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Nutritional and Sensory Quality of Bread Containing Different Quantities of Grape Pomace from Different Grape Cultivars

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Abstract

Grape pomace (GP) is a wine making by-product rich in polyphenols and dietary fiber (DF). In this study GPs from four grape cultivars were used to replace 5-10% of flour in a white bread formula. The bread without GP was used as control. Reformulated dough was baked following standard bread making procedure. Loaf weight, volume, inside color, dietary fiber, polyphenol contents and antioxidant activities of the products were determined. Consumer preferences of products were evaluated using 15 untrained panelists. Results show that bread with 5% GP had similar loaf volume but darker color compared to the control, while the bread with10% GP became denser. The DF, polyphenol and antioxidant activity of the bread increased with increasing GP content in the formula. GP cultivar significantly affected the consumer preferences on aroma, taste and texture of the bread. The preference of GP containing bread color was slightly lower than that of control but higher than that of rye breads. This study indicates that the GP has great potential to be used as good source of dietary polyphenols and fiber in bread making to add nutritional value of GP to a largely consumed product.

Keywords: *Grape Pomace; Dietary Fiber; Polyphenol; Nutritional Quality; Sensory Quality*

Abbreviations: GP: Grape Pomace; DF: Dietary Fiber; TP: Total Polyphenol; TA: Total Anthocyanin; TF: Total Flavonoid; ABTS: 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid); TDF: Total Dietary Fiber; IDF: Insoluble Dietary Fiber; NDF: Neutral Detergent Fiber; TEAC: Trolox Equivalent Antioxidant Capacity; GAE: Gallic Acid Equivalent; Cab: Cabernet; Mus: Muscadine

Introduction

Foods rich in dietary fiber play important roles in the digestion and absorption of lipids in the small intestine, blood glucose and cholesterol attenuation, weight control by increasing satiety and increasing intestinal regularity, and protection against colon cancer [1-3]. Polyphenols from fruits and vegetables have shown many health benefits such as antimutagenic and anti-carcinogenic activity [4,5], anti-oxidant and anti-inflammatory activities [6], attenuation of blood pressure, prevention and delay of cardiovascular diseases [7,8], increase of lifespan, and retardation of the onset of age-related markers [9]. Grape seed polyphenols also showed antimicrobial and antioxidant activities in food products [4,10,11].

Fortification of food products is a common practice to enhance the nutritional value and functional properties of foods. Grape pomace (GP) is a dietary fiber (DF) and polyphenol rich by-product from wine making, while bread is a commonly and largely consumed food product that would assist in passing the health benefits of GP to the consumers. The utilization of GP in food products has been undergone many investigations. Deseeded GP was used in cookie formula to increase dietary fiber content [12], while grape seed flour was used in frankfurters to decline the oxidation level of the products [13]. Grape seed extract was also used as additive to increase the antioxidant activity of bread [14]. GP was used in sourdough [15] and minced fish [16] to increase the dietary fiber contents and phenolic compounds of these products. Hoye and Ross reported the use of grape seed flour in bread in 2011 [17]. Although inclusion of GP in food products could result in functional foods with beneficial effects of dietary fiber and grape polyphenols, it was reported that the apparent negative effects of incorporated fibers on the final bread quality include reduced loaf volume, increased crumb firmness, darkened crumb appearance, and possibly unpleasant tastes [18]. Therefore, in this study we developed bread using GPs from different grape cultivars. The effects of GP concentrations and grape cultivars on the nutritional value (determined as proximate composition, polyphenol contents, total antioxidant activity, dietary fiber contents), and sensory quality of the breads were evaluated and compared to the white bread produced under same baking condition.

Materials and Methods

Materials

Grape pomaces from two grape varieties, Muscadine (Noble and Scuppernong) and Cabernet (Franc and Sauvignons), were obtained from two North Carolina wineries. The samples were collected immediately after the press of fermented grapes. The pomaces were spread in trays in about one inch thick and dried in a well ventilated air conditioning room at about 22ºC for one week, then ground into powders. No mold growth was observed during drying. The ground pomace was sieved to remove any larger particles. The powder passed through 40 mesh screen was used for bread formulation. Other ingredients for bread making (all purpose flour, non-fat dry milk, vegetable oil, sugar and salt) were purchased from a local grocery store (Greensboro, North Carolina, USA).

