The Annals of the University Dunarea de Jos of Galati
Fascicle VI – Food Technology (2017), 41(2), 127-140

ORIGINAL RESEARCH PAPER

THE USE OF SEEDLESS GRAPE VARIETIES FOR DEVELOPING DAIRY-FREE CREAMS

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Received on 29th March 2017
Revised on 16th October 2017

The demand for use of natural fruit-based raw material for the manufacture of non-dairy desserts has significantly grown over the past decennium due to the increased number of people suffering from lactose intolerance, allergy to milk proteins and obesity. This study investigated the main physicochemical and rheological properties of non-dairy creams prepared from white and black seedless grape varieties, sunflower oil and stabilizers (inulin and xanthan gum) without added sugar. Generally, all cream samples showed a slight decrease in total polyphenols and antioxidant activity after processing, as compared to the reference raw material (fresh grapes). The Bingham, Casson and Herschel-Bulkley rheological models were used to predict the flow behavior of the developed creams. From the performance data analysis, it was found that only the Herschel-Bulkley model has been adequately fitted to the shear stress-shear rate data of all cream samples, resulting in the lower mean absolute error (MAE) and the strong correlations ($R > 0.8$) with a significant evidence ($p < 0.05$). The study also revealed that creams prepared with higher percentage of fruit part (grape puree >80%) and lower oil content (<15%) recorded higher yield stress values (>100 Pa) and were more viscous than the rest of the samples.

Keywords: cream, emulsion, viscosity, grape varieties, inulin

Introduction

Nowadays, consumer demand for non-dairy desserts without added sugar and with reduced fat content is growing at a much faster rate than ever before, due to the increased number of people suffering from lactose intolerance, allergy to milk proteins, high cholesterol, obesity, metabolic syndrome and non-communicable diseases (WHO, 2014). A continuously growing health awareness and consumer demands towards foods for special groups have motivated the food industry to produce low-calorie, low-fat and reduced-sugar products, including different desserts with creamy texture (Sandrou and Arvanitoyannis, 2000). Moreover, the consumption of low-sugar and fat products is recommended for weight reduction, diabetes and prevention of dental cavities (Iop et al., 1999). Therefore, the development of non-dairy desserts with reduced sugar and fat content has become of particular interest for food manufacturers in the present time. A number of studies were carried out to find a proper alternative for principal raw material in non-dairy desserts, beverages and foods, including the utilization of nuts, cereals and oilseeds (Blandino et al., 2003; Angelov et al., 2006; Isanga ans Zhang, 2009; Alija and Talents, 2012; Bansal et al., 2015). However, these investigations practically didn't assume the use of natural fruits and berries, which can enrich the final product with polyphenols, vitamins, dietary fiber, organic acids, macro- and microelements, while providing health benefits to consumers (Fărcaş et al., 2012; Cropotova et al., 2015). In this regards, grape (Vitis spp.) represents one of the best raw materials for manufacturing fruit creams without added sugar. It is the second most widely cultivated fruit in the world after the orange (Azzouz et al., 2016), which is widely used for producing wine, juice, jelly and jam (Hasan et al., 2014). Generally, grapes are rich in simple sugars (mainly glucose and fructose) and thus may be used as principal raw material for adding sweetness to a wide variety of processed foods and beverages, including dessert creams (Fortes & Pais, 2016). The use of seedless varieties of table grapes is of special interest for food manufacturers, as their processing does not require any preliminary steps of seeds removal and is economically advantageous. Moreover, among all other fruits, grapes represent an abundant source of antioxidant phenolic compounds, particularly flavonoids, which possess a great capacity for capturing free radicals, causing ‘‘oxidative stress’’, and therefore may be used for preventing cardiovascular diseases and some types of cancer (Schramm et al., 1998; Ishige et al., 2001; Katsube et al., 2003).

