Wine Grape Pomace as Antioxidant Dietary Fiber for Enhancing Nutritional Value and Improving Storability of Yogurt and Salad Dressing

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ABSTRACT

Wine grape pomace (WGP) as a source of antioxidant dietary fiber (ADF) was fortified in yogurt (Y), Italian (I) and Thousand Island (T) salad dressings. During the three weeks of storage at 4 °C, viscosity and pH of WGP-Y increased and decreased, respectively, but syneresis and lactic acid percentage of WGP-Y and pH of WGP-I and WGP-T were stable. Adding WGP resulted in 35-65% reduction of peroxide values in all samples. Dried whole pomace powder (WP) fortified products had dietary fiber content of 0.94-3.6% (w/w product), mainly insoluble fractions. Total phenolic content and DPPH radical scavenging activity were 958-1340 mg GAE/kg product and 710-936 mg AAE/kg product, respectively. The highest ADF were obtained in 3%WP-Y, 1%WP-I and 2%WP-T, while 1%WP-Y, 0.5%WP-I and 1%WP-T were mostly liked by consumers based on the sensory study. Study demonstrated that WGP may be used as a functional food ingredient for promoting human health and extending shelf-life of food products.

Key words: antioxidant dietary fiber, wine grape pomace, yogurt, salad dressing, storability

1. Introduction

The concept of antioxidant dietary fiber (ADF) was first proposed by Saura-Calixto (1998) with the criteria that one gram of ADF should have DPPH free radical scavenging capacity equivalent to at least 50 mg vitamin E and dietary fiber content higher than 50% dry matter from the natural constituents of the material. Wine grape pomace (WGP), the residual seed and skins from winemaking, contain high phenolic compounds and dietary fiber (Deng, Penner & Zhao, 2011; Llobera & Cañellas, 2007). Our previous study found that WGP met the definition of ADF even after 16 weeks of storage under vacuum condition at 15 °C (Tseng & Zhao, 2012). Jiménez et al. (2008) also found that fibers from grapes show higher reducing efficacy in lipid profile and blood pressure than that from oat fiber or psyllium due to combined effect of dietary fiber and antioxidants. WGP as ADF not only retarded human low-density lipoprotein oxidation *in vitro* (Meyer, Jepsen & Sorensen, 1998), but also helped enhance the gastrointestinal health of the host by promoting a beneficial microbiota profile (Pozuelo et al., 2012).

There are increasing interests in applying fruit processing wastes as functional food ingredients since they are rich source of dietary fiber, and most of the beneficial bioactive compounds are remained in those byproducts (Balasundram, Sundram & Samman, 2006). ADF may be incorporated with flour for making high dietary fiber bakery goods, while the polyphenols in ADF could contribute as antioxidant for improving color, aroma and taste of the product. For instance, mango peel powders were used for preparing macaroni to enhance the antioxidant properties (Ajila, Aalami, Leelavathi & Rao, 2010). Apple pomace was incorporated into wheat flour as fiber source to improve the rheological characteristics of cake (Sudha, Baskaran & Leelavathi, 2007). Grape pomace was mixed with sourdough for rye bread (Mildner-

Szkudlarz, Zawirska-Wojtasiak, Szwengiel & Pacyński, 2011) and grape seed flour for cereal bars, pancakes and noodles (Rosales Soto, Brown & Ross, 2012).

Aside from promoting human health, WGP as ADF plays important role as antioxidant and antimicrobial agent to extend the shelf-life of food product. For example, WGP was added into minced fish and chicken breast to delay the lipid oxidation (Goni, Sayago-Ayerdi, Brenes & Viveros, 2009; Sánchez-Alonso, Jiménez-Escrig, Saura-Calixto & Borderías, 2007). Also, WGP extract exhibited antimicrobial effect against foodborne pathogens when added into beef patties (Sagdic, Ozturk, Yilmaz & Yetim, 2011). Research has indicated that WGP seed extracts show better antioxidant activities than that of synthetic antioxidant of butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) (Baydar, Ozkan & Yasar, 2007).

Yogurt is the most popular fermented dairy product with high nutritional value, but not being considered as a significant source of polyphenols and dietary fibers. Fruit are commonly blended in after milk is fermented to make stirred yogurt that is non-Newtonian with weak viscoelastic property (Lubbers, Decourcelle, Vallet & Guichard, 2004). The effects of different types of fruit as source of dietary fiber on the rheological properties of yogurt have been studied (Sendra, Kuri, Fernández-López, Sayas-Barberá, Navarro & Pérez-Alvarez, 2010), and showed stable physicochemical properties of fortified yogurt during storage (Staffolo, Bertola, Martino & Bevilacqua, 2004). A few studies also reported good stability of the bioactive compounds from grape and other plant extract in fortified yogurt (Karaaslan, Ozden, Vardin & Turkoglu, 2011; Wallace & Giusti, 2008).

Salad dressing containing high amount of fat with oil-in-water emulsions can be readily oxidized during processing and storage, which led to the formation of undesirable volatile compounds (Shahidi & Zhong, 2005). Previous studies had added antioxidants to inhibit the lipid oxidation, such as honey (Rasmussen, Wang, Leung, Andrae-Nightingale, Schmidt & Engeseth, 2008), ascorbyl palmitate, α-tocopherol, and ethylenediaminetetraacetic acid (EDTA) (Let, Jacobsen & Meyer, 2007). Orange pulps were also incorporated into salad dressing for enhancing the rheological property and improving storability (Chatsisvili, Amvrosiadis & Kiosseoglou, 2012).

The objective of this study was to investigate the feasibility of fortifying WGP as the source of dietary fiber and polyphenols, i.e., ADF in yogurt and salad dressing for enhancing nutritional value and improving storability of the products. Three different forms of WGP were evaluated, including dried whole grape pomace (WP), pomace liquid extract (LE) and freeze dried liquid extract (FDE). Dietary fiber content were determined for all products, and the quality parameters of fortified products, including pH, peroxide value, total phenolic contents and antiradical scavenging activity were monitored during the refrigeration storage at 4 ^{o}C. Yogurt was further analyzed for viscosity, syneresis and lactic acid percentage. Moreover, consumer acceptance of WGP fortified yogurt and salad dressing was evaluated through a consumer sensory study. Based on our best knowledge, no study has reported the use of WGP in yogurt and salad dressing and how it may impact the quality of the products.

2. Materials and Methods

2.1 Preparation of wine grape pomace ingredients

The red wine grape pomace (WGP), *Vitis vinifera* L. cv. Pinot Noir, was obtained from the Oregon State University Research Winery (Corvallis, OR, USA). Stems were manually removed to collect seeds and skins. WGP was freeze-dried under -55 °C and vacuum of 17.33 Pa (Model 651 m-9WDF20, Hull Corp., Hatboro, PA) till no further weight loss was observed. Dried WGP was then ground (Gien Mills Inc., NJ) and passed through different sizes of sieves to obtain powders with particle size of 0.85 mm for the analysis of chemical composition and bioactive compounds, and with particle size of 0.18 mm for the fortification in yogurt and salad dressings. Based on our preliminary studies, particle size of WGP directly impacted the sensory quality of fortified products, especially the mouth feeling of fortified yogurt (data not shown). Hence, smaller particle size of 0.18 mm was selected for the fortification.

For preparing the liquid extracts for fortification, WGP powders were extracted by 70% acetone at a solvent to WGP powder ratio of 4:1 (v/w) and ultrasonicated (Branson B-220H, SmithKline Co., Shelton, CT, USA) at room temperature for 60 min. The mixture was centrifuged (International Equipment Co., Boston, MA) at 10,000 g for 15 min and repeated for three times. All supernatants were combined and concentrated by rotation evaporator (Brinkmann Instruments, Westbury, NY, USA) at 40 °C to remove acetone and obtain the WGP liquid extract (LE). The liquid extract was further freeze-dried to obtain freeze-dried pomace extract (FDE). The yield rate of LE and FDE from WGP were about 279% and 8%, respectively. In this study, three forms of WGP, including dried whole powders (WP), LE and FDE, were evaluated for their fortifications in yogurt and salad dressing.

2.2 Chemical composition of WGP

Moisture, ash, protein, fat, condensed tannin and pectin contents of WGP were determined by AOAC methods (Tseng et al., 2012). Dietary fiber (DF), including soluble (SDF) and insoluble dietary fiber (IDF) fractions, was analyzed by the enzymatic-gravimetric method (AOAC 994.13) with some modifications (Deng et al., 2011). In brief, pomace were treated with protease (P-5459, Sigma Chemical Co., USA) in 0.05 M, pH 7.5 phosphate buffer at 60 °C for

30 min and then centrifuged. IDF was obtained from the residues, while SDF was the supernatant.

