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Cakes from Gluten-Free Composite Flour Blends

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ABSTRACT

People with celiac disease (CD) depend only to strict adherence to a gluten-free diet to maintain quality of life. This study aimed to determine the physico-chemical, bacteriological, organoleptic and physical properties of cakes using wheat flour (WF) and gluten-free composite flour blends (GFCFB) having different percentage composition of rice flour (RF), potato starch (PS), tapioca starch (TS), millet flour (MF), and corn flour (CF). The experimental design was laid out in the study with six treatments in three replications using CRD under controlled condition. The experimental samples were subjected to different laboratory analyses. Sensory evaluation revealed that there was a significant mean differences($p<0.05$) in odor, flavor, texture, taste attributes and general acceptability among treatments. Cakes from WF exhibited quality sensory attributes among treatments, however cakes fromT_5 (GFCFB 5) had the highest sensory ratings compared to cakes made from other gluten-free flour blends. There was no significant difference was observed in color attribute among treatments. Utilizing available functional ingredients can produce cakes from gluten-free composite flours with comparable quality characteristics with the cakes from wheat flours. Cakes using GFCFB with milkfish spines meal were formulated and found very acceptable in all attributes. The continuous production for commercialization of these gluten-free bakery products is recommended.

Keywords: gluten-free, flour blend, celiac disease, milkfish spine meal

INTRODUCTION

Flour is one of the components in cakes and pastries.The gluten content in Wheat flour (WF) gives structure to cakes. Gluten, the protein in flour, is responsible for the elastic characteristics of dough(Arendt *et al*., 2002; Gallagher *et al*., 2004). Elimination of gluten in bakery products would result to inferior quality (Majzoobi*et al*., 2016).However, observance of gluten-free diet is an effective treatment for celiac disease (CD) patients (Murray, 1999).This study determines the cakes physical properties, nutritional composition, bacteriological quality, sensory quality and consumer overall acceptability utilizing gluten-free flour blends enriched with milkfish spine meal.

People suffering from CD depend on gluten-free foods to maintain quality of life (Brown, 2005). Sensitivity of some individuals to gluten leads to the malabsorption of essential nutrients, adversely results in malnutrition (Ranjbar, 2012;Feighery, 1999). When gluten-free flour is mixed to form dough, it does not form dough structure and consequently fails to produce good quality cakes. Xantham gum was used to improve the quality of cakes at level of 0.5% (Hussein *et al*., 2012).Cakes formulated with xantham gum has improved cakes quality characteristics

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(Preichardt*et al*., 2011).

Gluten-free food products possess poor protein structure forming ability which decreases sensory quality (Torbica *et al*., 2012; Jambrec *et al*., 2012). Further, these products are of inferior nutritive value than that of conventional products (Hathan and Prassana, 2011;Ergin and Herken, 2012).Some gluten-reduced bakery products used hydrocolloids to mimic the visco-elastic characteristics of gluten (Clement, 2011).The addition of hydrocolloids (gum) increases volume and decrease staling rate in cakes (Gomez *et al*., 2005;Ranjbar 2012).Accordingly, different attempts have been made to enrich the nutritional quality of gluten free products. However, limited research has been carried out on gluten free cakes enriched with milkfish spine meal (MSM) and devoid of any hydrocolloids.

Milkfish spine meal is a by-product of milkfish deboning. During deboning 25% of the total fish weight was discarded as processing waste. These discarded materials were made into a functional food ingredient added to cakes. Cakes from formulated gluten-free composite flour blends were prepared with acceptable sensory characteristics. These challenges catapulted this investigation to provide healthy options for gluten intolerance. Alongside the advocacy on meeting the demands of gluten-free diets, this study aimed to develop cakes with functional ingredients for people with special dietary needs..

Conceptual Framework

This study was anchored on the theory that fish bone contains essential protein content. The protein content of fish enriched food products with less protein value and is favorable for CD patients.It should be noted that fish meal is a standard ingredient in livestock, poultry and fish feed principally as a source of animal protein (Yap *et al*., 2007).On the other hand, organic fish farms alternatively use milkfish spine as protein component in aquatic feeds

Among many bakery products, cakes are mostly preferred. Obtaining these products with adequate crumb structure and texture is a difficult task (Gomez and Sciarini, 2015). This challenges people suffering from abnormal cereal protein ingestion resulting to celiac disease (Levent and Bilgicli, 2011). Tandurok (2005) reported the prevalence of celiac disease in the USA, Europe and Turkey where the rising demands of gluten-free foods parallels this increase.

