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Bakery and Steamed Products Made of Resistant Starch-Rich Banana Flour as Functional Foods

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ABSTRACT

Starch of unripe "uli" plantain variety (*Musa paradisiaca*) was modified by 24 h fermentation of banana chips followed by autoclaving-cooling to increase the resistant starch (RS) content of the flour. The modified RS-rich banana flour (MBF) was then formulated with various ratios of wheat flour (WF) into bakery and steamed products i.e. cookies, bread and brownies cake. The modification process could significantly increase the RS content (9.19%) of MBF compared to the unmodified flour (6.17%). Sensory test revealed that the most preferable product with certain formulation (MBF:WF) according to the panelists were 60:40, 20:80, and 70:20, for banana cookies, bread and brownies, respectively. Different MBF formulations and baking and steaming process contributed to the RS content of the products with the highest RS content was found in cookies (3.68%), followed by brownies (1.51%) and bread (1.45%). Starch digestibility of the products were relatively low i.e. 47.74% (cookies), 45.63% (bread) and 45.91% (brownies).

Keywords: resistant starch, banana flour, cookies, bread, **brownies**

1. Introduction

The development of new products is a strategic area of the food industry. Consumers are demanding foods that show two main properties: the first-one deals with the nutritional aspects of the food, whereas, as a second feature, additional health benefits are expected from its regular ingestion. These kinds of food products are often called functional or nutraceutical foods. In a rapidly changing world, with altered food habits and stressful life styles, it is more and more recognized that a healthy digestive system is essential for the overall quality of life (Brouns et al., 2002).

One of the current tendencies in nutrition and health is to consume low-carbohydrate food products. Resistant starch (RS) is known to be slowly digestible and has evident impact on the rate of starch digestion. RS is the sum of starch and starch degradation products that are not absorbed in the small intestine of healthy individuals, due to their resistance to enzyme digestion (Asp, 1992).

In the 1980s, dietary fiber was identified as an important component of a healthy diet, and the food industry looked for palatable ways to increase the fiber content of their products. The first commercially available product to provide a concentrated source of RS was reported in the mid 1990s.

Various RS types have been characterized in common foods. According to Englyst et al. 1992), these indigestible starch fractions may be classified according both to the nature of the starch and its environment in the food. Thus, RS1 corresponds to physically inaccessible starches, entrapped in a cellular matrix, as in cooked legume seeds, and RS2 are native uncooked granules of some starches, such as those in raw potatoes and green bananas, whose crystallinity makes them scarcely susceptible to hydrolysis RS3, on the other hand, consists mainly of retrograded starch fractions, which may be formed in cooked foods that are kept at low or room temperature. More recently, a fourth type (RS4), has been associated to certain fractions of chemically modified starches (Tovar et al., 1999; Laurentı´n et al., 2003).

Resistant starch can be found in both processed and rawfood materials. From the four RS types, RS3 seems to be particularly interesting because it retains its indigestibility when added as an ingredient to processed foods. RS3 is produced by a combination of the gelatinization process, which is a disruption of the granular structure by heating starch with an excess of water (Farhat et al., 2001); and retrogradation, a slow recrystalization of starch components (amylose and amylopectin) upon cooling or dehydration (Shamai et al., 2003). As it was mentioned before, modern food manufacturing methods destroy most forms of resistant starch, making them unsuitable as ingredients in highly processed food systems. This fact gives importance to the production of RS-rich powders that may be used in the formulation of diverse products. Potential applications for such a type of ingredient include breads, tortillas, pizza crust, cookies, muffins, waffles, breakfast cereals, snack products and nutritional bars, as well as lowfat fermented milks, ultra-heat treatment (UHT) flavored milk drinks, and ready-to-use powdered mixes, such as instant soups and chocolate drinks. In a recent study, a resistant starch-rich flour was prepared from fermented banana flour, which retains its amylolysis resistant features after subsequent heat and cool treatment (Jenie et al. 2009).

The objective of this research was to obtain appropriate substitution of modified banana flour (MBF) in foods model (cookies, bread, brownies) processing and analyze the effect of replacing part of the wheat flour with MBF to sensory characteristic and resistant starch content in the products.

2. Materials and Methods

2.1. Modified banana flour

Unripe (*Musa paradisiacal* sp) banana flour was purchased at the local market in Leuwiuliang Bogor (West Java). They were peeled, cut into 5mm, immediately rinsed in steril aquadest solution (750 g/L) and then incubation at room terperature for 24h. The chips were drainedn) and pressure-cooked at 121^{0}C for 15 min in an autoclave. The mixture was cooled to room temperature, and stored at 47C for 24 h. After twice repetitions of the autoclaving and cooling cycles, the sample was dried and ground into fine particles (60 mesh U.S.).

