydroxyanisole (BHA), which was used to stabilize fats and oils, is found in butter [13]. In addition, ingredients such as egg yolk contributed to the antioxidant level of the plain cookie [14].

The incorporation of mango puree had demonstrated an increase of antioxidant activity between mango cookie and plain cookie. Reduction of antioxidant activity was shown after 28 days of storage for all samples. The greatest reduction of antioxidant activity was exhibited in the plain cookie, followed by mango peel, mango puree, mango flesh and mango cookie, respectively. With only a small decrease of antioxidant activity even after 28 days, it showed that the mango cookie could retain most of its antioxidants.

The mango puree in the mango cookie was processed using citric acid. Ascorbic acid has beneficial effort on extending storage stability of antioxidant activity [15]. This could explain the high antioxidant level in mango puree and its antioxidant activity decreased slower than the plain cookie over 28 days. As shown from Table 1, the antioxidant activity of mango puree in cookie could have extended the shelf-life of gluten-free mango cookies as there was only 3.4% decrease of ORAC units after 28 days.

Sugar played an important role in the baking process of cookies. It caramelized during the process of baking which gave the cookies a pleasant flavor. Besides enhancing the flavor, browning, texture of the cookie, sugar is also a food preservative [16].

Butter fats within the cookie promoted fat oxidation to occur. Fats were creamed with crystalline sugar and tiny air cells were incorporated into the dough which allowed the end-product to have fine and aerated texture. If fat oxidation occurs, the amount of fats reduces thereby increases the chances where the end-product will lack of flavor and be tough and full of tunnels in the cookie. Therefore, it is important to keep fat oxidation away from fat-containing products [16].

By adding antioxidants, it prevents or slows down the rancidity of fats by slowing down the process of oxidation due to exposure to the oxygen in the air [17]. This is turn will slow down the cookie spoilage and extend its shelf-life. In addition, antioxidants are used as food additives to retain the flavor [18], thereby extending the food shelf-life.

The significant decrease of ORAC units could result in a negative effect on the shelf-life of the food products. The reduction of antioxidants in foods is likely to decrease their storage stability, hence reducing their shelf-life. However, further researches may be conducted to determine the types and amount of antioxidants present in these mango puree and mango cookies.

B. Total Dietary Fiber content

Mango peel and gluten-free plain cookie were used as controls to compare the TDF contents of mango puree and gluten-free mango cookie after Day 28.

Table 1 shows the TDF contents of the four food samples after 28 days. The mango peel had the highest TDF content, followed by the gluten-free mango cookie, gluten-free plain cookie, and finally the mango puree.

The TDF value obtained for mango peel in this study was higher than the reported values [19-21] even after 28 days. This variation could be due to the differences in the methodology applied for fiber content determination in mango, mango cultivars (or varieties) and ripening stage of mango. Besides antioxidant level, high fiber value is essential for the requirement of nutraceutical foods as dietary fiber plays an important role in decreasing health disorder such as diabetes and cardiovascular diseases [22].

High amount of dietary fiber is found in the mango peel. There is about 45 % to 78% of dietary fiber content in the mango peel [5]. Dietary fiber in foods is essential as it is able to control water absorption in food products by reducing the amount of moisture absorbed by the food. This slows down the increase of water activity within the food products when exposed to the atmosphere. As the water activity in the cookies is slowed down, the microbial growth is also lessened [23]. The shelf-life of foods could be extended.

Mango puree had a lower TDF content than mango peel as some antioxidants were lost during the peel processing. The TDF content of mango peel was the highest (8.93%) which was partly due to the presence of mango flesh adhered to its peel. Mango flesh naturally has high dietary fiber content, which attributed to high TDF content of mango peel. Moreover, mango peel was reported to have high dietary fiber content of up to 78% [5]. Furthermore, there is a correlation between antioxidant activity and TDF [3, 20], as mango puree had significant antioxidant activity (1080 ORAC units) and TDF content (2.02%).

The presence of mango puree in gluten-free mango cookie showed a higher TDF content (0.16% TDF more) than gluten-free plain cookie. The presence of complex carbohydrates present in gluten-free cookie contributed to the increase of antioxidant activity and TDF, respectively [3, 20]. Despite over 28 days, the cookie was still edible and stayed fresh. The significant values of antioxidant activity and TDF content are important in the storage stability of the gluten-free mango cookie.

C. Implications

From the results observed in this study, it is evident that the nutraceutical mango products especially the peel and gluten-free mango cookies are sources of antioxidants and TDF. Antioxidants and TDF are important components associated with a number of health benefits. Although the data generated from this study might be preliminary, they will be useful for research in further analysis of fruit by-products. Future studies could include a two-month shelf-life study of these gluten-free mango cookies before commercialisation.

IV. CONCLUSION

Overall, the TDF and ORAC results from this study indicated that the nutraceutical mango products will deliver health benefits such as prevention of coronary heart disease and cancer. The gluten-free products are also protective against cellular damage and suitable for consumers who have gluten allergy. TDF contents of the samples were evaluated and the mango food products offer more fiber. Although there was a reduction of antioxidant activity for all samples, the amount of antioxidants present was still significant. Further tests can be conducted to determine the types of antioxidants present in these nutraceutical mango products.

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