MATERIALS AND METHODS

The study was laid out in Completely Randomized Design (CRD) with six treatments replicated three times. The experimental samples were formulated at the food laboratory of Cebu Technological University- Main Campus, Cebu City, Philippines. After the ingredients were purchased from the local markets good manufacturing practices were observed during food processing.

Preparation of flour blends and milkfish spine meal. The wheat (*Triticumaestivum* L.) flour, rice (*Oryza sativa*) flour, potato (*Solanumtuberosum*) flour, tapioca (*Manihotesculenta*) starch, foxtail millet (*Setariaitalica*) flour and corn (*Zea mays*) meal were brought from

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commercial market in the locality. Milkfish spines were processed and were made into a food meal as a value-added food product from milkfish deboning.

Table 1. Composition percentage of flour treatments

Flour Treatments	Ingredients %					
	Wheat flour	Rice flour	Potato starch	Tapioca 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% rice flour, 35% cornstarch, 7.5% defatted soy flour and 7.5% 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.

Preparation of cakes. All ingredients were at room temperature and properly weighed. Pre-heating the oven until desired temperature of 325 ^{0}F was obtained. The ingredients were blended such as flour, sweetener, meal, leavening agent, and salt to produce dry mixture. Combined together water, eggyolk, flavoring agents to produce liquid mixture and were added to dry mixture. The eggwhites were whipped together with the sweetener and cream of tartar to produce soft peak meringue using an electric mixer. Fold in the batter and meringue mixtures together until fluffy batter mixture was produced. Cake mixture was poured in baking pans. Bake the mixture in pre-heated oven for 60 minutes, cooled, packed and stored at chilled temperature.

Formulation of treatments. The different treatments formulation of gluten-free chiffon cakes is presented in Table 2.

Table 2.Chiffon-basedcake formulation of treatments

Treatments	Flour (g)	Egg (g)	Sweetener (g)	Shortening (g)	Water (g)	Milkfish spine meal (g)	Flavoring (g)	Leavening Agents (g)	Cream of tartar (g)	Salt (g)
T_0	156 WF	400	200	35	30	20	5	3	1.5	1
T_1	240 GF	400	200	35	30	20	5	3	1.5	1
T_2	240 GF	400	200	35	30	20	5	3	1.5	1
T_3	240 GF	400	200	35	30	20	5	3	1.5	1
T_4	240 GF	400	200	35	30	20	5	3	1.5	1
T_5	240 GF	400	200	35	30	20	5	3	1.5	1

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Physical properties determination. Physical measurements in terms of width (mm) and thickness (mm) of samples were measured using vernier caliper with 20 micron accuracy measurement. Digital weighing scale was used to determine the weight (g) of cakes. Specific volume g/cm^3 was calculated by dividing of the volume to weight. Density and specific gravity of cake samples were calculated.

Chemical and bacteriological analyses. Analytical methods such as ash and moisture were determined by AOAC (1990), total fat (Solvent extraction method), protein (Kjeldahl method, *N x 6.25*), carbohydrate was determined by calculation the total percentage of moisture, ash, crude fat, fiber and crude protein is subtracted to 100% and the difference now could be the percent carbohydrate, food energy value was calculated by using physiological energy factors expressed in kilocalories (kcal), calcium, potassium, sodium and iron were determined by flame atomic absorption spectrophotometry (AAS), pH (electrometric method), Aw (water activity meter) and crude gluten using gravimetric method. The aerobic plate count was determined following Bacteriological Analytical Manual (2001).

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 fifteen trained panelists and fifty consumer panelists. Coded samples in three digits were presented to the trained panelists in a single simple method in spaced intervals.

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 5%.

RESULTS AND DISCUSSION

After processing, milkfish spines meal samples were subjected to laboratory analyses and the result of the physico-chemical composition is presented in Table 3.