2.2 Preparation of cookies, bread and brownies cake

The formulation used for the cookies, berad and brownies is shown in Table 1. In all cases, the products contained either wheat flour (control) or the modified banana flour mix. Margarine (containing a blend of vegetable oils, whey milk, soy lecithin, citric acid, etc.) was creamed, mixed with confectioner's sugar and a whole egg, added to the wheat flour or the wheat flour/RSRP blend and mixed thoroughly; dough was rolled out to a 2 cm height on flat surface. Cookies were cut with a circular mold (6 cm diameter) and placed on greased luminum cookie sheets. The cookies were baked in a household oven (Hotpoint, 6B4411LO, Leisser S.A. de C.V., San Luis Potosi, Me´xico), at an approximate temperature of 200 1C for 20 min. Once baked, cookies were allowed to cool down during 30 min and stored in a plastic container with hermetic cover.

2.3 Chemical composition

Moisture content was determined by gravimetric heating (13072 1C for 2 h) using a 2–3 g sample. Ash, protein and fat were analyzed according to AACC methods 08–01, 46–13, and 30–25, respectively (American Association of Cereal Chemists: Approved Methods of the AACC, 2000).

2.4 Resistant starch analysis

The resistant starch (RS) content was measured using the procedure of *Goñi* et al. [16]. The method comprises the following steps: removal of protein with pepsin (Sigma A-7000, 407C, 1 h, pH 1.5), incubation with a-amylase (Sigma A-3176, 377C, 16 h) to hydrolyze digestible starch, treatment of precipitates with 2 M KOH to solubilize RS, incubation with amyloglucosidase (Sigma A-3514, 607C, 45 min, pH 4.75), and determination of glucose, using the phenolic method. RS was calculated as glucose x 0.9.

2.5 Statistical analysis

Results were expressed by means of values7standard error of three separate determinations. Comparison of means was performed by one-way analysis of variance (ANOVA) followed by Tukey's test.

3. Results and Discussion

3.1 Production of modified banana flour

Spontaneous fermentation followed with autoclaving-coolin process can increase resistant starch (RS) content in plantain banana flour from 6,17% (db) to 9,19%(db). Modified banana flour (MBF) is also a source of functional fiber (18,38%) with potential health benefits.

3.2 Affective tests at cookies

Three substitutions of modified banana flour were varied; as follows 60%, 80% and 100% of total flour used in making cookies. The result showed that the wheat flour could be replaced as a whole by the modified banana flour (100% substitution). Based on research, water activity (a_w) value, crispness and cohesiveness among 3 formulations substitued with MBF were not significantly different ($p>0,05$). Otherwise, colour measured with chromameter instrument shows that greater amount of MBF resulted the darker color of cookies.

MBF substitution affected the panelist preference. This is referred by sensory evaluation analysis which includes rating and ranking hedonic evaluation. Rating hedonic analysis reported that cookies with 60% MBF substitution had taste and overall properties most preferred by the panelists. This result was confirmed with ranking analysis showed that the cookies made of 60% MBF substitution was most preferred by the panelists (1.54^a), followed by cookies with 80% MBF substitution (2.05^b) and the least preferred was a cookie with 100% MBF substitution (2.41^b). According to rating and ranking hedonic analysis, MBF substitution affected cookies sensory characteristic. The best formula (cookies with 60% MBF substitution) would be further analyzed for resistant starch content, total dietary fiber and starch hydrolisis *in vitro* compared to a control with no replacement.

The best formula cookie's composition (60% MBF substitution): water content 2,97%, ash content 2,74% (db), protein 12,64% (db), fat 18,04% (db), carbohydrate 66,58% (db), total starch 24,36% (db), total dietary fiber 9,88% (db), RS 3,68% (db) dan starch hydrolisis *in vitro* 47,74%. RS content in cookies with 60% MBF (3,68%) were three times higher than control cookies (1,02%). Baking process also can increase RS content in cookies which was showed that RS increase as much as 40,59% from initial RS content in dough. Starch hydrolisis in cookies with 60% MBF subtitution (47,74%) was lower than control cookies (59,74%). Beside RS content, cookies with 60% MBF substitution also had higher total dietary fiber (9,88%) than control cookies (2,84%). The present results proved that modified banana flour (MBF) have good potential for developing cookies rich in dietary fiber and RS compared with control cookies.

3.2 Affective tests at bread

In the first stage, sweet bread was prepared using several substitutions of banana flour. There were three substitution of banana flour (20%, 30% and 40% from total weight of flour) which are acceptable both in the dough, color, aroma or taste sensory. The evalution which using hedonic rating and ranking test showed that all formulations was significantly different on attributes, color, flavor, texture, taste or overall at 95% confidence level. Also based on the average value of preferences, sweet bread made of 20% banana flour substitute were more preferable than 30% and 40 % banana flour substitute. In the last stage of the study, the best banana sweet bread based on sensory evaluation analyzed for resistant starch content, dietary fiber, starch digestibility and approximate compotition. The analyzed showed that banana sweet bread has resistant starch value (1.55%) higher than wheat sweet bread (0.45%). Banana sweet bread has 2.48% IDF and 3.66 SDF, whereas wheat sweet bread only has 1.23% IDF and 2.07% SDF. Starch digestibility banana sweet bread lower (45.6%) than wheat sweet bread (85.5%). Approximate compotition showed that banana sweet bread has water content (26.43%), ash (2.29%), protein (11.68), fat (11.84%) and carbohydrate (54.58%).

