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DEVELOPMENT OF GLUTEN-FREE COMPOSITE FLOUR BLENDS

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ABSTRACT

People with celiac disease depend on gluten-free foods to maintain quality of life. This study aimed to determine the physico-chemical and organoleptic properties of gluten-free composite flour blends for celiac disease patients utilizing different percentage composition of rice flour, potato starch, cassava starch, millet flour and corn flour. The experimental design was laid out in the study with six (6) treatments in three (3) replications using Completely Randomized Design (CRD) under controlled condition. The experimental samples were subjected to different laboratory analyses. Sensory evaluation of the control and gluten-free treatments had revealed that there were no significant mean differences among treatments in all of the sensory characteristics. However, gluten-free flour blend (T_2) had higher level of acceptance as compared to other gluten-free flour blend treatments. The composite gluten-free flour blends had 0 percent crude gluten. Utilizing available novel/functional ingredients can produce gluten-free composite flour with a comparable sensory characteristics and nutritional quality except protein content with the commercially wheat flours. Hence, it is recommended for the use of gluten-free composite flour blends for food and pharmaceutical uses.

Keywords: gluten-free composite flour, sensory, proximate analysis, celiac disease

INTRODUCTION

People suffering from celiac disease, wheat allergies and wheat intolerances depend on gluten-free foods to maintain their quality of life (Brown, 2005). Celiac disease or gluten sensitive enteropathy is a chronic disorder of the small intestine caused by exposure to gluten in the genetically predisposed individuals (Hamer, 2005 and Laurin *et al.*, 2002). It is characterized by a strong immune response to certain amino acids sequences found in the gliadin fractions of wheat, barley oats and rye (Hill, 2005 and Murray, 1999).

When people with celiac disease eat foods or use products containing gluten, their immune system reacts negatively by destroying the intestinal villi leading to the malabsorption of nutrients, thus adversely affecting system of the body (Feighery, 1999). Consumption of gluten can damage the intestines which causes abdominal bloating and pain, chronic diarrhea, fatigue, weight loss and failure-to-thrive in infants and the malabsorption of essential nutrients would results in malnutrition (Brown, 2005).

An observance to a gluten-free diet remains effective treatment for celiac disease throughout the patients' lifetime (Murray, 1999). Gluten free diet has benefits such as the recovery of the villi of the small intestine and reduced risk of malignant complications (Seraphin and Mobarhan, 2002).

Since the diet of celiac patients must be completely free of any gluten, so all the products from wheat, rye, barley and oat must be replaced with corn, rice, millet equivalents and various types of starch (corn, rice and potato) or appropriate mixtures (Lazaridou *et al*., 2007 and Moore *et al*., 2006 as cited by Hegazy *et al*., 2009). The availability of these raw materials are abundant in the locality, thus maximum utilization will have a domino effect to the economy and to the country.

Gluten is the main structure-forming protein in flour, and is responsible for the elastic characteristics of dough, and contributes to the appearance and crumb structure of many baked products (Arendt *et al*., 2002 as cited by Gallagher *et al*., 2004). They play an important role in culinary, food product development and other commercial uses.

Flour is one of the components in food preparation and pharmaceutical mixes. The usage of flour in our daily diet is far more comparable than rice. A number of Filipinos has been diagnosed of gluten intolerance and to provide a safe alternative food choice to people with restricted diet is a great challenge.

This study aimed to develop gluten-free composite flour blends utilizing locally available functional materials, evaluate the physico-chemical composition and sensory qualities and test its significant differences, as basis for future product innovations.

MATERIALS AND METHODS

Novel available ingredients such as rice flour, potato flour, cassava starch, corn flour and millet flour were purchased from the local markets in Cebu City, Philippines.

The study was laid out in Completely Randomized Design (CRD) with six (6) treatments replicated three (3) times. The experimental samples were formulated at the food laboratory right after the ingredients were purchased. Preparation of gluten-free flour blends were prepared following proper food handling practices.

Experimental Treatments

Preparation of each experimental treatment of gluten-free (GF) composite flour blend was weighed, individually blended to be homogenized, packed in polyethylene bags, tightly closed and kept at chilled condition until ready for laboratory evaluation. Figure 1 show the research flow of the study.