Table 3.Physico-chemical composition of milkfish spines meal

Parameters	Results
Moisture	51.9 %
Protein	32.6 %
Total Fat	7.60 %
Ash	5.44 %
pH	5.04
Carbohydrates	2.46 %
Food Energy Value	209 kcal/100g
Calcium (as Ca)	17800 mg/kg
Potassium (as K)	1573 mg/kg
Sodium (as Na)	499 mg/kg
Iron (as Fe)	11.04 ppm

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The physico-chemical composition of milkfish spines meal was relatively high in moisture content, protein content, ash content, calcium, and potassium with a food energy value of 209 kcal/100g. Milkfish spines meal is a good source of protein, calcium and potassium. The carbohydrates content (2.46%) of the sample is low and the product is a low-acid food with a pH of 5.04. The iron (11.04 ppm) of the product is within the RDA iron ranges from 10 mg to 15 mg. The sodium content (499 mg/kg) of the product is within the standard for special dietary food with *low sodium* content which is not more than 120 mg/100g of the final product as normally consumed (CODEX STAN 53-1981).

Table 4. Pathogen and aerobic plate counts of milkfish spines meal with months of storage

	Parameters				
Storage Periods	Aerobic Plate Count cfu/g	*E.coli* MPN/g	*Staph.aureus*cfu/g	*Salmonella* in 25 g	*Shigella* in 25 g
0 month	<2,500	<1.8	<10	Absent	absent
1 month	<100	<1.8	<10	Absent	absent
2 months	<100	<1.8	<10	Absent	Absent
3 months	<100	<1.8	<10	Absent	Absent

After three (3) months of storage the product aerobic plate count decreases and stable at < 100 cfu/g. This bacterial load was within the BFAD microbial standard for processed product.

Escherichia coli and *Staphylococcus aureus*counts of the samples remain stable during storage with a count of <1.8 MPN/g of *E. coli* and <10 cfu/g of *Staph. aureus*. However, the *Salmonella* and *Shigella* species were not detected; these pathogens were affected by the heat treatment applied to the product. The product underwent thermal processing and stored at freezing point below 0 ^{0}C for three months, which also affects the stability of the count.

Physico-chemical properties of gluten-free composite flour blends. Proximate and gluten composition of GFCFB are shown in Table 5.

Table 5. Proximate composition and gluten content of composite GF flour blends

	Parameters						
GF Flour Blends	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% to 0.40 %. The presence of ash in the flour indicates that flour blend is a good source of minerals

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for mineral supplementation. The study of Tseng and Lai, 2002 the in-wheat flour had an ash content of 0.42%.

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% m/m max (CODEX STAN 152-1985) in which the moisture content of gluten-free flour blend is within the standard. Based on secondary data, WF has the following proximate composition: 16.27% crude protein, 1.76% crude fat, 1.01 % ash, 0.04% Calcium and 0.24% potassium (FAO Corporate Documentary Repository).

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% crude protein (Tseng and Lai, 2002). This data support the laboratory results that newly formulated flour blends had 0% gluten. Gluten is a protein from wheat flour which gives structure to baked products.

Physical properties determination

The results obtained from the physical measurements in terms of weight, volume and specific gravity of chiffon-based cakes using wheat flour and gluten-free composite flour blends are shown in Table 6.

Table 6. Baking quality of chiffon-based cakes

Cake Samples	Parameters		
	Weight (g)	Volume (cm^3)	Specific gravity
T_0(WF)	1200	1816.50	0.66
T_1 (GFCFB 1)	1170	1835.28	0.64
T_2 (GFCFB 2)	1200	1947.99	0.62
T_3 (GFCFB 3)	1300	1966.79	0.66
T_4(GFCFB 4)	1190	1837.80	0.65
T_5 (GFCFB 5)	1250	1694.09	0.74

The physical characteristics of the produced cakes as presented in Table 6 showed that the cake from T_3 (GFCFB 3) had the highest weight (g) and volume (cm^3) as compared with other samples. This effect may be due to high fiber content from cereals and starch. Fiber is characterized by their high water hold capacity. Specific gravity of WF and T_3 (GFCFB 3) are the same. Loaf volume and specific gravity is affected by the addition of leavening agent on the mixture.