SDF fraction was dialysized in deionized water by the tubing with a molecule weight cutoff of 12,000-14,000 (Spectrum Laboratories, Inc., USA) for 48 h. The dialysate was freeze-dried and hydrolyzed with 72% sulfuric acid at 121 °C for 1 h. Neutral sugar (NS) was determined based on the anthrone method as D-glucose (Sigma Chemical Co., USA) equivalent. Uronic acid (UA) was quantified by using galacturonic acid (Spectrum Chemical, Co., USA) as standard along with spectrometric assay (UV160U, Shimadzu, Japan). After mixing, 98% H_2SO_4 and boric acid-sodium chloride solution was incubated at 70 °C for 40 min, the solvent was then treated with 3,5-dimethyphenol-glacial acetic acid (Sigma Chemical Co., USA) and the absorbance was measured at 400 and 450 nm, respectively. SDF was calculated by the sum of NS and UA.

IDF fraction was hydrolyzed by 72% sulfuric acid at 30 °C for 1 h, followed at 121 °C for 1 h. The mixture was filtrated by fritted crucible, in which the filtrate was used for NS and UA measurement as described for SDF, while the residue was considered as Klason lignin (KL) after drying for 16 h at 105 °C. IDF was quantified by the sum of KL, NS and UA, and total dietary fiber content was calculated as sum of IDF and SDF.

2.3 Total phenolic content and DPPH radical scavenging activity of WGP

WGP was extracted by using 70% acetone /0.1% HCl (v/v) at solvent/pomace powder ratio of 4:1 (v/w) (Deng et al., 2011) and followed the same procedure as described above in obtaining LE. The final extract was used for determining total phenolic content (TPC) and DPPH radical scavenging activity (RSA).

TPC was measured by the Folin-Ciocalteu assay along with spectrometer. The diluted extract was reacted with Folin-Ciocalteu reagent (Sigma Chemical Co., MO, USA) for 10 min followed with addition of 20% $NaCO_3$ and incubation in a 40 °C water bath for 15 min (UV160U, Shimadzu, Japan). Gallic acid (Sigma Chemical Co., USA) was applied as a standard, and the results were expressed as mg gallic acid equivalent (GAE)/g WGP at absorbance of 765 nm using a spectrometer (UV160U, Shimadzu, Japan).

RSA was determined by 1,1-diphenyl-2-picryhydrazyl (DPPH) (Kasel Kogyo Co. Ltd, Japan) assay based on ascorbic acid (Mallinckrodt Baker Inc., USA) equivalent. The diluted extract was mixed with DPPH-methanol reagent (9 mg DPPH in 100 mL methanol) for 10 min at room temperature and the absorbance was read at 517 nm. The results were expressed as mg ascorbic acid equivalents (AAE)/g WGP.

2.4 Preparation of yogurt and salad dressing

Yogurt was prepared using reduced fat milk (2% milk fat, Darigold, USA) with 4% sugar (w/v milk) addition. Sugar was dissolved in the milk and pasteurized in 85 ºC water bath for 30 min and then cooled down to 45 ºC. Starter culture (ABY 2C, Dairy Connection Inc., Wisconsin, USA), a combination of *Streptococcus thermophiles, Lactobacillus delbrueckii subsp. Bulgaricus, Lactobacillus acidophilus* and *Bifidobacterium lactis* was added. The mixture was fermented in a 45 ºC water bath till the final pH of 4.5 (about 4.5 h). After the milk was coagulated, 1, 2, or 3 g WP was added to make 100 g yogurt and stirred gently, named as 1%, 2% and 3% WP (w/w yogurt), respectively. Based on our preliminary study, 2% WP (w/w yogurt) sample obtained the best overall physicochemical properties and stability during storage. The amount of LE and FDE added into yogurt was then calculated to achieve approximate same amount of TPC as that in 2% WP. Hence, 5.59 mL LE and 0.215 g FDE were added into 100 g of yogurt and named LE-Y and FDE-Y, respectively. Yogurt samples were packed into polyethylene bottle (Dynalab Corp., NY, USA) and stored at 4 ºC refrigerator under dark for quality evaluation at day 1 (overnight), 7, 14 and 21.

Two types of commercial salad dressing were purchased from a local grocery store, Italian and Thousand Island (Kraft, USA), representing the liquid and creaming type, respectively. Based on our preliminary study on the texture and visual appearance of WP fortified dressing, 0.5 g and 1 g of WP (named 0.5% WP and 1% WP (w/w Italian), respectively), 2.795 mL LE (named LE-I) and 0.1075 g FDE (named FDE-I) were added into 100 g of Italian dressing, while 1 g and 2 g of WP (named 1% WP and 2% WP (w/w Thousand Island), respectively), 5.59 mL LE (named LE-T) and 0.215 g FDE (named FDE-T) were incorporated into 100 g of Thousand Island. WGP fortified salad dressings were stored at the same 4 ºC refrigerator for quality evaluation at day 0, 7, 14, 21 and 28.

2.5 Color and pH of WGP fortified yogurt and salad dressings

Color of the samples was monitored by a colorimeter (Lab Scan II, Hunter Associate Laboratory Inc., Reston, VA, USA). Samples were placed inside a glass refract cup on the light pore size of 44.45 mm. Data were recorded as CIE L* values indicating lightness, as well as Chroma value of $(a^2+b^2)^{1/2}$ and Hue angle of $\tan^{-1}(b/a)$ to represent the saturation and shade of the color, respectively. The pH of the samples was measured by a pH meter (Corning, NY, USA).

2.6 Syneresis, viscosity, and lactic acid percentage of WGP fortified yogurt

Syneresis is defined as whey separation from gel matrix and considered as an important quality indicator of yogurt. To determine syneresis, 20 g of yogurt was spread as a thin layer on the Whatman No.1 filter paper and vacuum drained by a Buchner funnel. Syneresis was calculated as the percentage of whey loss by the total sample. Viscosity of the yogurt was measured by a rotational viscometer (DV-III, Brookfield, MA, USA) with spindle No. 93 at the speed of 25 rpm, and recorded as centipoises (cP). Lactic acid percentage was determined by titration with standard 0.1 N NaOH until reaching pH 8.2.

2.7 Peroxide value of WGP fortified yogurt and salad dressings

Peroxide value (PV) was expressed as the amount of peroxides formed in oils and fats during oxidation and was measured by the acetic acid-chloroform method (AOCS Cd 8-53). In brief, 2 g of sample was homogenized with 30 mL of acetic acid: chloroform at 3:2 (v/v) and filtrated by Whatman No.1 filter paper. Filtrate was added with 0.5 mL saturated potassium iodine and occasionally shaken for 1 min. Thirty mL of water was then added, and the mixture was titrated with 0.01 N standard sodium thiosulfate until transparent. The results were expressed as milliequivalent peroxide/kg product.

2.8 Total phenolic compound, DPPH radical scavenging activity and dietary fiber of WGP fortified yogurt and salad dressings

To extract the bioactive compounds in WGP fortified yogurt and salad dressings, a 20 g of sample was mixed with 30 mL 70% acetone /0.1% HCl (v/v) and set at 4 °C overnight. Solution was then passed through filter paper (Whatman No.1) to collect the filtrate, and concentrated using a rotation evaporator at 40 °C. TPC and RSA were quantified by the same procedures for

WGP described above (section 2.3), and the results were express as mg GAE/kg and mg AAE/kg product, respectively. For DF analysis, samples were washed with petroleum ether twice under ultrasonication and then followed the steps as described above for WGP determination. The results were expressed as TDF, IDF and SDF percentage of product. The commercial fiber-added yogurt (FiberOne with blueberry, YoPlait, USA) was set as reference, and its TPC, RSA and DF were determined right after purchase, while TPC and RSA of WGP fortified yogurt and salad dressings were measured during 3 and 4 weeks of storage at 4 °C, respectively.

2.9 Sensory evaluation of WGP fortified yogurt and salad dressings

Permission of the sensory study was obtained from the Institutional Review Board at the Oregon State University. Panelists were recruited by E-mails and screened to meet the requirement of consuming flavored yogurt or salad with dressing more than 3 times a week. Twelve panelists (age between 18 and 39, 4-5 males and 7-8 females depending on the type of product tested) were participated in the sensory evaluation of each product.

Only products fortified with WP were evaluated for consumer sensory acceptance since WP provides the highest amount of ADF. Commercial vanilla flavor plain yogurt (YoPlait Original, USA) mixed with 5.59% grape juice concentrate (v/w yogurt) (Albertson, USA) was used as a control to avoid the discrimination in color and flavor. Salad dressings were served with field green salad (Dole, USA), by giving instruction to the panelists to pour the dressings on the salad based on their preferred amount. Panelists were asked to rate the likeness on appearance, overall, flavor and texture quality of the samples by using a 9-point hedonic scale (9=like extremely, 1=dislike extremely). The consistency of the products were evaluated by ‘Just About Right’ scale

(5=too thick, 1=too thin, and 3= just about right). An open-end question was also asked at the end to describe the reasons for liking and disliking the products.