Water and ash content of banana sweet bread agree with requisite quality of banana flour (SNI 01-3840-1995), but fat content of banana sweet bread disagree with requisite quality of banana flour. This matter is caused by using fat which too much when it baked.

Thereby can be concluded that sweet bread product with addition 20% of modification banana flour can maximize its function as RS and dietary fiber, and also low of starch digestion which can support potency of prebiotic from product.

3.3 Affective tests at brownies

Based on four sensory quality ranking test : flavor (2.125), taste (3.650), texture (2.450), and color (1.775). Thus, highest to lowest ranking in a row is taste, texture, flavor and color. In accordance with this result, taste sensory quality gain the highest weighting score (4 points), and texture (3 points), aroma (2 points), and color (1 point). The hedonic rating values of each sensory quality from each formula are weighted with weighting scores to obtain the best formula. Overall sensory quality formulas will be rated based on earned total weight value. Assessment of the overall sensory quality of each MBF steamed brownies formula can be seen in the following Table 2.

Table 2. Sensory Quality MBF Steamed Brownies Weighting Value

Quality parameter	Score	% Substitusi TPM							
		70% (F1)		80% (F2)		90% (F3)		100% (F4)	
		RV	WV	RV	WV	RV	WV	RV	WV
Taste	4	4.18[b]	16.27	3.90[b]	15.60	3.80[b]	15.20	3.27[a]	13.08
Texture	3	3.72[c]	11.16	3.08[b]	9.24	3.02[a,b]	9.06	2.65[a]	7.95
Aroma	2	4.75[b]	9.50	4.50[a,b]	9.00	4.32[a]	8.64	4.25[a]	8.50
Color	1	4.23[b]	4.23	4.25[b]	4.25	3.82[a]	3.82	4.10[a,b]	4.10
Total Value			41.46		38.09		36.72		33.63

RV = Rating value, WV = weighting value
Description: These numbers are followed by the same letters indicate values are not significantly different (p> 0.05)

The best formula that is 70% substitution of TPM (F1) with the highest total score (41.46) was obtained from this weighting value data. As a comparison the overall parameters (full assessment). Figure 2 below shows that the highest overall sensory quality score among the four formulas are obtained by substitution of 70% TPM (F1) which is 4:33 in the range a rather like to like. These results are in accordance with the weighting results, that 70% substitution of TMBF (F1) is the best formula.

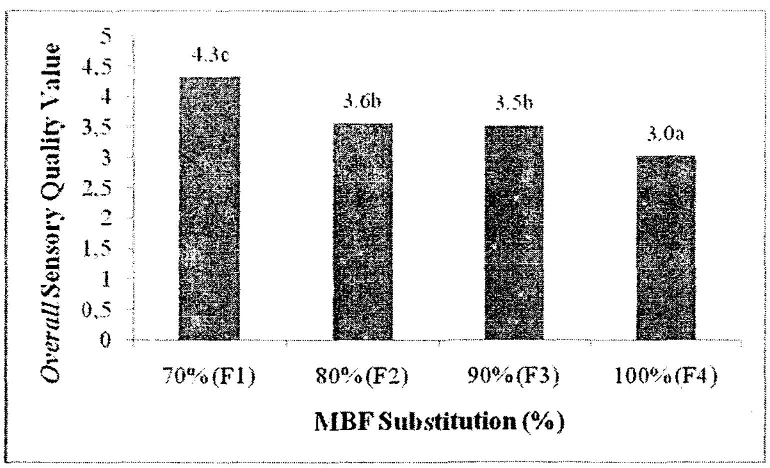

Figure 2. The effect of MBF substitution level on overall quality score MBF steamed brownie

Conclusions

The best formula cookie's composition (60% MBF substitution): water content 2,97%, ash content 2,74% (db), protein 12,64% (db), fat 18,04% (db), carbohydrate 66,58% (db), total starch 24,36% (db), total dietary fiber 9,88% (db), RS 3,68% (db) dan starch hydrolisis *in vitro* 47,74%. RS content in cookies with 60% MBF (3,68%) were three times higher than control cookies (1,02%). Baking process also can increase RS content in cookies which was showed that RS increase as much as 40,59% from initial RS content in dough. Starch hydrolisis in cookies with 60% MBF subtitution (47,74%) was lower than control cookies (59,74%). Beside RS content, cookies with 60% MBF substitution also had higher total dietary fiber (9,88%) than control cookies (2,84%). The present results proved that modified banana flour (MBF) have good potential for developing cookies rich in dietary fiber and RS compared with control cookies.

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