The use of sunflower oil in non-dairy creams may be considered a healthy substitute for dairy fat due to its balanced ratio between saturated fatty acids (ca. 6%) and monounsaturated fatty acids (ca. 20%), as well as its high content of polyunsaturated fatty acids constituting 68–72% of the total fatty acids (Gordon, 1991). In this regard, sunflower oil represents one of the best alternatives of low-cost fat source with healthy benefits, because it is rich in antioxidants (mainly vitamin E) and essential fatty acids (mainly linoleic acid) that may significantly contribute to potential health benefits through their consumption (Gordon, 1991). Moreover, the simultaneous use of sunflower oil with natural grape-based raw material may bring additional nutritional benefits to dessert creams, since the lower molecular weight triacylglycerols in the oil are easily absorbed and rapidly metabolized by the organism in comparison with animal fats (Marten et al., 2006), while grape antioxidants such as polyphenols and vitamins reduce the oxidative degradation of the final product (Hamied et al., 2009). Thus, natural fruits may act in synergy with vegetable oils to create healthy non-dairy desserts with creamy texture, which are stable to oxidative degradation during storage.

These desserts belong to the category of oil-in-water emulsions, which represent complex systems built up generally of two immiscible liquid phases, where the oil phase is dispersed under the form of fine droplets into the aqueous one (Dickinson, 1992). Their compositions represent thermodynamically unstable systems, because the increased interfacial tension of the two phases (i.e. water and oil) tends to separate them. This process of emulsion destabilization cannot be entirely prevented and is only slowed down by the addition of different surfactants, such as hydrocolloids, gums, etc. (Dickinson, 1992; Walstra, 2003). The shear rate may promote the formation of the desired visco-elastic structure of oil-in-water emulsions by adding surfactants to the initial fluid emulsion and decreasing the elasticity of the interfacial film through intensive mixing (Vanapalli et al., 2002). In this context, it is supposed that xanthan gum as a good surfactant thickening agent could be combined with a dietary fiber possessing strong water-holding capacity to build up a desirable stabilizing complex for low-sugar cream formulations. Long-chain inulin is one of the best candidates for use as bulking agent along with xanthan gum in cream compositions with high fruit content to prevent syneresis. It is a plant-derived fermentable dietary fiber with prebiotic properties and low caloric value (1.5 kcal/g), which may significantly enhance calcium absorption and improve gut function in food formulations, while helping to prevent constipation and possible colon and rectal cancer (Roberfroid 2005; Aidoo, Afoakwa, & Dewettinck, 2014). In dessert creams prepared without added sugar inulin could also fulfill a structural function, by bounding free water and creating a body of the product.

Taking into account the beneficial properties of the aforementioned raw materials and ingredients, the main objectives of the present study were: (1) to investigate the possibility of replacing dairy fat in dessert formulations by a combination of sunflower oil, grapes and long-chain inulin in order to produce prebiotic non-dairy creams without added sugar; (2) to determine the main physicochemical and rheological characteristics of the dessert creams developed; and (3) to assess the effect of simultaneous lowering of fat and sugar contents in cream formulations.

Materials and methods

Raw material and ingredients

The following raw material and ingredients were used in the study for preparing non-dairy creams: white and black table seedless grape varieties “Aperen roz basarabean” and “Aperen negru de grozeşti” respectively, refined deodorized sunflower oil “Floris” (moisture and volatile compounds content 0.14%, JV “FLOAREA SOARELUI”, Republic of Moldova), long-chain inulin Orafti HP (moisture content 5.0%, BENEO, Belgium) and xanthan gum KELTROL (moisture content 10%, CP KELCO, U.S.).