Bread Formulation and Baking

The breads were prepared using a 1-lb Basic white bread recipe by replacing 5 and 10% of white flour (Gold All Purpose Flour, Greensboro, NC) with GP. The bread with 0% GP was used as control. Commercial Arnold whole wheat bread and Russian rye bread were used as references for comparison. The ingredient composition of each formula is shown in Table 1. The ingredients were mixed in a Kitchen Aid stand mixer using a dough hook for about 7 minutes, and the dough was allowed to rise at room temperature. Once the dough had almost doubled in size the dough was shaped and placed in a lightly greased loaf pan, covered with a piece of wax paper and a damp cloth, and allowed to rise for 1 hour at room temperature. The dough was then baked in an oven for 25 minutes at 425ºF. After cooling the weight and volume were measured. The bread was then stored for further use.

Ingredient	Control	5% GP	10% GP
GP	0	16.01	32.06
Powdered Milk:	6.39	6.35	6.35
Salt (Morton salt)	3.59	3.59	3.59
Sugar	6.54	6.58	6.55
Shortening	15.85	15.75	15.54
Flour (Gold All Purpose Flour)	321	305.1	288
Yeast (Star Fast Rising Yeast)	1.12	1.12	1.12
Water (Tap water)	200	200	200

Table 1: *Ingredient composition of bread formulas (%, w/w).*

Determination of Proximate Composition of bread samples

Proximate composition includes moisture, ash, crude protein, crude fat and total carbohydrate of the bread products. The moisture of bread samples were determined by vacuum oven drying method using an Isotemp Vacuum Oven (Fisher Scientific, Georgia, USA). The ash content was determined using a Barnstead Thermolyne 30400 muffle furnace (Dubuque, Iowa, USA) by heating samples at 550°C for 5-6 hours. The crude protein contents of bread samples were determined by a combustion method using Leco TruSpec NC Elemental

Analyzer (Leco Corporation, Warrendale, Michigan, USA) using a conversion factor of 6.25. Crude fat contents of bread samples were determined by semi-automated Soxlet method using Soxtec 2050 extractor (Hilleroed, Demark) and petroleum ether. The carbohydrate contents of samples were determined by difference. All analysis except moisture was conducted with dry samples. All measurements were conducted in triplicate and results were expressed as mean ± standard deviation.

Instrumental Determination of Bread Color

The internal color of the bread sample was determined by CIE *L*, a** and b* color scale using CM-3500d Spectrophotometer (Konica-Minolta, Tokyo, Japan). The lightness *L** represents the darkest black at *L** = 0, and the brightest white at *L** = 100. The color channels, *a** and *b**, represent true neutral gray values at *a** = 0 and *b** = 0, represents green and blue at negative *a** and *b**values, and red and yellow at positive *a** and *b** values, respectively. Bread sample containing 0% GP was used as control and commercial whole wheat bread and rye bread were used as references. The results were expressed as the mean of 5 measurements.

Polyphenol Extraction and Determination

Polyphenols in bread samples were extracted using 70% ethanol. Briefly, 20 ml of 70% ethanol was added to 3g of fresh bread sample in a 50 ml centrifuge tube. The samples were homogenized for three minutes, and then centrifuged for 20 minutes at 3000g using an Eppendorf 5810 R centrifuge (Westbury, NY, USA). The supernates were collected and placed into clean tubes. The volume was measured using a graduated cylinder. Total polyphenol (TP) concentrations of the bread extracts were determined by Folin-Ciocalteu micro-method [19]. Total anthocyanin (TA) was determined by AOAC method 2005.02 [20], and total flavonoid (TF) was determined by the method reported by Xu and Chang [21]. The TP concentration was expressed as Gallic Acid Equivalent (GAE)/ml; the TA concentration was expressed as cyanidin-3-glucoside equivalents and the TF concentration was expressed as (+) - catechin equivalents (μg/ml). The content of each category of polyphenols in the bread samples was calculated as μg/g bread.