2.10 Data analysis

All the experiments, except the sensory evaluation, were conducted triplicate and the mean values were compared based on LSD at 95% confidence level. For storage study, the analysis of variance (ANOVA) was performed to evaluate significant treatment effect of two independent factors: WGP forms (different WP concentrations, LE and FDE) and storage time. All data were analyzed by general linear model procedure (PROC GLM) of SAS 9.2 (SAS Inst. Inc., USA). For sensory evaluation, the results were exported from Compusense Programme (Compusense 5.0, version 4.6, Guleph, Canada), and the means of consumer acceptance results for each attribute were analyzed by ANOVA and compared at the $P<0.05$ level by Tukey test.

3. Results and Discussions

3.1 Chemical composition of WGP

Fat, protein, soluble sugar, pectin and condensed tannin content of WGP were 11.09, 10.32, 3.89, 3.68 and 12.11%, respectively (Table 1), comparable to the data in previous study (Llobera et al., 2007). TPC of WGP was 67.74 mg GAE/g. Note that phenolic compounds in WGP are influenced by many factors, including grape variety, growth climate and location, harvest time, as well as processing and storage conditions, extraction and analytical methods (Lafka, Sinanoglou & Lazos, 2007). Thimothe, Bonsi, Padilla-Zakour and Koo (2007) reported that Pinot Noir pomace after fermentation in winemaking has slightly higher TPC than that of whole Pinot Noir fruit. In general, phenolic acids including gallic acid and ellagic acid, and flavonoids, such as catechin, epicatechin, procyanidins and anthocyanins are the major polyphenols in WGP (Lafka et al., 2007; Yilmaz & Toledo, 2006). Lu and Foo (1999) detected 17 polyphenols in WGP by NMR spectroscopy; Schieber, Kammerer, Claus & Carle (2004) further quantified 13 anthocyanins, 11 phenolic acids, 13 flavonoids, and 2 stilbenes in WGP by HPLC. Anthocyanin contributed to the color of the WGP was identified as malvidin derivatives, malvidin-3-glucoside and malvidin-3-acetylglucoside (de Torres, Díaz-Maroto, Hermosín-Gutiérrez & Pérez-Coello, 2010).Phenolic compounds are the secondary metabolites of plants and characterized by the structure-activity relationship of the hydroxyl group and the nature of substitutions on aromatic ring. Based on their structure-activity relationship, there are several different antioxidant mechanisms of phenolics, such as free radicals scavenging ability, hydrogen atoms or electron donation and metal cations chelation (Amarowicz, Pegg, Rahimi-Moghaddam, Barl & Weil, 2004).

Total DF content of WGP was about 61%, met the definition of ADF with over 50% dry matter. In respect to RSA, 1 mg AAE/g equaled to 2.45 mg α-tocopherol equilibrium (TE)/g based on our previous study (Tseng et al., 2012). RSA of WGP was 37.46 AAE/g or 91.78 TE/g, also met the requirement for ADF of having free radical scavenging at least equivalent to 50 mg of vitamin E by DPPH method. These properties are intrinsic to the WGP, deriving from the natural constituents of the material. Additionally, WGP retained the ADF characteristic even after 16 weeks of storage at 15 °C in vacuum package (Tseng et al., 2012). Therefore, WGP could be claimed as antioxidant dietary fiber and fortified in yogurt and salad dressings in this study.

3.2 Color of WGP and WGP fortified yogurt and salad dressings

L*, Hue and Chroma values of freeze dried WGP and its fortified products are presented in Table 3. The control yogurt sample without the addition of WGP received the highest L* of 92.18, but the lowest Hue value of -1.26. As expected, the lightness and Hue values decreased, but the Chroma increased along with increased amount of WP added, but no significant difference ($P<0.05$) between 2% WP and 3% WP (w/w yogurt) samples. Overall, LE-Y and FDF-Y samples obtained the higher ($P<0.05$) L* and Hue values, but lower Chroma value than those of 2% WP (w/w yogurt) sample. These results reflected that the LE and FDE fortified samples provide more homogeneous but less saturated color in the product. Also, WP presented more redness and blueness compared to LE and FDE that showed higher a* value, but lower b* value (data not shown).

In respect to WGP fortified salad dressings, the control sample received the lightest color, 43.59 and 72.25 in Italian and Thousand Island dressing, respectively; while the darkest color was found in 1% WP (w/w Italian) (36.96) and 2% WP (w/w Thousand Island) (60.33) samples. In Italian dressing, the lowest Hue value was found in LE-I (1.09), but no difference ($P>0.05$) among all Thousand Island samples regardless of the concentration and type of WGP added. Both Italian and Thousand Island samples had the high Chroma value of 29.06 and 39.47, respectively, and the samples with the highest amount of WGP received the lowest Chroma values, 21.79 in 1% WP (w/w Italian) and 28.16 in 2% WP (w/w Thousand Island).

3.3 pH of WGP fortified yogurt and salad dressings

Figure 1 shows the pH of WGP fortified products during 4 weeks of storage under 4 °C. Adding WGP into the yogurt immediately reduced the pH from 4.78 to 4.47-4.60. Since WGP liquid extract had a low pH of 3.63, LE-Y showed the lowest pH of 4.47. The pH of all samples continuously dropped (P<0.05) during the first 2 weeks of storage. At the end of 4 weeks, control sample remained the highest pH of 4.44, while LE-Y had pH of 4.30. These results were consistent with previous study in orange fiber fortified yogurt, in which about 0.2 unit of pH reduction was observed after 14 days of storage (García-Pérez, Lario, Fernández-López, Sayas, Pérez-Alvarez & Sendra, 2005). Beal, Skokanova, Latrille, Martin and Corrieu (1999) explained that the high rate of production of lactic acid and galactose was observed at the initial 14 days due to the high bacterial metabolic activity with the consumption of lactose.

The pH of WGP fortified Italian salad dressing was lower than control initially, but no difference (P>0.05) in pH among all fortified samples no matter of the type and concentration of WGP added. The control and WGP fortified samples had pH of 3.41 and ~3.38, respectively at day 0. Overall, the pH was slightly dropped during storage under 4 °C and received the value of 3.35 and 3.31 in control and 1% WP (w/w Italian) samples, respectively at the end of 4 weeks of storage. For Thousand Island salad dressing, 2% WP (w/w Thousand Island) obtained the relatively low pH of 3.53, whereas the control had a pH of 3.57. The pH of LE-T sample was slightly higher, probably due to the higher pH of the extract. The pH of the Thousand Island dressing remained stable, about 3.5 to 3.6 during 4 weeks of storage.

3.4 Syneresis, viscosity and lactic acid percentage of WGP fortified yogurt

Based on our preliminary study, 2% reduced fat milk could not coagulate if >5% WP (w/w yogurt) was added before fermentation. Also, it required longer fermentation time when adding more than 3% WP (w/w yogurt) into milk beforehand, which was undesirable due to increasing in syneresis. Mazaheri, Tehrani and Shahidi (2008) also found that syneresis was lower when fruit were added after fermentation. Therefore, WGP was added after the milk had coagulated, i.e., yogurt had formed in this study.

Viscosity, syneresis and lactic acid percentage of WGP fortified yogurt during 4 weeks of storage at 4°C are reported in Table 4. No difference ($P>0.05$) on syneresis among all the samples was observed initially, ranged from 16.82 to 20.13% (Table 4). The syneresis increased significantly ($P<0.05$) only in 3% WP (w/w yogurt) sample (33.58%), while all other samples remained stable during 3 weeks of storage. The amount of WP addition in yogurt is critical because the protein in WP rearranged the gel matrix. Hence, 2% WP (w/w yogurt) was selected as the optimum level of WGP fortification in yogurt and the same concentration was then applied to select the level of LE-Y and FDE-Y to be added in yogurt. Staffolo and others (2004) reported that no syneresis was occurred when yogurt was fortified with 1.3% of wheat, bamboo, inulin and apple fiber during 21 days of storage.

Adding WGP reduced viscosity of yogurt, in which 3% WP (w/w yogurt) sample had the lowest value of 533 cP, while it was 1267 cP in the control (Table 4). This result was probably because stirring high concentration of WP in yogurt broke down the coagulated milk, thus reduced the viscosity. Viscosity of FDE-Y and WP fortified yogurt samples all increased during 3 weeks of storage, in which FDE-Y samples increased from 1533 cP to 3407 cP, and 1% WP, 2%WP and 3% WP (w/w yogurt) samples increased 252, 351 and 428%, respectively, higher than those of control, LE-Y and FDE-Y samples, probably contributed by the insoluble dietary fiber fraction in WP. Ramaswamy and Basak (1992) stated that the addition of WGP or fruit concentrate generally decreased the consistency of the products owning to reduced water-binding capacity of proteins. During the storage time, the increased viscosity could be regarded as recovery of structure or rebodying (Lee & Lucey, 2010). In addition, dietary fiber in WGP may influence the viscosity of the products. Grigelmo-Miguel, Ibarz-Ribas & Martin-Belloso (1999) reported increased viscosity along with the increasing of fiber concentration in yogurt.