Preparation of creams

Fresh fruits of white and black table seedless grape varieties “Aperen roz basarabean” and “Aperen negru de grozeşti” respectively (~1000 g each), were washed and removed by hand from their peduncles. Blanching treatment in boiling water was applied prior to preparation of grape creams in order to inactivate the enzymatic systems (polyphenoloxidase and peroxidase activities) responsible for quality deterioration in the product (Ioannou & Ghoul, 2013). Thus, grape fruits removed from peduncle were immersed into boiling water 100ºC for 5 minutes to prevent enzymatic browning and prepare them for further processing. After blanching, the cooked grapes were homogenized in a blender at a high speed (Bosch, type MSM6700GB, Germany, 600 W) for 5 minutes until a thick puree-like consistency was obtained. Half of the homogenized grape puree resulted from both white and black varieties, was kept as control for analyses. The other part of the puree was used as raw material for preparing grape creams.

Six cream formulations based on white grapes (three samples) and black grapes (three samples) were prepared using different amounts of sunflower oil, as presented in Table 1. The amount of long-chain chicory inulin and xanthan gum required to obtain cream formulations with thick creamy texture without tendency to syneresis was decided based on preliminary experiments. At the beginning of preparation, sunflower oil was mixed with grape puree and xanthan gum. Afterwards, inulin was introduced under continuous mixing into the resulted emulsion according to the product formulations displayed in Table 1, and the obtained mixture was homogenized under the intense blending at 900 rpm for 2 minutes at 20ºC with a benchtop homogenizer type MPW-302 (Mechanika Precyzyjna, Warsaw, Poland), until a stable creamy product was created. The resulted creams were further subjected to physicochemical and rheological assays to establish their quality characteristics.

Table 1. Compositions of grape creams

No. sample	Ingredients (% w/w)			
	grape puree	**sunflower oil**	**long-chain inulin**	**xanthan gum**
White grape variety "*Aperen roz basarabean*"				
1	72.0	25.0	2.0	1.0
2	80.0	14.0	5.2	0.8
3	90.0	6.0	3.5	0.5
Black grape variety "*Aperen negru de grozeşti*"				
4	80.0	18.0	1.0	1.0
5	72.0	25.0	2.5	0.5
6	90.0	6.0	3.0	1.0

Physicochemical analysis

Physicochemical analyses were carried out on both grape berries (taken as reference) and creams prepared from them. Moisture and fat contents were determined according to the Official Methods of Analysis of AOAC International (AOAC, 2000) as follows. Dry matter and moisture were measured by the loss of sample mass during its drying in a vacuum oven at 102±2 °C. The fat content in grape creams was analyzed according to AOAC method 995.19 (AOAC, 2000). The fat was separated by liquid-liquid extraction from the known weight of cream. The extracted fat was dried to a constant weight and its percentage was calculated according to the method description. pH was measured potentiometrically by using a benchtop pH meter. Titratable acidity of the analyzed products was determined by titration of samples with 0.1 N NaOH solution in the presence of 1% phenolphthalein as indicator. The total polyphenol content in grape varieties and resulted creams was studied spectrophotometrically by using the Folin-Ciocalteu reagent (Singleton et al., 1999). The reaction was based on the reduction of phosphomolybdic acid by phenols in aqueous alkali. The total polyphenol content was expressed in mg·kg^{-1} tannin equivalents (mgTAE·kg^{-1}). The antioxidant activity was determined by liquid chromatography method coupled with amperometric detection conducted on LC-apparatus "Tsvet Yauza-01-AA" according to Adzhiakhmetova et al (2013). The total amount of antioxidants in grape raw material and creams was measured by using a calibration curve according to an output signal coming from the concentration of quercetin taken as reference and expressed in mg·g^{-1} quercetin equivalents (mg QUE·g^{-1}), as described in previous studies (Cropotova et al., 2016). Before analyzing the prepared creams for the total polyphenol content and antioxidant activity, they were subjected to oil phase separation as follows. Around 5 g of cream sample were filled with 40 cm^3 of 70% ethanol solution, mixed thoroughly, shaken well in a flask and left in a dark place for 3 days. Then, the resulted mix was shaken up and filtered through a filter paper in a 100 ml volumetric flask. The collected filtrate was further used for the analyses. Mean values from 3 replicate measurements and standard deviations were calculated.