Antioxidant Activity Determination

The antioxidant activities of bread samples were determined by ABTS method [22] using Trolox as standard. The ABTS radical solution was prepared by mixing 7 mM solution of ABTS with 2.45 mM solution of potassium peroxodisulfate in a ratio of 1:0.5. The mixture was allowed to stabilize for 12-16 hours and used within two days. Once stable the radical solution was diluted with deionized water until the absorbency at 734 nm was 0.700 ± 0.02. Fifty microliters of the polyphenol extract from the bread sample or standard solution was mixed with 50 μl of 70% ethanol and 1.8 ml of diluted ABTS. The mixture was incubated for 6 minutes at room temperature and then the absorbance was measured at 734 nm using a Genesys™ 10 Spectrophotometer (Spectronic Unican, NY, USA). Antioxidant activity of each bread sample was expressed as Trolox Equivalent Antioxidant Activity (TEAC) (μM TEAC/g bread). Triplicate analyses were carried out for each sample.

Fiber Analysis

Total Dietary Fiber (TDF): TDF of each bread sample was determined by AOAC Method 991.43 [23] using TDF Assay Kit (Sigma-Aldrich, St Louis, MO, USA).

Insoluble Dietary Fiber (IDF): Insoluble dietary fiber (IDF) consists mainly of cellulose, hemicellulose and lignin [3]. Because neutral detergent fiber (NDF) measures the combined content of cellulose, hemicellulose and lignin, NDF was used as the measurement of IDF to reduce the use of alcohol and increase the reproducibility of fiber analysis in this study. The NDF was determined by The Ankom Technologies method 6 using Ankom^{200} Fiber Analyzer (Ankom Technology, Macedon, NY, USA). The dry samples were weighed into Ankom filter bags labeled using a solvent resistant marker, sealed with a heat sealer, placed in the bag suspender, and then loaded in the fiber analyzer vessel. Samples were digested with neutral detergent containing heat resistant α-amylase for 1 hour at 100ºC. Sample bags were then washed with hot water and dried at 105ºC overnight. After cooling to room temperature in desiccators, the weight loss was recorded.

Sensory Evaluation

The sensory evaluation was conducted the day after the bread was baked using panel of 15 untrained panelists. The panelists evaluated their preference on four sensory attributes (color, aroma, texture and flavor) and overall liking of the product. The preference on each attribute was scored using a 9-point hedonic scale. The bread containing 0% GP was used as the control.

Data Analysis

All measurements were conducted in triplicate and the results were expressed as means ± standard deviations. Data collected from physical properties (L*, a* and b*) measurement and sensory tests were analyzed by ANOVA and Duncan test to determine whether significant difference exist among samples containing different types/amounts of grape pomace in terms of L*, a*, b*, and consumer preference.

Results

Effects of GP Inclusion on Bread Volume and Weight

The GP cultivar did not show significant effects on both bread weight and loaf volume, but the amount of GP added to the formula significantly affected bread weight and volume (Table 2). Adding 5% Cab GP did not cause significant changes in bread volume, but decreased bread weight. When GP level increased to 10%, the bread volumes decreased significantly.

GP Type	Loaf Weight (g)			Loaf Volume (cm^3)		
	Control	5% GP	10% GP	Control	5% GP	10% GP
Muscadine Noble	498.6	503.9	497.0	1583.4	1546.3	1372.5
Muscadine Scuppernong	498.6	501.0	498.0	1583.4	1515.2	1316.5
Cabernet Franc	498.6	484.6	485.3	1583.4	1546.9	1083.6
Cabernet Sauvignon	498.6	482.5	470.1	1583.4	1586.3	1076.3