WP fortified yogurt obtained relatively higher lactic acid percentage of 0.76 to 0.79% initially, while LE-Y and FDE-Y fortified ones had the lowest value of 0.67 and 0.65%, respectively (Table 4). It was probably because WP contained some lactic acid generated during the winemaking process, but this organic acid was washed away during extraction in LE and FDE. Overall, lactic acid percentage of WP fortified yogurt increased during 3 weeks of storage except in control, 1% WP, 2% WP and 3% WP (w/w yogurt) samples. At the end of 4 weeks of storage, control sample showed the lowest lactic acid percentage of 0.76 %, while there was no difference ($P>0.05$) among WGP fortified ones, ranging from 0.79% to 0.89%.

3.5 Peroxide value of WGP fortified yogurt and salad dressings

As shown in Figure 2, peroxide value (PV) increased along with storage time, and the control had significantly ($P<0.05$) higher values than those of WGP fortified ones. Control and 1% WP (w/w yogurt) samples started to oxidize within 7 days, while PV in 3% WP (w/w yogurt) was not detectable until almost 14 days. At the end of 3 weeks of storage, 3% WP (w/w yogurt) had the lowest PV of 1.81 meq/kg yogurt, while PV for other WGP fortified yogurt samples was in the range of 2.04 to 2.15 meq/kg yogurt, and PV of control was the highest, 7.08 meq/kg yogurt. These results indicated that the amount of WGP played more significant role on PV than that of the form of WGP.

PV of the commercial Italian and Thousand Island dressings (control) at the point of purchase were 3.45 and 7.21 meq/kg, respectively. PV of WGP fortified Italian dressing remained stable during 4 weeks of storage, except a slightly increase in 0.5% WP (w/w Italian).

At the end of 4 weeks of storage, PV of control was 14.47 meq/kg Italian, while that of 1% WP (w/w Italian), LE-I and FDE-I samples were 2.48, 4.03 and 4.13 meq/kg Italian, respectively, no difference among WGP fortified samples ($P>0.05$). In respect to the Thousand Island samples, PV of control at 4 weeks was 26.62 meq/kg Thousand Island, while that of 2% WP (w/w Thousand Island), LE-T and FDE-T samples were 16.69, 16.93 and 17.36 meq/kg Thousand Island, respectively, again no difference among WGP fortified samples ($P>0.05$). Ifesan et al. (2009) investigated salad dressing fortified with herb *Eleutherine americana* crude extract, and obtained lower thiobarbituric acid reactive substance (TBARS) value and retarded malonaldehyde formation due to the redox properties of antioxidant activity from the extract.

Lipid oxidation is one of the major concerns in food quality deterioration. The oxidative process may be catalyzed by light, heat, enzymes, metals, metalloproteins and microorganisms that lead the development of off-flavor. The formation of hydroperoxides (ROOH) may break down to a variety of nonvolatile and volatile secondary products. PV, represented as the total hydroperoxide content, is an indicator of the initial stages of oxidation and predicts rancidity of a product (Shahidi et al., 2005). No off-odor was detected subjectively in all WGP fortified products during the whole storage based on authors' observation. The phenolic hydroxyl groups in WGP could reduce the PV value and delay lipid oxidation by donating hydrogen atom to scavenge free radicals, such as hydroxyl, peroxyl, superoxide and nitric oxide, and form the stable end product in order to interfering the initiation or propagation for further lipid oxidation (Sánchez-Alonso et al., 2007).

WGP extract has been evaluated as safe and natural antioxidant fortified in various food products to inhibit the formation of toxic oxidation products, prevent rancidity in lipid systems and prolong the shelf-life. For examples, WGP extract showed high antioxidant effect in sunflower oil against the formation of secondary oxidation products and stronger antioxidant effect than that of tocopherols in soybean oil (Gamez-Meza et al., 2009); WGP fortified corn chips received lower peroxide value during storage (Rababah et al., 2011); flavanol oligomers from WGP were the most potent oxidation inhibitors for emulsions and frozen fish muscle (Medina, Pazos, Gallardo & Torres, 2005); and lipid stability in WGP added raw and cooked chicken was significantly increased (Sáyago-Ayerdi, Brenes & Goñi, 2009).

3.6 Dietary fiber fractions of WGP and WGP fortified yogurt and salad dressings

In WGP, IDF fraction took part of about 97-98% of TDF, while SDF fraction was only about 2% of TDF (Table 2). Those value were comparable with previous study (Llobera et al., 2007). The ratio of insoluble to soluble fraction, associated with the physiological effect, varied from 1.0 to 1.7 for fresh grape, whereas that of WGP was significantly higher, from 4.0 to 22.5 (González-Centeno, Rosselló, Simal, Garau, López & Femenia, 2010). In WGP fortified products, 3% WP (w/w yogurt) sample had the highest TDF of 3.2%, followed by 2% WP (w/w yogurt) one with about 1.9%. IDF contributed to the most of the fibers, in which 2% WP and 3% WP (w/w yogurt) samples had significantly ($P<0.05$) higher IDF, 3.1% and 1.9%, respectively. There was no significant difference ($P>0.05$) in SDF among all the samples, ranging from 0.04 to 0.07%. Although the 5% fiber-added commercial yogurt had 7.15% TDF, its TPC (855 mg GAE/kg, data not shown) was significantly less than that of 2% WP, 3% WP (w/w yogurt), LE-Y and FDE-Y fortified product. Also, no RSA was detected in commercial product (data not shown), indicated that WGP fortified yogurt had better antioxidant property.

For WGP fortified salad dressings, the highest TDF were detected in 0.5% WP (w/w Italian) and 1% WP (w/w Thousand Island) samples, 2.1% and 1.8%, respectively; whereas the least

TDF were in FDE fortified samples, 0.8% and 1.0%, respectively. The higher TDF in WP added Italian sample was due to the sedimentary ingredients in the Italian salad dressing base calculated as klason lignin in IDF. Overall, WGP contributed significantly to the dietary fiber content in fortified products, especially the samples fortified with WP.

Dietary fibers from fruit and vegetable byproduct may be developed as food ingredients to offer the physiological functionalities on solubility, viscosity, hydration property, oil-binding capacity and antioxidant activity on food products (Elleuch, Bedigian, Roiseux, Besbes, Blecker & Attia, 2011). Staffolo and others (2004) used apple wheat, bamboo and inulin as source of dietary fiber for improving rheological properties of yogurt. Sendra and others (2010) fortified yogurt with orange byproduct and showed increased viscosity and improved water absorption. Soukoulis and others (2009) reported that dietary fibers from oat, wheat, apple and inulin are able to control the crystallization and recrystallization in frozen dairy products by elevating the glass transition temperature.

3.7 Total phenolic content (TPC) of WGP fortified yogurt and salad dressings

TPC of WGP fortified products increased along with increased WP concentration in the product, 732, 985 and 1338 mg GAE/kg yogurt for 1% WP, 2% WP and 3% WP (w/w yogurt), respectively. TPC in LE-Y and FDE-Y samples were higher than that in 2% WP (w/w yogurt), probably because the bioactive compounds in LE and FDE forms were easier to be extracted. Except 1% WP (w/w yogurt) sample, TPC content generally dropped during storage, with reduction rate of 39, 45 and 40% for 2% WP (w/w yogurt), LE-Y and FDE-Y samples, respectively. Similar trend was found by Karaaslan, Ozden, Vardin and Turkoglu (2011) that TPC in 10% Merlot grape extract fortified yogurt was 78 mg GAE/kg on the first day of storage, but decreased remarkably after 14 days of storage. Wallace and Giusti (2008) also reported that TPC degrades rapidly during the first week of storage, but is relatively stable after 2 weeks in yogurt fortified with berry and purple carrot extracts.

In WGP fortified Italian salad dressing, there was no difference (P>0.05) in TPC initially, ranged from 473 to 585 mg GAE/kg Italian salad dressing. Overall, TPC of all Italian dressing samples decreased during storage. After 4 weeks of storage, there was no significant (P>0.05) difference among 1% WP (w/w Italian), LE-I and FDE-I samples, in which FDE-I sample had the best retention with reduction rate of 16%. For Thousand Island samples, 2% WP (w/w Thousand Island) one had the highest TPC of 1339 mg GAE/kg dressing, and no significant decrease (P>0.05) in TPC during 4 weeks of storage time.