Rheological measurements

The rheological characteristics of grape creams were investigated on a rotational viscometer Rheotest RV-2 (VEB MLW Prüfgerätewerk Medingen, Dresden, Germany) equipped with a concentric cylinder system, which measures the torsion moment arisen due to the ring-shaped layer between fixed and inner cylinders rotating with a constant angular velocity (ISO 3219, 1993). Rheological measurements and calibration were performed according to the procedure described in the international standard ISO 3219 (1993). Around 25 g of a cream sample was weighed into the rotational cylinder of the viscometer and the apparent viscosity measurements were performed at room temperature (20°C). A special thermostatic bath monitored the working temperature of 20°C±1°C. The viscometer was calibrated prior to measurement. The shear stress was measured at ten shear rates of the rotations of 3.0 s^{-1}, 5.4 s^{-1}, 9.0 s^{-1}, 16.2 s^{-1}, 27.0 s^{-1}, 48.6 s^{-1}, 81.0 s^{-1}, 145.8 s^{-1}, 243.0 s^{-1} and 437.4 s^{-1}, where each shear rate was maintained for the duration of 1 minute to achieve near equilibrium state. Furthermore, the flow behavior of grape creams was analyzed in terms of rheograms describing the relationship between the apparent viscosity calculated at each point as the ratio of shear stress and shear rate ranging from 3.0 to 437.4 s^{-1}. Three replicates were made for each of the measurements and mean values with standard deviations were calculated.

To identify and characterize the rheological behavior of the tested creams, their flow data were fitted to the following models: the Bingham (eq. 1), the Casson (eq. 2) and the Herschel-Bulkley (eq. 3), mentioned in many research studies (Holdsworth, 1971; Carbonell et al., 1991; Álvarez et al., 2006):

$$\tau = \tau_0 + \mu \cdot \dot{\gamma} \quad (1)$$

$$\sqrt{\tau} = \sqrt{\tau_0} + \sqrt{\mu} + \sqrt{\dot{\gamma}} \quad (2)$$

$$\tau = \tau_0 + K \cdot \dot{\gamma}^{n} \quad (3)$$

where τ is the shear stress (Pa), $\dot{\gamma}$ is the shear rate (s^{-1}), τ_0 is the yield stress (Pa), μ is the apparent viscosity (Pa·s), K is the consistency index and n is the flow behavior index or rate index.

In order to estimate the accuracy and reliability of the fitting conducted for each of the creams analyzed, the performance of the statistical estimation in terms of mean absolute error (MAE), correlation coefficient (R) and the p-value was determined. Rheological models fitted with high values of R (>0.8) and low MAE (<0.5) and p-values (<0.05) were considered adequate for the reliable prediction of their flow behavior.

Sensory analysis

A panel of 10 tasters, 4 men and 6 women, conducted a sensory analysis of grape creams. Nine experimental cream samples prepared from white and black table seedless grapes were compared to each other in respect to sensory acceptability. The samples were served at room temperature in disposable, transparent, odor-free plastic cups marked with three random digit numbers. Each panelist was provided with approximately the same quantity of a cream sample and water for rinsing the mouth. The equal amount of each grape cream was portioned in each plastic cup. The trays with plastic cups containing the cream samples and questionnaires were prepared in advance and randomized to make sure that the order of the samples would not affect the final result.

The color, flavor, taste, consistency and the overall acceptability were assessed by using a hedonic scale of five points (1 - disliked extremely; 3 - neither liked nor disliked; 5 - liked extremely).

Statistical analysis

Experimental data were assessed through ANOVA and t-test to compare means at a 95.0% confidence level by using STATGRAPHICS Centurion XVII Package (Statistical Graphics, Washington, USA).

Results and discussion

Physicochemical parameters

Table 2 and 3 show the data of physicochemical assays for white and black table seedless grapes (varieties "Aperen roz basarabean" and "Aperen negru de grozeşti" respectively) and creams prepared on their basis.