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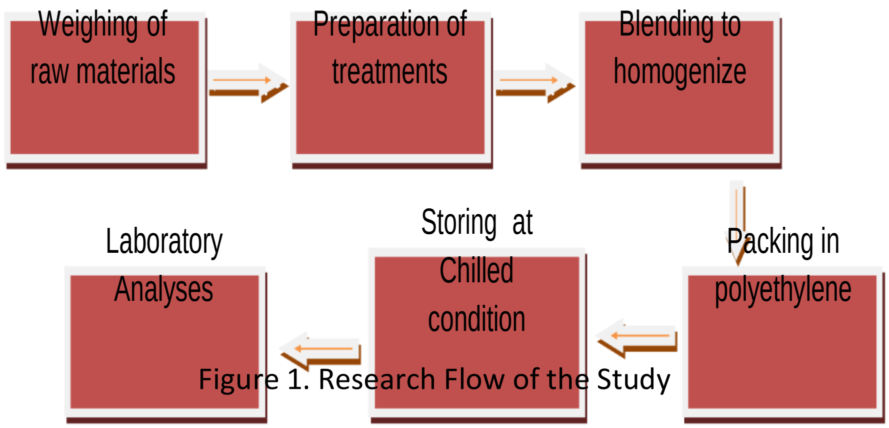

Figure 1. Research Flow of the Study

In this study wheat (*Triticum aestivum* L.) flour was used as the control. Rice (*Oryza sativa*) flour, potato (*Solanum tuberosum*) flour, cassava (*Manihot esculenta*) starch, millet (*Panicum milieaceum*) flour and corn (*Zea mays*) flour were used as blends for the formulation of GF treatments. T_0 with 100 percent wheat flour as control and T_1, T_2, T_3, T_4 and T_5 had varying percentage of rice flour, potato starch, cassava starch, millet flour and corn flour respectively. Each GF treatment is equal to 100 percent. Table 1 shows the composition of different treatments.

Table 1. Composition Percentage of Treatments

Tre tments	Ingredients %					
	Wheat flour	Rice flour	Potato starch	Cassava starch	Millet flour	Corn flour
T_0	100	-	-	-	-	-
T_1	-	50	40	5	3	2
T_2	-	50	30	10	5	5
T_3	-	50	20	20	5	5
T_4	-	50	10	30	5	5
T_5	-	50	5	40	2	3

In the study of Hegazy *et al*., 2009, revealed that blend with 50 percent rice flour, 35 percent cornstarch, 7.5 percent defatted soy flour and 7.5 percent chickpea flour exhibited good sensory properties compared with wheat flour when used in the preparation of bread. Gluten-free yeast breads were produced based on rice flour (80%) and potato starch (20%) in the study of Ylimaki *et al*., 1991.

Sensory Evaluation

Organoleptic properties of the control and gluten-free treatments were conducted using the 5-point descriptive test and 9-point hedonic rating scale for acceptability by 15 trained panelists. Coded samples in three (3) digits were presented to the trained panelists in a single

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simple method in spaced intervals. The panelists assessed the organoleptic attributes of the samples using their senses.

Physico-chemical analysis

The determination of the chemical composition of flour blend samples viz: gluten content, moisture content, ash content, protein content, total fat content, total carbohydrates, and food energy value that follows the standard analytical procedure.

Statistical analysis

Data generated from the sensory analysis were treated statistically using Standard Deviation, Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) at a significance probability of five (5) percent.

RESULTS AND DISCUSSION

Descriptive Sensory Evaluation Results

Table 2 presents the descriptive test of the 15 trained panelists who described the color, odor and texture of the sensory attributes of the control and gluten-free flour blends treatments using the 5-point parametric scale.

Table 2. Descriptive Sensory Evaluation of Treatments and Standard Deviation

Treatments	Color*	Verbal description	Odor*	Verbal description	Texture*	Verbal description
T_0	4.6 ±0.101	whiter color	4.7±0.153	pleasant odor	4.5±0.153	fine-powdery texture
T_1	4.4±0.170	whiter color	4.4±0.208	pleasant odor	4.4±0.153	fine-gritty texture
T_2	4.5±0.058	whiter color	4.5±0.153	pleasant odor	4.2±0.058	fine-gritty texture
T_3	4.3±0.100	whiter color	4.3±0.115	pleasant odor	4.1±0.100	fine-gritty texture
T_4	4.1±0.153	whiter color	4.4±0.208	pleasant odor	4.3±0.153	fine-gritty texture
T_5	4.2±0.153	whiter color	4.2±0.153	pleasant odor	4.4±0.208	fine-gritty texture

*Average mean scores ± Standard Deviation

The sensory panelists described the organoleptic properties of the control as whiter in color (4.6), pleasant odor (4.7) and fine-powdery texture (4.5). However, a gluten-free treatment was whiter in color, pleasant odor and fine-gritty texture. The whiter in color justify the fact that rice flour, potato starch and cassava starch underwent bleaching process. The yellow/amber color for corn flour and millet flour was due to the presence of carotenoids pigment mainly xanthrophyll but it does not influence much, because they are in small percentage. Flour had

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natural pleasant odor. However, the fine-gritty texture was influenced by the addition of millet and corn flours. This implies that the evaluated sensory properties of 100 percent wheat flour is not different from the developed gluten-free flour blends.