Oxygen, pH, temperature, light, metal ions, enzymes and moisture content are the main factors influencing the retention of polyphenols (Mazza, 1995). Compared to the WGP fortified yogurt with pH of 4.4-4.6, salad dressing products with pH of 3.4-3.6 tended to have less reduction in TPC during storage, probably because the polyphenols were more stable under acidic condition. Friedman and Jürgens (2000) studied the effect of pH on the stability of phenolic compounds, and found that the susceptibility was different depending on the structure of the phenol, in which gallic acid and catechin, the major bioactive compounds in WGP, were unstable under high pH environment and irreversible during food process (Friedman et al., 2000). Gauche, Malagoli and Bordignon Luiz (2010) also indicated that pH 3.3 was the optimum for anthocyanin, the main bioactive compounds in WGP skin.

In addition to the antioxidant activity, WGP has also shown good antimicrobial properties. The hydroxyl group in TPC could interact with the membrane protein of bacteria by hydrogen bonding and cause the changes in membrane permeability and cell destruction (Boulekbache-

Makhlouf, Slimani & Madani, 2013; Puupponen-Pimiä et al., 2001). Özkan,Sagdiç, Göktürk Baydar and Kurumahmutoglu (2004) indicated that WGP could inhibit several spoilage and pathogenic bacteria and more effective against Gram-positive bacteria. In addition, resveratrol from grape pomace extract played an important role to prevent the fungal foodborne contamination in apple or orange juices (Sagdic, Ozturk, Ozkan, Yetim, Ekici & Yilmaz, 2011a).

3.8 Radical scavenging activity of WGP fortified yogurt and salad dressings

As expected, 3% WP (w/w yogurt) sample received the highest RSA of 936 mg AAE/kg yogurt initially, followed by 2% WP (w/w yogurt), LE-Y and FED-Y samples with RSA value of 603, 487 and 442 mg AAE/kg yogurt, respectively (Figure 4). RSA of 3% WP (w/w yogurt) significantly ($P<0.05$) dropped during storage, and was 645 mg AAE/kg yogurt at week 4, while the reduction rate was about 29, 52, 30 and 17% for 2% WP, 3% WP, LE-Y and FDE-Y samples, respectively. Karaaslan et al. (2011) stated that RSA declined 1.16 to 3.78 times in yogurt fortified with10% red grape extract after 14 days of storage.

In respect to salad dressings, RSA of WP fortified samples were significantly higher than those fortified with LE and FDE under same concentration, initially and during 4 weeks of storage (Figure 4). Initial RSA were 585 and 710 mg AAE/kg dressing for 1% WP (w/w Italian) and 2% WP (w/w Thousand Island), respectively. RSA dropped during storage with reduction rate of 30% and 18% for 1% WP (w/w Italian) and 2% WP (w/w Thousand Island) samples, respectively at the end of 4 weeks.

Oxygen accelerated the oxidation, leading the decline of RSA and increase of PV during storage. With the less RSA to remove the reactive oxygen species (ROS), those free radicals could initiate the lipid oxidation, thus increased PV. Hence, PV could serve as an indicator of the initial stage of oxidation and predict rancidity (Shahidi et al., 2005). TPC presents broader range of substrates on both free and bound phenolics in the products, while RSA provides more direct information on how capable to prevent ROS from attacking lipoproteins, polyunsaturated fatty acids, DNA, amino acids and sugars in biological and food systems (Sagdic, Ozturk, Ozkan, Yetim, Ekici & Yilmaz, 2011b).

Another reason of the RSA drop in WGP fortified yogurt after first week of storage might be due to the protein-polyphenol interaction. The covalent binding between proteins and phenolic compounds released the free phenolic hydroxyl groups, which can act as antioxidants (Viljanen, Kylli, Kivikari & Heinonen, 2004). However, antioxidant activity from phenolic compounds can be masked by interactions with proteins (Heinonen, Rein, Satué-Gracia, Huang, German & Frankel, 1998). Arts et al. (2002) indicated that the masking depends on both type and amount of protein and bioactive compound, and the highest masking was observed in the combination of casein in milk with gallic acid in tea. In WGP fortified yogurt, casein in yogurt and gallic acid as a major phenolic compound in WGP acted masking effect, which might explain the significant TPC and RSA reduction in WGP fortified yogurt at the first week of storage.

3.9 Consumer acceptance of WGP fortified yogurt and salad dressings

In WGP fortified yogurt, appearance liking and overall liking among the control, 1% WP and 2% WP (w/w yogurt) samples were not scored differently (P>0.05) by the panelists (Table 5). However, 2% WP (w/w yogurt) sample received lower score on flavor and texture liking. Although equal numbers of panelists gave liking and disliking scores on the flavor of WGP fortified yogurt, more panelists ranked “like very much” on the flavor of 1% WP (w/w yogurt) than that of 2% WP (w/w yogurt) (data now shown). Also, 8 out of 12 panelists liked the texture of 1% WP (w/w yogurt), but only 3 out of 12 panelists liked the texture of 2% WP (w/w yogurt) (data not shown). The consistency scores showed that 1% WP (w/w yogurt) sample was the closest to “just about right”, neither too thick nor too thin. Some panelists indicated their appreciation on the nutritional value and fruity taste of WGP fortified yogurt, but others stated their disliking on the chalky and medical aftertaste which might come from the astringency of tannin in WGP.

In WGP fortified Italian dressing, overall, there was no difference (P>0.05) on all measured sensory attributes among control, 0.5% WP and 1% WP (w/w Italian) samples. In 0.5% WP (w/w Italian), 5, 5, 6 and 6 out of 12 panelists ranked “like very much” on the appearance, overall, flavor and texture liking, respectively (data not shown). The consistency of 0.5% WP (w/w Italian) sample was also scored “just about right”. Most panelists commented that they like the healthy, less oily and taste of WGP fortified Italian dressing, but a few panelists pointed that the fortified one is too sour.

In respective to WGP fortified Thousand Island dressing, there was no significant difference (P>0.05) on appearance, overall and flavor liking among control, 1% WP and 2% WP (w/w Thousand Island) samples. Over10 panelists ranked liking on 1% WP (w/w Thousand Island) sample on appearance, overall, flavor and texture, while over 7 panelists ranked liking on 2% WP (w/w Thousand Island) (data not shown). The 2% WP (w/w Thousand Island) sample was thicker in the texture, which might make some panelists disliking the product. In summary, WGP fortified yogurt and salad dressing were well accepted by consumer, but the amount of WP that may be added into the products was less based on consumer sensory study than that from the analytical results.

4. Conclusion

This study demonstrated that Pinot Noir wine grape pomace may be utilized as an alternative source of antioxidant dietary fiber to fortify yogurt and salad dressing for not only increasing dietary fiber and total phenolic content, but also delaying lipid oxidation of samples during refrigeration storage. Although products fortified with the pomace extracts (liquid and freeze dried) obtained the most similar physicochemical properties to the control (no pomace added), those fortified with dried whole pomace powders (WP) had higher dietary fiber content. Unfortunately, total phenolic content (TPC) and DPPH radical scavenging activity (RSA) of fortified samples decreased during storage, in which more reduction was observed in yogurt than that in salad dressings, probably due to the interactions between proteins in yogurt and phenolic compounds in pomace. Therefore, it is necessary to further investigate the mechanisms and methods of retention of TPC and RSA in the products in the future studies by using chromatographic techniques to profile the change of pheonolic compounds. Based on the balance in DF and TPC contents, RSA value, physicochemical qualities and consumer acceptance, the best received products were 1% (w/w) WP fortified yogurt, 0.5% (w/w) WP fortified Italian dressing, and 1% (w/w) WP fortified Thousand Island dressing.

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Table 1

Chemical composition, total phenolic content and DPPH radical scavenging activity of wine grape pomace (WGP)

	% Composition (DM) *
Moisture Content	5.63 ± 0.10
Ash	5.07 ± 0.05
Protein	10.32 ± 0.22
Lipid	11.09 ± 0.33
Soluble Sugar	3.89 ± 0.3
Pectin	3.68 ± 0.05
Condensed Tannin	12.11 ± 1.17
Dietary Fiber	61.32 ± 1.69
Total Phenolic Compound (mg GAE/g)	67.74 ± 6.91
Radical Scavenge Activity (mg AAE/g)	37.46 ± 1.86
Radical Scavenge Activity (mg TE/g)	91.78 ± 4.58

* DM = dry matter. The table was modified from the Tseng & Zhao (2012).