Moisture content significantly influences textural and quality characteristics of food emulsions (creams, spreads, mayonnaises, etc.) and therefore should be carefully monitored (Baucal et al., 2004; Akhtar et al., 2006). High-moisture emulsions are quite unstable and may undergo phase separation and microbial spoilage (Sajedi et al., 2014; Ihara et al., 2015). The data of moisture content in the analyzed creams ranged from 55.9±0.2 to 74.1±0.2 and raised along with an increase in the grape puree content in the sample. As expected, the mean values of fat content varying from 5.9±0.2 to 24.5±0.5 for all creams were similar to the percentage of sunflower oil added into their compositions. pH and titratable acidity results displayed in Table 3, varied from 2.9±0.0 to 3.4±0.1 and from 0.30±0.01 to 0.39±0.02 respectively, in relation to grape puree content in the sample.

Table 2. Data of physicochemical analyses for white and black seedless grapes. Average values±SD are reported*

Grape variety	Dry matter, %	pH	Titratable acidity, g malic acid / 100 mL	Total polyphenols, mg TAE/kg**	Antioxidant activity, mg QUE/g***
White grape variety "Aperen roz basarabean"	18.0±0.4[a]	3.0±0.1[a]	0.44±0.01[a]	1546.51±11.26[a]	0.13±0.01[a]
Black grape variety "Aperen negru de grozeşti"	22.5±0.4[b]	3.2±0.1[b]	0.56±0.01[b]	1853.25±8.17[b]	0.28±0.02[b]

*Values with different superscript letters are statistically significant at $p<0.05$.

**TAE – tannin equivalents

***QUE – quercetin equivalents

Table 3. Data of physicochemical analyses for creams prepared from white and black seedless grapes. Average values±SD are reported*

No sample	Moisture, %	Total fat, %	pH	Titratable acidity, g malic acid/100mL	Total polyphenols, mg TAE/kg**	Antioxidant activity, mg QUE/g***
Creams prepared from white seedless grape variety "Aperen roz basarabean"						
1	58.4±0.5[a]	20.0±0.0[a]	2.9±0.0[a]	0.38±0.01[a]	740.1± 1.8[a]	0.04±0.01[a]
2	66.0±0.1[a]	13.5±0.2[a]	3.3±0.1[b]	0.34±0.02[a]	954.7±5.2[b]	0.06±0.01[a]
3	74.1±0.2[b]	5.8±0.5[a]	3.4±0.1[b]	0.30±0.01[a]	1198.4±10.1[b]	0.07±0.00[a]
Creams prepared from black seedless grape variety "Aperen negru de grozeşti"						
4	62.0±0.2[a]	17.8±0.2[b]	3.2±0.1[a,b]	0.39±0.02[b]	965.1±50.7[a]	0.13±0.01[b]
5	55.9±0.2[a]	24.5±0.5[b]	3.2±0.2[b]	0.40±0.01[b]	948.9±5.2[a]	0.11±0.00[b]
6	70.1±0.1[b]	5.9±0.2[b]	3.4±0.0[b]	0.35±0.01[b]	1443.7±272.6[b]	0.16±0.00[b]

*Values with different superscript letters are statistically significant within two groups of cream samples at $p<0.05$.

**TAE – tannin equivalents

***QUE – quercetin equivalents

According to data from Table 3, cream samples prepared with a higher amount of grape puree (samples no 2, 3, 4 and 6) showed a pronounced increase in total polyphenols and antioxidant activity in comparison with the other ones (samples no 2 and 5). However, cream samples prepared from black seedless grapes displayed higher values for both total polyphenols and antioxidant activity in comparison to creams prepared from white grapes (sample no: 1 vs. 5, 2 vs. 4 and 3 vs. 6). This phenomenon may be explained by the initially higher content of phenolic compounds in the peel of black grape varieties when compared to the white ones (Krikorian et al., 2010; Hasan et al., 2014). Nevertheless, all creams possess rather high polyphenol content and antioxidant activity in relation to fresh grapes used for their preparation and therefore may be recommended for use in the food industry as confectionary light desserts with health benefits. These data are in full agreement with research studies of other authors, which have discovered that both grape fruits and foods produced from them contained high amounts of different phenolic compounds, such as anthocyanin, catechins, stilbenes, flavonols and proanthocyanidins (Krikorian et al., 2010; Hasan et al., 2014). Thus, foods rich in phenolic compounds, and particularly creams prepared from grapes are beneficial to human health, because they can prevent cardiovascular diseases and different kinds of cancer (Thomasset, 2006).