Table 2: *Effects of GP Inclusion on the weights and volumes of breads.*

Sample Name	% GP Added	% Moisture	% Ash	% Fat	% Protein	% Carbohydrate
White Bread	0	36.99 ± 1.03^{C}	1.54 ± 0.06^{C}	3.34 ± 0.07^{A}	14.40 ± 0.23^{C}	43.73
Muscadine	5	39.17 ± 0.08^{A}	1.88 ± 0.10^{B}	3.37 ± 0.20^{A}	13.56 ± 0.24^{D}	42.02
Noble	10	40.23 ± 0.97^{A}	2.58 ± 0.12^{B}	3.74 ± 0.46^{B}	13.40 ± 0.10^{D}	40.77
Muscadine	5	40.51 ± 0.41^{A}	2.11 ± 0.08^{B}	2.68 ± 0.07^{B}	12.91 ± 0.24^{E}	41.80
Scuppernong	10	38.29 ± 0.86^{AB}	1.93 ± 0.33^{B}	3.56 ± 0.04^{B}	12.92 ± 0.18^{E}	43.30
Cabernet Franc	5	38.47 ± 0.21^{AB}	2.38 ± 0.67^{B}	3.58 ± 0.89^{AB}	11.65 ± 0.30^{G}	44.77
	10	38.77 ± 0.29^{AB}	2.19 ± 0.15^{B}	3.77 ± 0.11^{B}	11.88 ± 0.19^{G}	44.03
Cabernet	5	39.74 ± 0.12^{A}	2.10 ± 0.14^{B}	3.49 ± 0.07^{B}	12.31 ± 0.15^{F}	43.16
Sauvignon	10	39.89 ± 0.15^{A}	2.32 ± 0.20^{B}	4.52 ± 0.21^{C}	12.57 ± 0.07^{F}	39.96
Russian Rye	0	34.96 ± 2.40^{BC}	3.13 ± 0.08^{A}	1.89 ± 0.02^{D}	17.07 ± 0.13^{AB}	42.59
Whole Wheat	0	38.21 ± 1.58^{A}	3.17 ± 0.11^{A}	1.80 ± 0.16^{D}	17.08 ± 0.33^{A}	40.16

Table 3: *Proximate composition of breads containing different types and amounts of grape pomace.*
Means followed by the same capital letter in same column were not significantly different (P > 0.05).

Table 3 summarizes the proximate composition of bread samples. All GP containing bread samples had higher moisture and ash contents than white bread. There is no significant difference in moisture contents of bread samples containing various percentages and types of GP. Fat contents of samples containing 5% of GP were similar to that of control. A significant increase in bread fat contents was observed ($P < 0.05$) at 10% GP inclusion level, particularly, for the bread containing 10% Cab Sauvignon GP. Protein contents of all GP containing breads were slightly lower than that of control. The breads containing Cab Franc GP showed lowest protein contents. Compared to commercial Rye and whole wheat breads, GP fortified breads showed lower mineral and protein contents, but higher fat contents. The results suggest that GP had better water binding capacity, higher mineral and fat contents, but slightly lower protein contents than wheat flour.

Effect of GP on the Color of Bread

Table 4 shows the color change of bread due to GP inclusion. All GP containing bread samples showed a significant darkening as indicated by decreased L* value, but they were more comparable with Russian Rye breads. The bread samples with 10% Muscadine Noble, Cabernet Franc and Cabernet Sauvignon pomace had lowest L* and b* values but highest a* values compared to control (white bread), while the bread samples with Muscadine Scuppernong pomace had lower a* values, and higher b* values than other GP containing samples. Overall, the *L values of GP containing bread samples were similar to that of Rye bread (Arnold) but lower than that of whole wheat bread (Sara Lee), while the a* and b* values of GP breads were lower than that of Rye bread and whole wheat bread.

Sample Name	L*	a*	b*
White Bread	63.01 ± 2.00^{B}	0.16 ± 0.01^{D}	9.44 ± 0.61^{B}
5% Mus Noble	50.21 ± 1.79^{C}	1.84 ± 0.20^{B}	3.83 ± 0.42^{EF}
10% Muse Noble	47.55 ± 0.40^{C}	2.29 ± 0.19^{B}	3.13 ± 0.17^{EF}
5% Mus Scuppernong	50.53 ± 2.83^{C}	1.13 ± 0.08^{C}	4.30 ± 0.58^{D}
10% Mus Scuppernong	50.54 ± 1.92^{C}	1.77 ± 0.05^{C}	4.85 ± 0.40^{D}
5% Cab Franc	52.19 ± 1.03^{C}	1.86 ± 0.07^{B}	3.98 ± 0.29^{E}
10% Cab Franc	48.47 ± 1.55^{C}	2.11 ± 0.13^{B}	3.21 ± 0.29^{E}
5% Cab Sauvignon	51.04 ± 1.28^{C}	1.85 ± 0.12^{B}	3.18 ± 0.28^{F}
10% Cab Sauvignon	48.35 ± 1.92^{C}	2.32 ± 0.30^{B}	2.66 ± 0.22^{F}
Whole Wheat	58.22 ± 0.82^{A}	4.32 ± 0.15^{A}	12.65 ± 0.35^{A}
Russian Rye	48.78 ± 1.04^{C}	4.22 ± 0.48^{A}	8.05 ± 0.81^{C}