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Table 7. Descriptive test results of chiffon-based cakes

Cake Samples	Sensory Parameters				
	Color	Flavor	Odor	Taste	Texture
T_0(WF)	3.47	3.82	3.73	3.64	4.2
T_1 (GFCFB 1)	2.97	3.51	3.33	3.29	3.25
T_2 (GFCFB 2)	2.90	3.37	3.27	3.29	3.49
T_3 (GFCFB 3)	2.98	3.39	3.21	3.24	3.20
T_4 (GFCFB 4)	2.79	3.39	3.23	3.31	3.57
T_5 (GFCFB 5)	2.99	3.49	3.41	3.67	3.67

Sensory panelists described sensory properties in allcake samples as Moderately Yellow Color (MYC) in crumbs and Moderately Yellow-brown Color (MYBC) in the crust. The browning of the cakes could also occur due to the caramelization of the sugar during the baking process. Moreover, the darkening of the color of the cakes might be due to Maillard browning reactions between reducing sugars and proteins.

As to flavor, T0 and T1 had a Very Much Butter Flavor (VMBF) and Moderately Butter Flavor (MBF) had been observed in T2, T3, T4 and T5 respectively. Very Moderately Pleasant Odor (VMPO) in control cake samples compared to other cake samples described as Moderately Pleasant Odor (MPO). Panelists described the taste attribute of T0 and T5 as Extremely Sweet Taste (EST) while T1, T2, T3 and T4 had a Moderately Sweet Taste (MST). As to texture attribute T0, T4 and T5 were described as Very Much Soft and Spongy Texture (VMSST) while T1, T2 and T3 with Moderately Soft and Spongy Texture (MSST). Cakes sensory attributes were influenced by the different proportions of cereals and starches. The baking conditions such as temperature, baking time, composition, amounts of water absorbed during dough mixing and evaporated during baking, all contributed to the attributes of the final product.

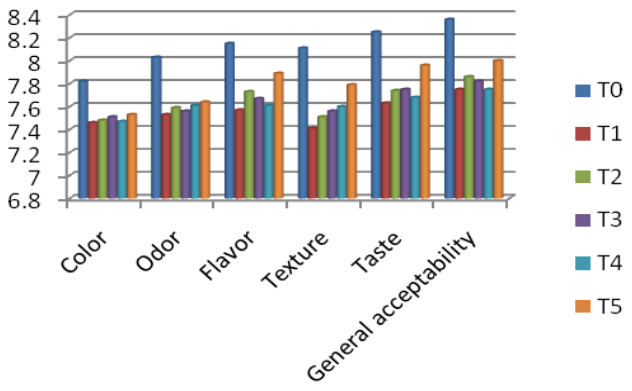

Fig. 1. Preference test results of cake samples

Preference test and general acceptability results revealed that there was a significant mean difference ($p<0.05$) in odor, flavor, texture, taste attributes and general acceptability.

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Cakes from WF exhibited quality sensory attributes among treatments, however cakes from T_5 (GFCFB 5) had the highest ratings compared to cakes made other gluten-free flour blends. There was no significant difference was observed in color attribute among treatments. This implies that in terms of color, all cakes are comparable with each other.

Physico-chemical properties of chiffon-based cakes. Proximate composition of WF and GFCFB chiffon-based cakes most preferred treatment are shown in Table 5.

Table 5. Proximate composition of WF and GFCFB chiffon-based cakes

Flour Used	Parameters						
	Ash %	Moisture %	Total Fat %	Protein %	Total Carbohydrate %	Food Energy Value kcal/100g	Water Activity
WF Chiffon Cake (Control)	1.08	43.00	2.29	7.43	46.2	235	0.953
GFCFB Chiffon Cake (Most Preferred)	0.97	43.3	6.25	5.82	43.70	254	0.954

Table 6. Bacteriological results of WF and GF flour blend chiffon-based cakes.

Cakes	**Parameter** **Estimated Aerobic Plate Count/g**
WF Chiffon Cake (Control)	$< 1.0 \times 10^2$
GFCFB Chiffon Cake (Most Preferred)	$< 1.0 \times 10^2$

CONCLUSION AND RECOMMENDATION

Gluten-free composite flour blends (GFCFB) are suitable for chiffon-based cakes added with milkfish spines meal and devoid of hydrocolloid. However, cakes from T_5 (50% RF:5% PS:40% TS: 2% MF:3% CF) had superior sensory characteristics and nutritional value over other gluten-free flour blends.The continuous production for commercialization of these gluten-free bakery products is recommended.