Flow behavior

The rheograms (dynamic viscosity - shear rate dependence) for grape creams are shown in Figure 1. As shown, all cream samples exhibited a non-linear rheological behavior with a yield stress (amount of energy required to initiate fluid flow) and apparent viscosity (energy required to keep fluid in motion) characteristic for a non-Newtonian liquid (Rao, 2007). Figure 1 displays a decrease of apparent viscosity with the increasing of shear rate in the range 10-70 s^{-1}, followed by a slower one after 100 s^{-1}.

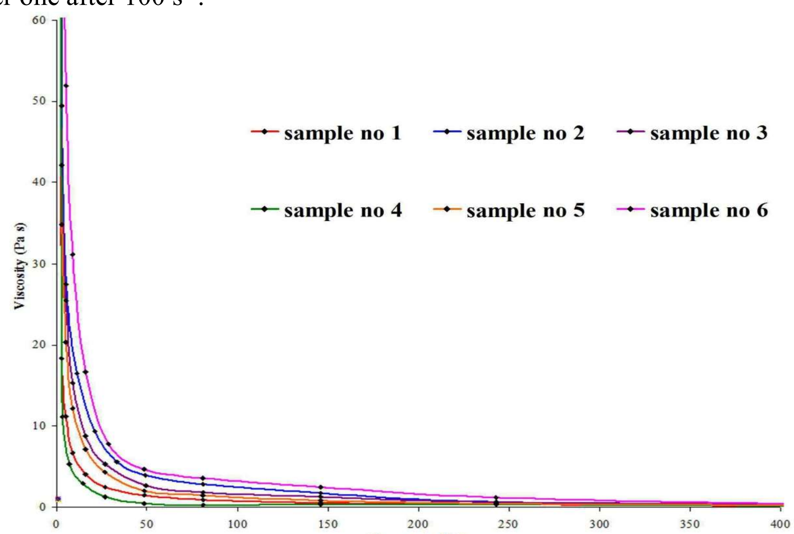

Figure 1. Rheograms of the developed creams: apparent viscosity-shear rate dependence

From the rheograms displayed in Figure 1, it is clearly seen that the apparent viscosity of the prepared creams goes down upon decreasing the amount of grape puree and inulin and increasing the oil phase in the samples. In particular, sample 6 showed the highest apparent viscosity on the rheograms (Figure 1), followed by samples 2 and 3, while sample 4 and 1 had the lowest apparent viscosity values. This tendency may be explained by the formation of more aggregate composition with less void space between particles in the cream samples with low amount of fat which promotes particle-particle interactions (Afoakwa et al., 2007).

The obtained flow curves may significantly facilitate pumping/injection operations with creams, as they show how the pumping pressure (shear stress) will be affected by the pumping rate (shear rate) influenced by the product formulation. Regarding this statement, it is reported in many studies (Sajedi et al., 2014; Ihara et al., 2015; Nguyen et al., 2015) that the nonlinear rheological behavior of food emulsions depends extremely on their compositions, which mainly include several immiscible phase components and stabilizers. Thus, according to the rheograms of the analyzed creams (Figures 1 and 2), the samples prepared with higher amount of grape puree and inulin content were characterized as more viscous. This tendency may be explained by the high content of mono- di- (simple sugars) and polysaccharides (dietary fiber) in the raw materials used for preparation, which give the product body and increase its viscosity (Bornet, 1994). Moreover, by comparing cream samples prepared with the same amounts of grape puree to each other (1 and 5, 2 and 4, 3 and 6), it was established that long-chain inulin leads to an increase in the apparent viscosity. This phenomenon may be explained by good water-binding and thickening properties of this dietary fiber, acknowledged in many research studies (Roberfroid, 2005; Mitchell, 2006). Thus, in the present application, inulin provides a creamy texture to the final product by slightly increasing its viscosity, while compensating for some fat reduction.