Table 4: *Physical properties of bread containing different types and amounts of GP.*
Means followed by the same superscript letter in same column were not significantly different. L represents the darkest black at L* = 0, and the brightest white at L* = 100, a* and b* represent true neutral gray values at a* = 0 and b* = 0, represents green and blue at negative a* and b*values, and red and yellow at positive a* and b* values, respectively.*

Effects of GP Inclusion on Polyphenol Contents of Bread

For the same pomace, TP and TF contents of the bread increased linearly as the GP concentration increased (Figure 1a and 1b). At same GP inclusion level, bread samples with Cabernet pomaces had lower TP and TF contents compared to bread samples containing Muscadine pomaces. Table 5 shows that although 21-33% of added TP from GP lost during baking due to thermal degradation/oxidation, 67-79% of TP retained depending on the cultivar of GP added in the bread formula.

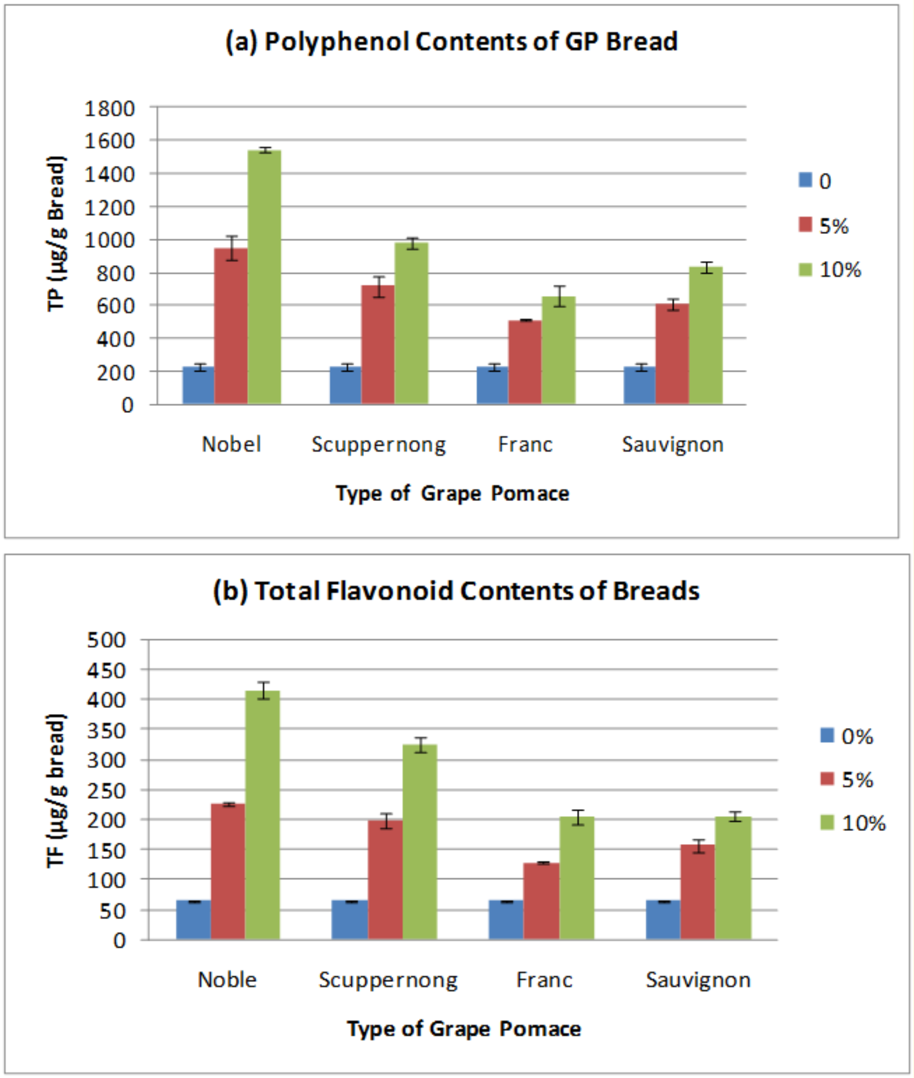

Figure 1: *The effects of adding GP on the total polyphenol (a) and total flavonoid (b) contents of bread.*