Table 2
Dietary fiber fractions of wine grape pomace (WGP) and WGP fortified yogurt and salad dressings *

		IDF	SDF	TDF
WGP		59.88 ± 1.64	1.44 ± 0.05	61.32 ± 1.69
WGP fortified Yogurt	1% WP	0.89 ± 0.00 c	0.04 ± 0.00 a	0.94 ± 0.01 c
	2% WP	1.92 ± 0.00 b	0.06 ± 0.00 a	1.98 ± 0.01 b
	3% WP	3.08 ± 0.01 a	0.07 ± 0.00 a	3.16 ± 0.01 a
	LE-Y	0.29 ± 0.00 c	0.05 ± 0.00 a	0.34 ± 0.00 c
	FDE-Y	0.74 ± 0.00 c	0.06 ± 0.00 a	0.80 ± 0.00 c
Commercial yogurt**		6.30 ± 1.18 a	0.86 ± 1.02 a	7.16 ± 2.20 a
WGP fortified Italian	0.5% WP	1.64 ± 0.02 b	0.09 ± 0.01 b	1.73 ± 0.02 b
	1% WP	2.00 ± 0.03 a	0.12 ± 0.01 a	2.12 ± 0.04 a
	LE-I	1.63 ± 0.04 b	0.06 ± 0.00 c	1.69 ± 0.04 b
	FDE-I	0.76 ± 0.01 c	0.05 ± 0.00 c	0.81 ± 0.02 c
WGP fortified Thousand Island	1% WP	1.50 ± 0.00 b	0.17 ± 0.02 b	1.66 ± 0.02 b
	2% WP	1.62 ± 0.01 a	0.21 ± 0.01 a	1.83 ± 0.02 a
	LE-T	1.32 ± 0.06 c	0.08 ± 0.00 d	1.40 ± 0.06 c
	FDE-T	0.88 ± 0.09 d	0.13 ± 0.00 c	1.02 ± 0.09 d

* Means followed by the same lowercase letters (a–d) in the same column within each concentration were not significantly different ($P > 0.05$). Control= no pomace added, WP= whole pomace powder, LE= pomace liquid extract, and FDE= freeze dried pomace extract.
** The commercial FiberOne yogurt contained 5% dietary fiber from blueberries (YoPlait, USA).

Table 3
Color of wine grape pomace (WGP) and WGP fortified yogurt and salad dressing *

		Lightness	Hue	Chroma
WGP		43.32 ± 0.35	0.73 ± 0.00	15.25 ± 0.23
WGP fortified Yogurt	Control	92.18 ± 0.61 a	-1.26 ± 0.01c	8.11 ± 0.69 b
	1 % WP	79.53 ± 9.89 b	0.93 ± 0.07 a	6.37 ± 0.48 c
	2 % WP	61.68 ± 0.94 c	0.84 ± 0.04 b	9.99 ± 1.18 a
	3 % WP	58.17 ± 1.35 c	0.80 ± 0.05 b	10.46 ± 1.77 a
	LE-Y	83.47 ± 0.25 b	0.96 ± 0.03 a	6.23 ± 0.13 c
	FDE-Y	81.96 ± 0.20 b	0.93 ± 0.02 a	6.86 ± 0.14 bc
WGP fortified House Italian	Control	43.59 ± 0.20 a	1.14 ± 0.01 a	29.96 ± 0.33 a
	0.5 % WP	39.76 ± 0.28 c	1.06 ± 0.05 bc	24.04 ± 2.13 c
	1 % WP	36.96 ± 0.17 d	1.02 ± 0.01 b	21.79 ± 0.35 d
	LE-I	43.39 ± 0.45 a	1.09 ± 0.00 c	26.60 ± 0.16 b
	FDE-I	41.49 ± 0.14 b	1.09 ± 0.01 b	27.43 ± 0.23 b
WGP fortified Thousand Island	Control	72.25 ± 0.17 a	1.10 ± 0.00 a	39.47 ± 0.23 a
	1 % WP	68.04 ± 0.07 c	1.10 ± 0.01 a	34.21 ± 0.43 d
	2 % WP	60.33 ± 0.47 d	1.11 ± 0.02 a	28.16 ± 0.05 e
	LE-T	70.65 ± 0.38 b	1.09 ± 0.02 a	35.40 ± 0.41 c
	FDE-T	71.99 ± 1.16 a	1.10 ± 0.02 a	36.36 ± 0.49 b

* Means followed by the lowercase letters (a - d) in the same column within each concentration of WGP fortified product were not significantly different ($P > 0.05$). Control= no pomace added, WP= whole pomace powder, LE= liquid pomace extract, and FDE= freeze dried pomace extract.

Table 4

Syneresis, viscosity, and lactic acid percentage of wine grape pomace (WGP) fortified yogurt during 3 weeks of storage at 4 °C *

Parameter	Treatment	0 day	7 day	14 day	21 day
Syneresis	Control	A 18.59 ± 2.17 a	BC 25.16 ± 3.85 a	A 25.05 ± 6.56 a	A 19.60 ± 5.81a
	1 % WP	A 17.25 ± 3.67 a	AB 20.10 ± 0.74 a	A 21.21 ± 4.87 a	A 20.49 ± 0.60 a
	2 % WP	A 19.67 ± 3.10 a	BC 23.85 ± 6.00 a	A 22.13 ± 4.12 a	AB 25.49 ± 8.65 a
	3 % WP	A 18.70 ± 3.07 a	C 27.57 ± 5.26 ab	A 27.21 ± 2.87ab	B 33.58 ± 12.99 b
	LE	A 20.13 ± 2.39 a	A 18.47 ± 2.49 a	A 27.08 ± 1.44 a	A 20.94 ± 1.38 a
	FDE	A 16.82 ± 5.57 ab	AB 16.18 ± 3.40 ab	A 23.53 ± 2.39 b	A 15.70 ± 4.14 a
Viscosity	Control	B 1266.67 ± 41.63 c	B 2380.00 ± 346.99 b	AB 2770.00± 710.84 ab	AB 3246.67 ± 141.89 a
	1 % WP	C 613.33 ± 41.63 b	BC 2213.33 ± 162.89 a	B 1860.00 ± 650.23 a	C 2160.00 ± 713.58 a
	2 % WP	C 580.00 ± 72.11 c	C 1874.50 ± 128.34 b	AB 2013.33 ± 498.93 b	BC 2620.00 ± 321.87 a
	3 % WP	C 553.33 ± 23.09 c	C 1940.00 ± 419.05 b	B 1936.67 ± 539.48 b	AB 2924.67 ± 348.35 a
	LE	B 1320.00 ± 72.11 c	AB 2600.00 ± 69.28 ab	AB 2183.33 ± 195.02 b	AB 2913.33 ± 438.79 a
	FDE	A 1533.33 ± 23.09 b	A 2861.67 ± 150.53 a	A 2983.33 ± 739.21 a	A 3406.67 ± 306.16 a
Lactic Acid Percentage	Control	AB 0.73 ± 0.01 a	AB 0.73 ± 0.10 a	BC 0.74 ± 0.05 a	B 0.76± 0.04 a
	1 % WP	A 0.76 ± 0.05 a	AB 0.77 ± 0.04 a	A 0.83 ± 0.07 a	A 0.87 ± 0.07 a
	2 % WP	A 0.79 ± 0.05 a	A 0.82 ± 0.01 a	AB 0.82 ± 0.04 a	A 0.88 ± 0.10 a
	3 % WP	A 0.77 ± 0.07 a	AB 0.78 ± 0.11 a	A 0.85 ± 0.03 a	A 0.89 ± 0.01 a
	LE	B 0.67 ± 0.02 c	B 0.66 ± 0.01 c	C 0.73 ± 0.03 b	AB 0.79 ± 0.03 a
	FDE	B 0.65 ± 0.02 b	AB 0.79 ± 0.04 a	ABC 0.78 ± 0.03 a	AB 0.82 ± 0.02 a

* Means followed by same capital letters (A – D) in same column within each concentration were not significantly different ($P > 0.05$).

Means followed by same lowercase letters (a – d) in same row within each storage day were not significantly different ($P > 0.05$).
Control= no pomace added, WP= whole pomace powder, LE= liquid pomace extract, and FDE= freeze dried pomace extract.