To characterize the rheological behavior of the tested creams, their flow data were fitted to the Bingham (eq. 1), the Casson (eq. 2) and the Herschel-Bulkley (eq. 3) models. In order to assess the accuracy and reliability of the fitting between the experimental shear stress-shear rate data and the rheological models for each of the cream samples analyzed, the performance estimations of the criteria for fitting in terms of correlation coefficient (R), mean absolute error (MAE) and p-value were determined.

Through the fitting applied for the tested creams it was revealed that the Herschel-Bulkley model best describes the nonlinearity of their flow curves (i.e., shear stress-shear rate curve) by the expression of power index n, while exhibiting the nonlinearity of the pseudoplastic behavior when $n<1$ (Álvarez et al., 2006). Low error values between the measured shear stress values and the predicted ones with high correlation coefficients and small numerical p-values (<0.05) displayed in Table 4 imply that the Herschel-Bulkley model enables the most adequate fitting of the rheological behavior of the prepared cream samples in comparison to other rheological models. The Casson (eq. 2) and the Herschel-Bulkley (eq. 3) rheological models produced very high mean absolute errors (>10), and therefore were considered unacceptable as potential candidates for estimating the flow behavior of the analyzed creams.

The yield stress in the fitted models of grape creams is an important parameter affecting their flow behavior. The yield stress is the stress required to make cream begin to flow, which is influenced by particle-particle interactions, the number and specific surface area of the particles, emulsifiers, and moisture content in the sample (Rao, 2007). According to the data displayed in Table 4, the highest yield stress is observed for cream sample no 6 possessing yield-dilatant behavior. The main effect that results in this shear thickening behavior may be attributed to the inter-particle repulsive forces that transform a flocculent state of the system into a dispersed one (Rao, 2007). However, a big amount of fruit part (90% grape puree) and a thickening agent (3% inulin) with a low percentage of oil phase in the (no 6) could be considered as inappropriate for pumping/injection operations due to high values of apparent viscosity and yield stress. Therefore, it is better to maintain the ratio between water and oil phase in fruit creams in the range from 4 to 8.6 to ensure yield-plastic behavior, which is typical for the rest of the cream samples (no 1-5). Generally, as it can be observed in Table 4, cream samples no 2, 3 and 6 which were prepared with higher amount of grape puree (>80%) and lower oil content (<15%) possess the highest values of yield stress (>100 Pa) and may be considered highly viscous in comparison with the rest of the samples. This phenomenon can be explained by a more dense aggregation of particles in the cream compositions prepared with lower amounts of vegetable oil which promotes particle-particle interactions (Afoakwa et al., 2007).

Table 4. Rheological constants of cream samples obtained from fitting the experimental data with the Herschel-Bulkley model

No.	τ_0, Pa	*K*	*n*	Correlation coefficient *R*	p-value	Mean absolute error
1	45.15	1.79	0.75	0.99	0.000	0.16
2	148.36	0.75	0.76	0.95	0.001	0.01
3	132.63	0.86	0.73	0.98	0.000	0.01
4	55.48	2.09	0.74	0.99	0.000	0.03
5	99.87	1.31	0.74	0.96	0.000	0.02
6	256.26	1.38	0.75	0.92	0.001	0.01

Sensory data

The data of sensory assessment of grape creams displayed in Table 5 clearly demonstrate that all analyzed samples were acceptable to consumers.