	TP Added (mg/g Bread)	TP in Bread (mg/g bread)	TP Retention (mg/g bread)	% TP Retention*
Control	0.00	113.46		
Mus Noble	1036.88	807.66	694.22	66.95
Mus Scuppernong	517.08	487.44	373.98	72.33
Cab Franc	277.69	332.51	219.05	78.88
Cab Sauvignon	351.46	391.84	278.38	79.21

Table 5: *Polyphenol retentions in GP fortified bread samples after baking.*

**: %TP retention = (TP added – TP in baked bread – 113.46)*100/TP added. Mus: Muascadine, Cab: Cabernet*

Antioxidant Activity of GP Fortified Bread

The antioxidant activity of bread (as TEAC) was significantly higher in the presence of GP and the TEAC increased with increasing amount of GP in the bread (Figure 2). The bread samples containing Muscadine Scuppernong and Noble pomace had significantly higher TEAC values than the bread samples containing Cabernet Franc and Sauvignon pomace. The high antioxidant activity of GP fortified bread may slow down lipid oxidation of bread. This property will be more important to the food products containing higher amount of lipid such as cookies and sausages.

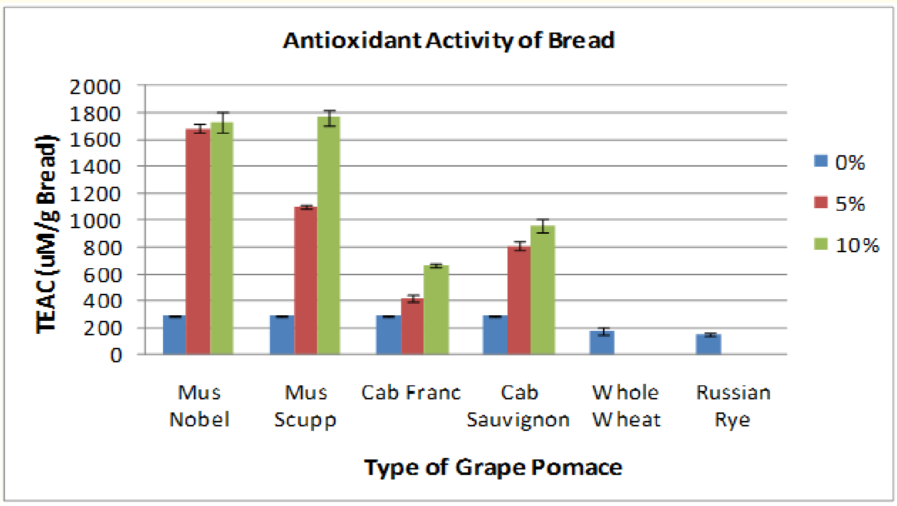

Figure 2: *Effects of adding GP powder on the antioxidant activity of bread.*

Total Dietary Fiber (TDF) and Insoluble Dietary Fiber (IDF) of GP Fortified Bread

Substitution 5-10% of white flour with GP in the bread formula significantly increased dietary fiber content of bread. Fig.3a shows that TDF of bread increased linearly with the amount of GP powder added, and there were no significant difference amount TDF contents of bread samples containing same amount of different type of GP powder. The TDF of breads fortified with 10% GP is comparable to that of whole wheat bread but slightly lower than that of rye bread ($P < 0.05$). Figure 3b shows that the breads with 5% of GP had comparable IDF contents as the whole wheat bread, but the breads with 10% GP had significantly higher IDF than the whole wheat bread ($P < 0.05$), although lower than the rye bread.

Consumer Preference of GP Containing Breads

The results of sensory evaluation show that the cultivar of grape not the level of GP inclusion had significant effects on the consumer preferences of aroma, flavor and texture of the GP containing bread ($P < 0.05$) when the replacement of wheat flour by GP was within 10%. The color of the breads containing 5% Cab Franc and the 10% Muscadine Scuppernong was least acceptable. The aroma and texture of the breads containing 5% and 10% Cabernet Sauvignon were the most preferred among GP fortified breads, while the aroma of 5% and 10% Muscadine Noble pomace fortified breads was least pleasing. The bread containing 10% Muscadine Noble/Scuppernong pomace had the most unpleasant texture. Overall, the consumer preference and acceptability of the bread fortified with Cabernet Sauvignon were similar to that of white bread.