Table 5
Consumer acceptance of wine grape pomace (WGP) fortified yogurt and salad dressings *

		Appearance liking	Overall liking	Flavor linking	Texture linking	Consistency
WGP Fortified Yogurt	Control	6.58 ± 2.02 a	5.83 ± 2.29 a	6.25 ± 1.76 a	6.50 ± 1.68 a	2.50 ± 0.80 b
	1% WP	5.50 ± 2.07 a	4.83 ± 2.52 a	4.92 ± 1.98 b	5.83 ± 1.19 a	2.83 ± 0.58 a
	2% WP	5.83 ± 1.70 a	4.83 ± 1.95 a	4.75 ± 2.09 b	4.75 ± 1.54 b	2.75 ± 0.62 ab
WGP Fortified Italian	Control	5.83 ± 1.90 a	6.67 ± 1.15 a	6.75 ± 0.87 a	6.25 ± 0.97 a	2.58 ± 0.67 a
	0.5% WP	6.92 ± 1.24 a	7.08 ± 1.00 a	7.00 ± 1.28 a	6.83 ± 1.59 a	2.92 ± 0.90 a
	1% WP	6.50 ± 1.09 a	6.58 ± 0.90 a	6.42 ± 1.44 a	6.50 ± 1.38 a	2.83 ± 0.58 a
WGP Fortified Thousand Island	Control	6.85 ± 1.21 a	7.00 ± 1.22 a	6.69 ± 1.70 a	7.23 ± 1.30 a	3.31 ± 0.48 b
	1% WP	7.00 ± 0.82 a	6.62 ± 1.45 a	7.00 ± 1.29 a	6.85 ± 1.14 ab	3.46 ± 0.52 ab
	2% WP	6.08 ± 1.85 a	6.38 ± 1.80 a	6.46 ± 1.33 a	6.15 ± 1.34 b	3.92 ± 0.76 a

* Scale from 9 to 1. For liking attributes, 9 = like extremely and 1= dislike extremely; for consistency, 5=too thick, 1=too thin, and 3= just about right. Results are the mean of 12 replicates ± SD. Means followed by the same lowercase letters (a–d) in the same column within each concentration were not significantly different (P>0.05). Control= no pomace added and WP= dried whole pomace powder.

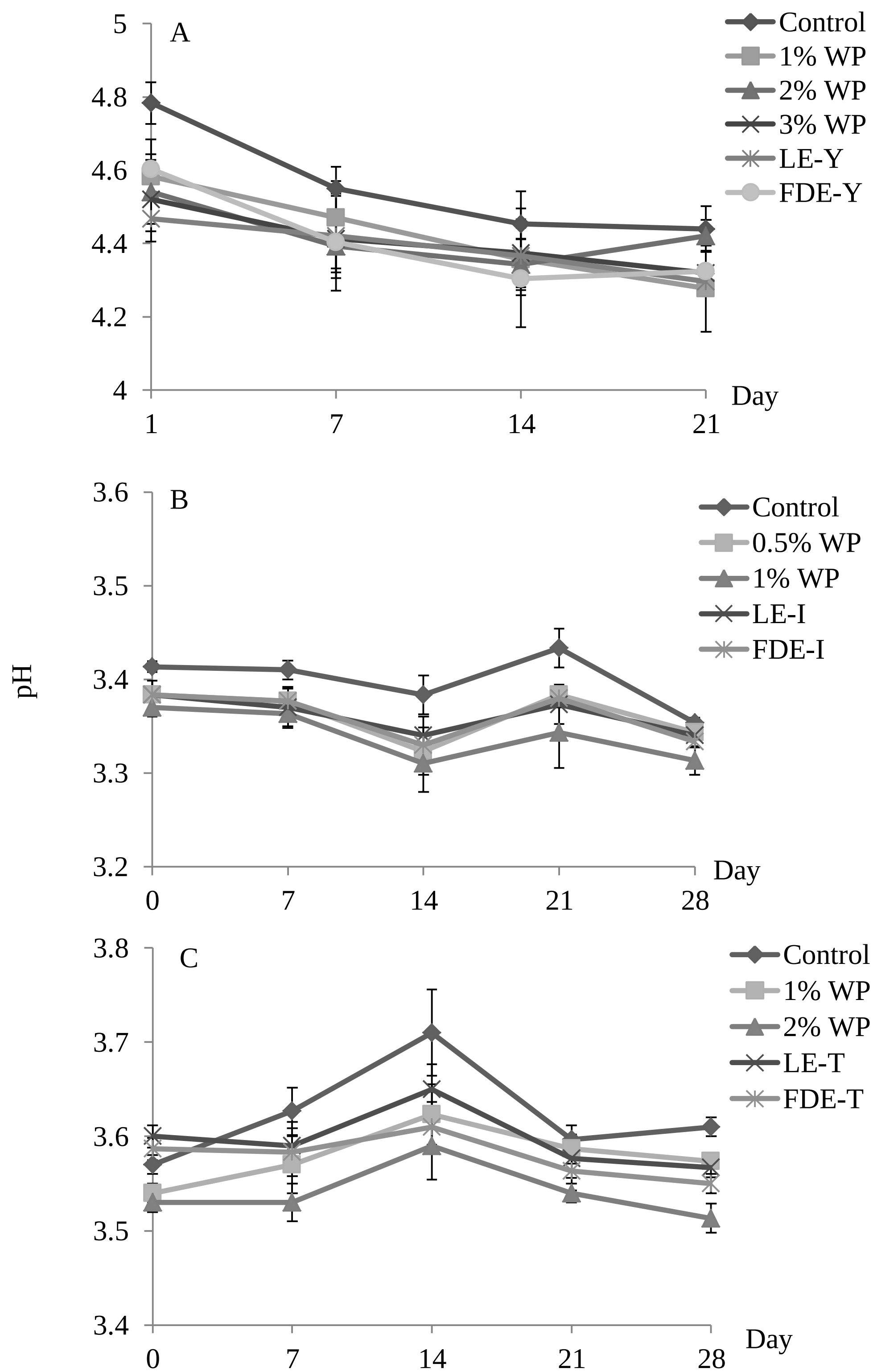

Fig. 1. pH value of samples during storage at 4 °C. (A) WGP fortified yogurt, (B) WGP fortified Italian salad dressing, and (C) WGP fortified Thousand Island salad dressing.

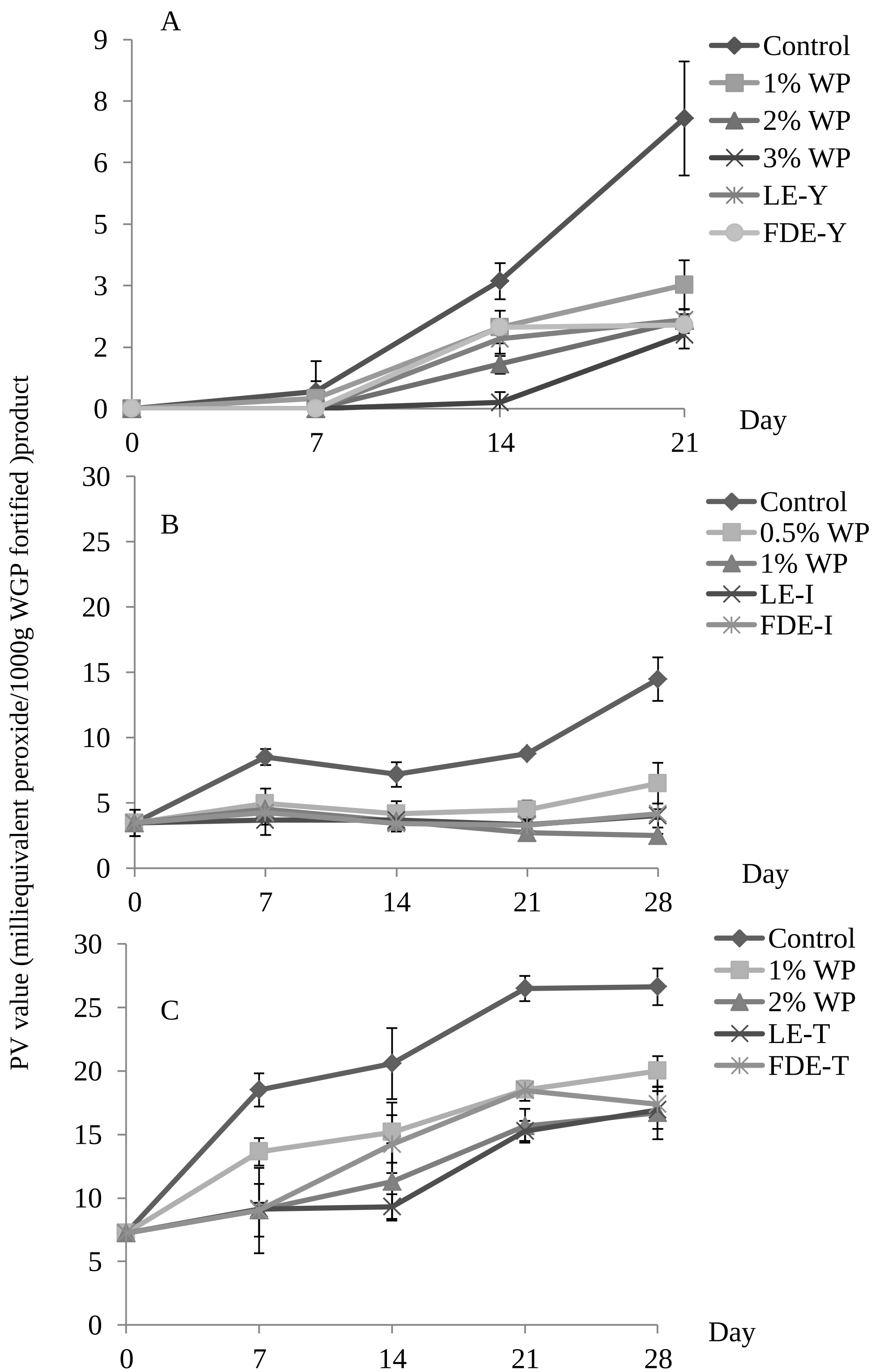

Fig. 2. Peroxide value of samples during storage at 4°C. (A) WGP fortified yogurt, (B) WGP fortified Italian salad dressing, and (C) WGP fortified Thousand Island salad dressing.