LITERATURE CITED

Brown, Amy. 2005. *Understanding Food Principles and Preparation*. Second Edition. Singapore: Thomson Learning Asia.

CODEX STANDARD 152-1985 For Wheat Flour

CODEX STANDARD 118-2008For Foods for Special Dietary Use for Persons Intolerant to Gluten

 ISSN: 1656-0264

Dvořáková, Petra, Iva Burešová and StanislavKráčmar. 2012. Buckwheat as gluten-free cereal in combination with maize flour. Journal of Microbiology, Biotechnology and Food Sciences, 1:897-907.

Feighery, C. 1999. Celiac disease. British Medical J., 319:236-239.

Gallagher, E., T.R. Gormley and E.K. Arendt. 2004. Recent advances in the formulation of gluten-free cereal-based products. Trends in Food Science and Technology 15:143-152.

Hamer, R.J. 2005. Coeliac disease: background and biochemical aspects. Biotechnology Advances, 23:401-408.

Hegazy, A.I., M.S. Ammar and M.I. Ibrahium. 2009. Production of Egyptian gluten-free bread. World J. of Dairy and Food Sciences, 4(2) 123-128.

Hill, I.D., M.H. Dirks, G.S. Liptak, R.B. Colletti, A. Fasano and S. Guandalini. 2005. Guideline for the diagnosis and treatment of celiac disease in children: recommendations of the North American Society for pediatric gastroenterology, hepatology and nutrition. J. Pediatric Gastroenterology and Nutrition, 40:1-19.

Hussein, Ahmed M.S., Nefisa A. Hegazy and Thanaa A.A. Ibrahim. 2012. Production and evaluation of gluten-free cakes. Australian Journal of Basic and Applied Sciences, 6(12): 482-491.

Institute for Food Technologists (2009, April 1). New Gluten-Free French BreadUnderway For Celiac Disease Patients.Science Daily. Retrieved December 8, 2011, from http://www.sciencedaily.com /releases/2009/04/090401191131.htm

Laurin, P., M. Wolving and K. Falth-Magnusson. 2002. Even small amounts of gluten cause relapse in children with celiac disease . J. Pediatric Gastroenterology and Nutrition, 32:26-30.

Lazaridou, A., D. Duta, M. Papageorgiou, N. Belc and C.G. Biliaderis. 2007. Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations. J. Food Engineering 79:1033-1047.

Mridula, D., R.K. Gupta and M.R. Manikantan. 2007. Effect of incorporation of sorghum flour to wheat flour on quality of biscuit fortified with defatted soy flour. American Journal of Food Technology 2(5):428-434.

Murray, J.A. 1999. The widening spectrum of celiac disease. American J. of Pediatric Gastroenterology and Nutrition, 27: 519-523.

Preichardt, Leidi D., Claire T. Vendruscolo, Marcia A. Gularte and Angelita da S. Moreira. 2011.

 ISSN: 1656-0264

The role of xanthan gum in the quality of gluten free cakes: Improved bakery products for coeliac patients. International Journal of Food Sciences and Technology46: 2591-2597.

Seraphin, P. and S. Mobarhan. 2002. Mortality in patients with celiac disease. Nutritional Rev., 60:116-118.

Tseng, C.S. and Lai, H.M. 2002. Physicochemical Properties of Wheat Flour Dough Modified by Microbial Transglutaminase. Journal of Food Science, 67:750-755.

Ylimaki, G., Hawrysh, Z.I. Hardin, R.T., and Thomson, A.B.R. 1991. Response surface methodology to the development of rice flour, yeast breads: sensory measurements. Journal of Food Science, 56:751-759.

Ylimaki, G., Hawrysh, Z.I. Hardin, R.T., and Thomson, A.B.R. 1988. Application of response surface methodology to the development of rice flour, yeast breads: objective measurements. Journal of Food Science, 53:1800-1805.doi 10.1111/j.1365-2621.1988.tb07846.x.