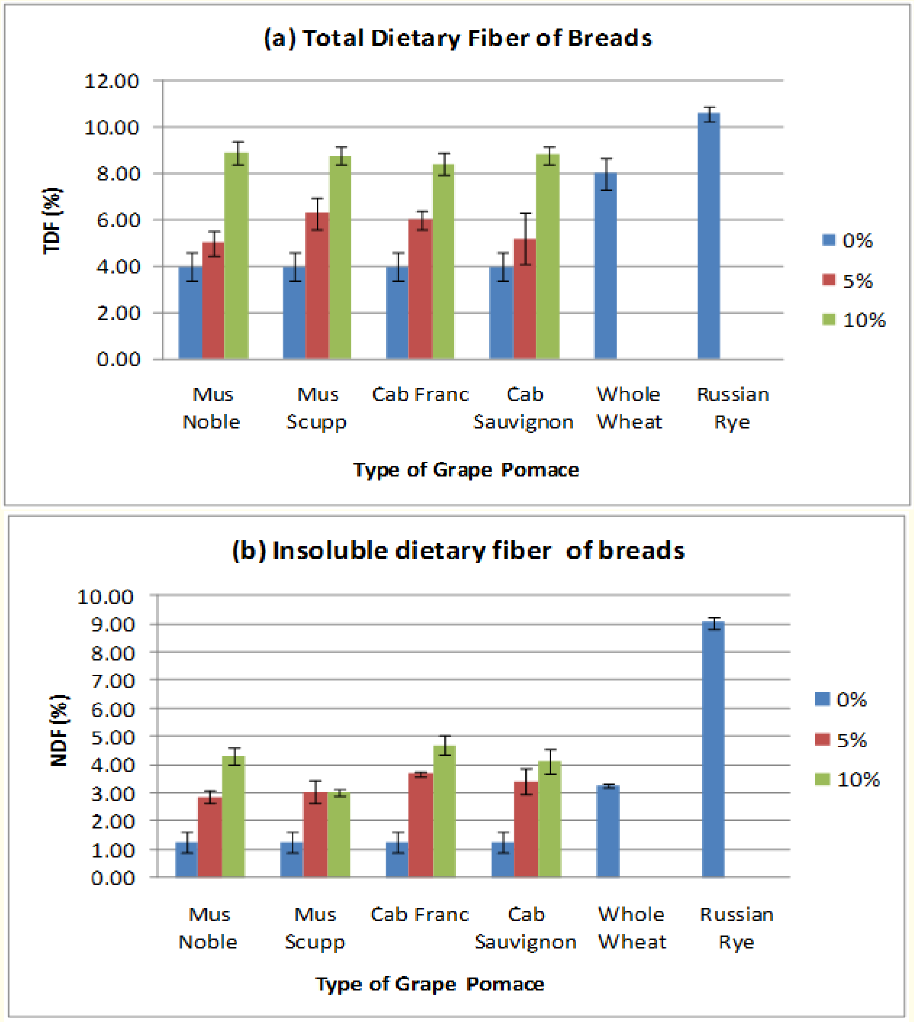

***Figure 3:** Effects of adding GP on the dietary fiber contents of breads. (a) Total dietary fiber and (b) Insoluble dietary fiber (determined as neutral detergent fiber).*

Discussion

This study shows that the loaf volume decreased but loaf density increased in the GP dose dependent manner due to the increase of fiber content. Similar results were reported that the incorporation of dietary fibers from different sources (such as apple, hazelnut and sugar beet fibers) into bread increased product density as a result of the water-binding capacity of fiber [24] and reduce bread loaf volume [25]. However, replacing 5% of wheat flour by GP powder did not cause negative changes in these quality attributes significantly.