Dvořáková *et al*., 2012 made a study on the use of maize-buckwheat mixtures from a minimum of 10 percent to a maximum of 90 percent ratios of cereal mixtures and apply this to bread and result showed that maize flour in mixtures improved texture characteristics of bread.

Preference Test Results

Table 3 showed the taste panels perception on the acceptability rating using the 9-point hedonic scale of the different treatments studied.

Table 3. Preference and Acceptability Scores of Treatments

Treatments	Color*	Odor*	Texture*	General* Acceptability
T_0	8.5^a±0.100	8.6^a±0.100	8.7^a±0.058	8.7^a±0.058
T_1	8.1^a±0.058	8.4^a±0.153	8.0^a±0.173	8.3a±0.208
T_2	8.4^a±0.100	8.5^a±0.058	8.4^a±0.100	8.4^a±0.115
T_3	8.0^a±0.208	8.2^a±0.252	8.0^a±0.153	8.1^a±0.265
T_4	8.3^a±0.231	8.2^a±0.153	8.2^a±0.231	8.2^a±0.058
T_5	8.1^a±0.208	8.0^a±0.361	8.4^a±0.153	8.3^a±0.153

*Average mean scores in the same column with different superscripts are significantly different (P<0.05) ± Standard Deviation

Preference and acceptability rating results of the control and gluten-free treatments had revealed that there were no significant mean difference (p<0.05) among treatments in all of the sensory characteristics. The result thus indicated that all treatments are the same and was accepted by the panelists. However, gluten-free flour blend (T_2) had the highest level of acceptance compared to other GF flour blend treatments. The findings of this study support the previous study of Hegazy *et al*. 2009 that with regard to the overall acceptability of the Gluten-free bread samples there were no significant differences among control and different Gluten-free bread samples.

Physico-Chemical Properties of Gluten-Free Flour Blends

Proximate composition and gluten content of composite flour blends are shown in Table 4.

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Table 4. Proximate Composition and Gluten Content of Composite Flour Blends

GF Flour Blends	Parameters						
	Ash %	Moisture %	Total Fat %	Protein %	Total Carbohydrate %	Food Energy Value kcal/100g	Gluten content %
T_1	0.334	12.8	0.528	4.17	82.2	350.25	0
T_2	0.380	12.1	0.647	4.61	82.3	353.463	0
T_3	0.383	11.5	1.20	4.61	82.3	358.44	0
T_4	0.40	10.9	1.04	4.71	82.9	359.80	0
T_5	0.321	10.6	1.17	4.21	83.7	362.17	0

The results show that the ash content of GF flour blend is between the range of 0.321 percent to 0.40 percent. The presence of ash in the flour indicates that flour blend is a good source of minerals for mineral supplementation. The study of Tseng and Lai, 2002 the in-wheat flour had an ash content of 0.42 percent.

The increase in the quantity of potato starch affects the increase of the moisture content of the GF flour blend. Moisture content has been an indicator for shelf life of flour as they encourage microbial proliferation that lead to spoilage. However, the quality factor for flour should have a moisture content of 15.5 percent m/m max (CODEX STAN 152-1985) in which the moisture content of gluten-free flour blend is within the standard.

The increase of the total fat content of the flour blend has been affected by the composite blending of different quantity of cereals and root crops. The protein content, total carbohydrate and food energy values of different treatments differ slightly from each other. This could be attributed that cereals and root crops are good sources of carbohydrates. Gluten-free composite flour blends had lower protein content (4.17%-4.71%) compared to wheat flour with 11.38 percent crude protein (Tseng and Lai, 2002). These data support the laboratory results that newly formulated flour blends had 0 percent gluten. Gluten is a protein from wheat flour which gives structure to baked products.

CONCLUSION

The use of locally available flour materials can produce a gluten-free composite flour with a comparable sensory characteristics and nutritional quality except protein content with the commercially wheat flours.

RECOMMENDATION

It is recommended to use gluten-free composite flour to food products and other commercial purposes.

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