However, black grape creams (nr. 4, 5, and 6) possessed the highest mean scores for color, flavor, taste and overall acceptability in comparison to creams made from white grapes. This fact revealed that the mouthfeel of creams was strongly influenced by the total polyphenol content in their compositions (Table 3). Surprisingly, the white grape creams were associated with a dry, astringent sensation, probably due to higher amount of polyphenols (presumingly tannins originating from grape skin) in their compositions (Gawel, 1998). Thus, flavor and taste highlighted the trend of higher quality in black grape creams probably due to the lower content of tannins in their formulations, by showing higher sensory results ranging from 4.83±0.41 to 4.98±0.04 and from 4.92±0.12 to

4.98±0.04, respectively. Generally, black and red grape varieties are richer in polyphenols (particularly, tannns) than the white ones (Harbertson et al., 2008). However, white creams tended to have higher content of polyphenols than black creams, because the extended contact of the grapes skins with boiling water during blanching could lead to their partial dissolution in water, while reducing the content of tannins in product formulations.

Table 5. Sensory characteristics of grape creams*

No sample	Color**	Flavor	Taste	Consistency	Overall acceptability
Creams prepared from white seedless grape variety "Aperen roz basarabean"					
1	4.91±0.10[a]	4.83±0.41[a]	4.83±0.41[a]	4.97±0.41[a]	4.88±0.04[a]
2	4.78±0.38[a]	4.98±0.04[a]	4.87±0.20[a]	5.00±0.00[a]	4.91±0.10[a]
3	4.69±0.38[a]	4.98±0.04[a]	4.95±0.08[a]	5.00±0.00[a]	4.91±0.15[a]
Creams prepared from black seedless grape variety "Aperen negru de grozeşti"					
4	4.97±0.05[b]	4.83±0.41[a]	4.92±0.12[b]	4.98±0.04[b]	4.93±0.07[b]
5	4.77±0.39[a]	4.98±0.02[a]	4.98±0.04[b]	4.98±0.04[b]	4.93±0.10[b]
6	4.79±0.40[b]	4.98±0.02[a]	4.98±0.04[b]	4.99±0.02[a]	4.94±0.09[b]

*Data are expressed as mean ± standard deviation ($p<0.05$)

**Values with different superscript letters are statistically significant within two groups of cream samples at $p<0.05$.

For the majority of panelists, white grape creams scored higher consistency. Probably, this is due to the higher content of long-chain inulin in their formulations in comparison to black grape creams, which significantly improves the texture and mouthfeel of the final product (Roberfroid 2005; Aidoo et al., 2014). Likewise, cream samples prepared with higher amounts of inulin (nr. 2, 3, 5 and 6) were clearly more preferred over the other ones (Table 5).

Conclusions

The substitution of dairy fat with sunflower oil in non-dairy creams prepared from white and black table seedless grape varieties with addition of inulin and xanthan gum, has resulted in high-quality product rich in dietary fiber and bio-active substances, which may be used as a healthy dessert by a wide circle of consumers suffering from lactose intolerance, allergy to milk proteins, high cholesterol and obesity.

The obtained rheological data showed how different ratios between principal fruit-based raw material and ingredients in cream formulations strongly affected their flow behavior. Particularly, different fat content due to variations in the amount of grape puree and sunflower oil involved changes in the particle-particle interaction, in terms of viscosity and the type of non-Newtonian behavior (pseudo-plastic or pseudo-dilatant) of the resulted creams. It was revealed that lower sunflower oil concentrations (<15%), parallel to the high amount of grape puree (>80%), could increase significantly the resistance to flow for creams by raising their yield stress and apparent viscosity.

Thus, the individual effect of each single ingredient in cream formulations, in terms of type and amount, must be carefully analyzed in order to predict and improve the quality characteristics of the final product according to manufacture requirements.

Acknowledgments

The authors would like to thank the Laboratory of Plant Gene Pool and Crop Improvement of the Institute for their valuable support in supplying white and black table seedless grape varieties "Aperen roz basarabean" and "Aperen negru de grozeşti" respectively, as well as useful technical discussions.

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