The increased water retention in the GP fortified bread is most likely due to the dietary fiber of GP, particularly, the water soluble fraction because the water holding capacity of soluble fibers (such as pectin and galactomannan) is greater than that of cellulose (insoluble fibers) [26]. The dietary fiber data obtained from this study are in good agreement to that reported by others that addition of 10% GP to sourdough accounted for 39% increase in bread IDF content [15]. Seed containing GP has significant amount of oil [27] which contributed to the higher fat contents of GP containing bread compared to the control. Decreased crude protein contents in breads after the addition of GP powder to replace flour also suggested a dilution effect on wheat proteins [28] due to the low protein content of GP [27]. To improve the protein content of GP fortified bread, certain amount of milk protein or soy protein isolate can be added in the formula.

GP Type	% GP Added	Sensory Rating			
		Colour	Aroma	Texture	Flavour
Control	0	7.40 ± 1.18 A	7.07 ± 1.00 A	6.86 ± 1.25 A	6.80 ± 1.61 A
Muscadine Noble	5	6.00 ± 1.29 B	4.67± 1.50 C	5.00 ± 1.68 C	4.93 ± 1.21 C
	10	5.71 ± 1.33 B	4.73 ± 1.28 C	4.85 ± 1.73 C	4.62 ± 1.50 C
Muscadine Scuppernong	5	5.80 ± 1.32 B	5.07 ± 1.79 C	5.47 ± 1.69 C	4.93 ± 2.05 C
	10	5.27 ± 1.34 B	5.13 ± 1.41 C	4.39 ± 1.50 C	4.73 ± 1.67 C
Cabernet Fran	5	5.21 ± 1.12 B	5.47 ± 1.51 C	5.20 ± 1.70B C	5.40 ± 1.96 BC
	10	5.64 ± 1.15 B	4.87 ± 1.46 C	5.33 ± 1.50B C	5.40 ± 1.68 BC
Cabernet Sauvignon	5	5.67 ± 1.29 B	6.00 ± 1.24 B	6.00 ± 1.30 AB	6.07 ± 1.38 AB
	10	6.53 ± 1.19 B	6.00 ± 1.11 B	6.20 ± 1.66 AB	5.73 ± 1.83 AB

Table 6: *Summary of sensory evaluation results (Preference Test, n = 15).*
Means followed by the same superscript letter in same column were not significantly different (P > 0.05).

The darkening of GP breads is expected because GP contains significant amount of polyphenol [29,30], particularly, anthocyanins and tannin that are purple red themselves at baking pH. Other researchers also reported product darkening of cookies due to the addition of grape skin [12] and the darkening of bread due to the addition of polyphenol extracts [14]. Overall, the *L values of GP containing bread samples were similar to that of Rye bread (Arnold) but lower than that of whole wheat bread (Sara Lee), while the a* and b* values of GP breads were lower than that of Rye bread and whole wheat bread.

The high TP and TF contents in GP fortified bread samples indicates that a significant amount of polyphenols in GP was transferred to the bread from an underutilized agricultural by-products even after high temperature exposure. Although baking resulted in some loss of added polyphenol, due to thermal degradation/oxidation, 67-79% of TP retained depending on the cultivar of GP added in the bread formula. The TP retention in this study is lower than that reported by [31], where the individual tea polyphenol retention in bread was 83% to 91% after baking. This may be because the lower thermal stability of anthocyanins in the GP than catechins in the tea extract, particularly, at the high moisture and neutral pH of bread making [32,33].

Our sensory results confirmed that the consumer acceptance of bread with 7.5-10% grape seed flour decreased, with exception of Cab Sauvignon fortified bread [17]. Therefore, the level of GP in the formula and the type of GP selected are very important for maintaining the sensory quality of the bread.

Conclusion

The inclusion of GP powder in the bread formula significantly increased polyphenol antioxidants and dietary fiber to the bread. The results indicate that GP is suitable to be used in bread making as a source of natural antioxidant and dietary fiber. However, the inclusion of GP in the bread also had some negative effects on the quality of bread such as reduced the loaf volume, darkening in color and hardening in texture. The degree of negative effects of GP on bread quality depends on the quantity of GP added and the variety/cultivar of grape because the polyphenol composition and DF content of GP are variety dependent. Therefore, care must be taken to minimize the negative effects of GP on the sensory quality of the products.

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Conflict of Interest

There are no financial interests or conflicts of interest.

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Volume 2 Issue 1 August 2015