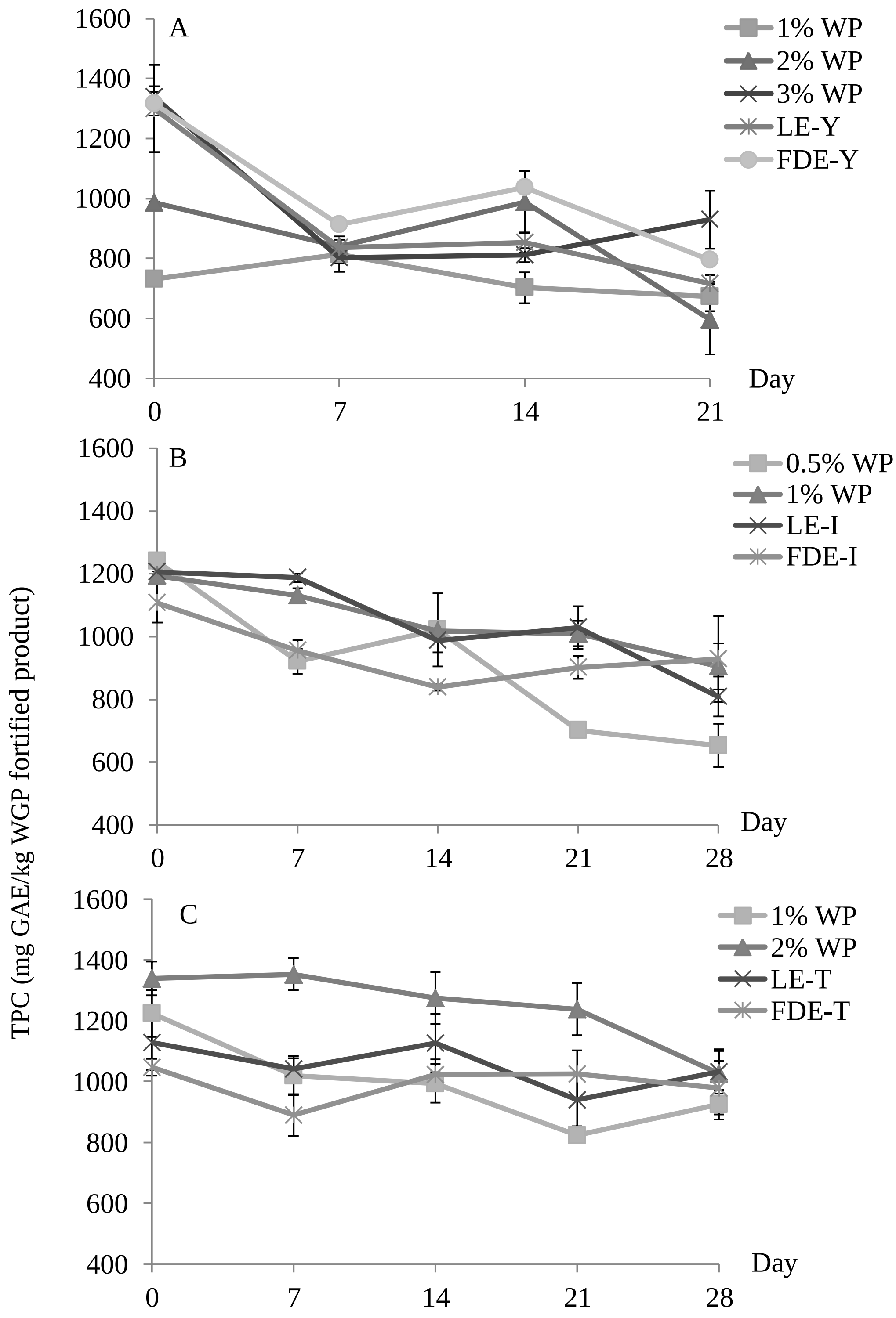

Fig. 3. Total phenolic content of samples during storage at 4°C. (A) WGP fortified yogurt, (B) WGP fortified Italian salad dressing, and (C) WGP fortified Thousand Island salad dressing.

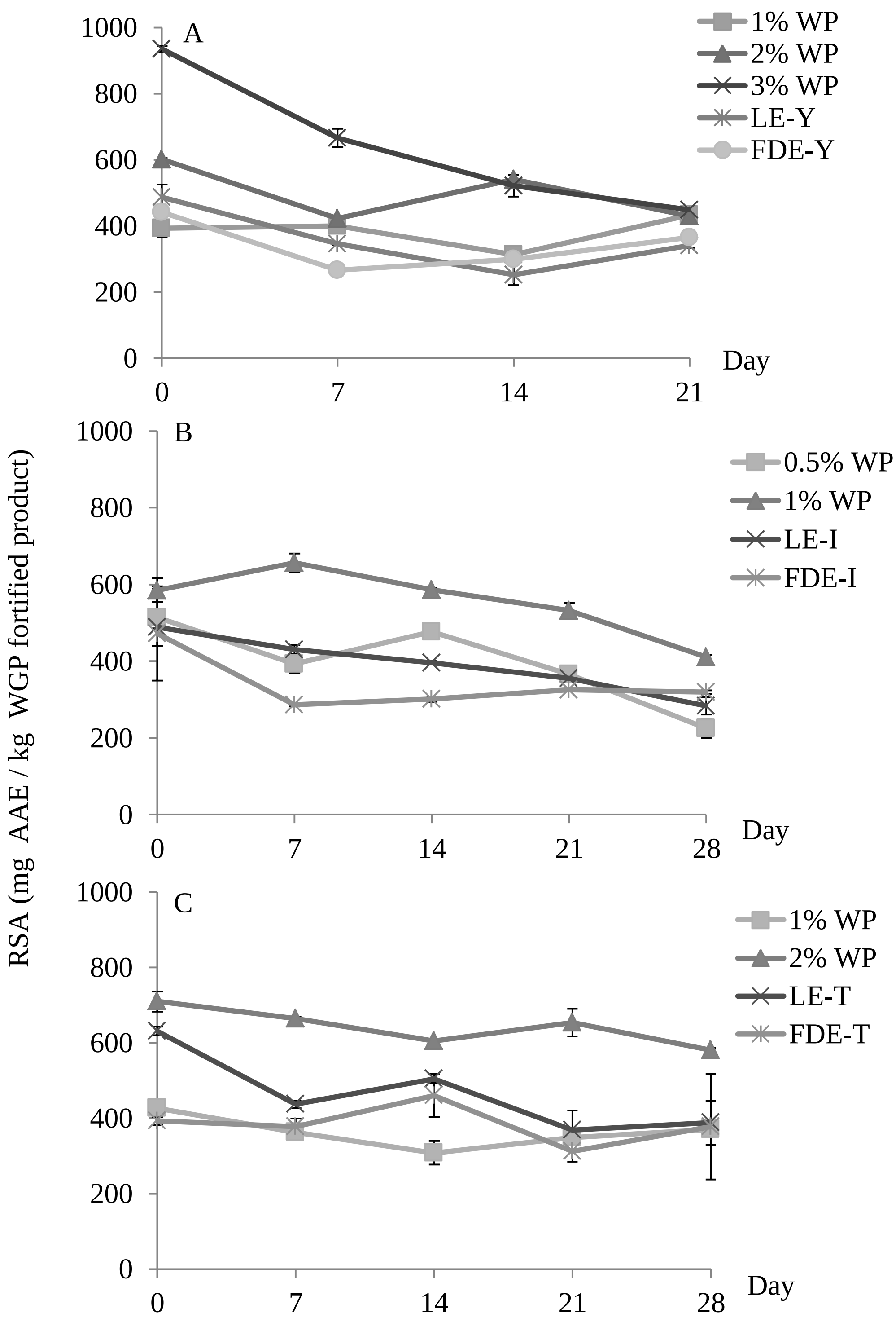

Fig. 4. DPPH radical scavenging activity of samples during storage at 4 °C. (A) WGP fortified yogurt, (B) WGP fortified Italian salad dressing, and (C) WGP fortified Thousand Island salad dressing.