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Optimization of some extraction parameters of phenolic content from apple peels and grape seeds and enrichment of yogurt by their powders: A comparative study

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Abstract

The present study aims to valorize the apple peels (AP) and grape seeds (GS) by the fortification of the yogurts using their powder. Firstly, the optimization of the extraction parameters for assessing maximum of total phenolic content (TPC) was achieved. Under the optimized conditions, the experimental maximum yields of TPC were 19.33 ± 2.33 and 240.59 ± 4.77 mg Gallic Acid Equivalents (GAE)/100 g Dry Weight (DW) for AP and GS, respectively, which was in close agreement with predicted values (19.32 ± 0.91 and 242.26 ± 11.08 mg GAE/100 g DW for AP and GS, respectively). The antioxidant capacity of GS extract was better with IC_{50} of 12.22 ± 0.89 and 225.47 ± 7.10 µg/ml in DPPH and phosphomolybdenum assays, respectively. Besides, powder from these by-products was incorporated into yogurt samples. The classification test revealed that the yogurt prepared with GS powder was the preferred one.

Practical applications

Natural products rich in antioxidants are increasingly in demand for their use to preserve, in particular, the perishable foods such as dairy products. Apple and grape are widely consumed fruits and they generate an enormous amount of waste, including peels and seeds. These by-products are valuable sources of natural antioxidants especially the phenolic compounds. In this line, the present study aims to optimize the extraction conditions to obtain the highest PC from these by-products. Additionally, a yogurt enriched with AP and GS as natural ingredients with antioxidant virtue was produced.

1 | INTRODUCTION

Apple and grape are widely consumed fruits, due in part to their wide-ranging positive health effects and they generate an enormous amount of by-products, including peels and seeds (Catană et al., 2018; Gülcü et al., 2019). By-products obtained from fruit and vegetable processing are valuable sources of natural antioxidant and bioactive compounds (Sagar et al., 2018) and thus their proper utilization is desirable. Recently, the phenolic extraction from agricultural and industrial wastes has attracted great attention because they are valuable cheap and safe sources of strong antioxidants (Chen et al., 2020). Numerous research studies have focused on the extraction and recovery of high-value compounds from apple (Deng, Xu, Li, & Li, 2015; Jusoh et al., 2017) and grape

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(Chen et al., 2020; Vural et al., 2018) by-products. These wastes contain a large number of phenolic compounds with anti-free radical activity. Among the major identified phenolics with high contents and important antioxidant capacities in apple by-products are procyanidins, chlorogenic acid, and phloridzin (Radenkovs et al., 2020). Besides, about 60%–70% of phenolic compounds of the grapes are found in their seeds (Garcia-Jares et al., 2015; Pantelić et al., 2016), examples are gallic acid, cyanidin-3-glucoside, epicatechin, catechin gallate, ferulic acid, rutin, and resveratrol (Tang et al., 2018). AP and GS extracts could therefore potentially be used for the production of nutraceutical compounds or functional foods (Sagar et al., 2018).

The extraction of phenolic compounds is dependent on several factors such as the solvent polarity, extraction procedures, temperature, time, pressure, particle size, etc. (Gunathilake et al., 2018).

The aim of this study was to examine some basic factors that are likely to govern the extractability of polyphenols from AP and GS, using Response Surface Methodology (RSM), this investigation was undertaken with the view to identifying the optimal operational conditions. Some previous studies have reported the use of RSM to extract phenolic compounds from apple (Deng et al., 2015; Jusoh et al., 2017) and grape (Vural et al., 2018) by-products. However, the studies concentrated on the enrichment of the yogurt by the powders of AP or GS (Karaca et al., 2019; Zhou, 2018) are scare and there is no comparative study between the two by-products. In addition, apple and grape by-products from Algeria are not exploited despite the fact that these two fruits are widely produced and consumed.

2 | MATERIALS AND METHODS

2.1 | Chemicals

Methanol, ethanol, and acetone were purchased from Merck (Darmstadt, Germany). Folin-Ciocalteu phenol reagent, sodium carbonate, gallic acid, sodium phosphate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), ammonium molybdate, and sulfuric acid were attained from Biochem Chemopharma (Montreal, Quebec). Quercetin, 2,2-Diphenyl-picrylhydrazyl (DPPH$^{\bullet}$) stable radical were got from Sigma Chemical Co. (St. Louis, MO, USA).

All reagents are of analytical grade.

2.2 | Samples preparation

The apples and grapes were obtained from local market (Bejaia, Algeria), and washed thoroughly with distilled water. After washing, the apples were peeled and the pips were removed from the grapes, the peels and the seeds were then dried in a ventilated oven (Memmert, Germany) at 40°C until they reached a steady mass value (it lasted 5 days). The dried samples were ground with an electrical grinder (IKA model-A11, Staufen, Baden-Württemberg, Germany) and were then placed in a dessiccator at room temperature (25°C) until further use.

2.3 | Extraction procedure

Powders of AP and GS were extracted by putting an accurate amount (about 0.5 g) of dried samples in an appropriate amount of extraction solvent. Extractions were carried out under magnetic stirring (VELP Scientifica, Milano, Italy), and at room temperature (25°C) for predetermined time periods. When the extraction was completed, the extracts were centrifuged at 4,000 g for 20 min, and the supernatant was obtained and stored at −20°C until used.

2.4 | Experimental design for the response surface procedure

Before using RSM, preliminary experiments were carried out to choose the relevant variables in phenolic antioxidants recovery as well as the experimental range for the independent factors.

In a first step, for the choice of solvent nature, the extraction of phenolics was performed using three different solvents (methanol 50% (*v/v*), ethanol 50% (*v/v*), and acetone 50% (*v/v*)). In order to choose the particle size, this parameter was fixed at three sizes namely below 250, 500, and 1,000 μm.

Then, the impacts of the concentration of ethanol for AP or acetone for GS (10%, 30%, 50%, 70%, and 90%), material/solvent ratio (1:10, 1:20, 1:30, 1:40, and 1:50 g/ml), and extracting time (5, 10, 15, 30, 60, 90, and 120 min) were considered individually (Table 1) based on extraction effectiveness and used to optimize experimental conditions.

Optimization of the extraction of TP from the AP and GS was performed by RSM. A three-factor and a three-level central composite design (CCD) composed of twenty experimental runs was utilized which included six replicates at the center point. The generated runs are shown in the Table 2.

Data relevant to three independent variables and one response variable were explored to obtain a second-order polynomial following model:

$$Y = \beta_0 + \sum_{i=0}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} X_i^2 + \sum_{i>1}^{k} \beta_{ij} X_i X_j + E \quad (1)$$

where β_0, β_i, β_{ii}, and β_{ij} are the regression coefficients for intercept, linear, quadratic, and interaction terms, respectively, and X_i, and X_j are the independent variables.

2.5 | Determination of the optimum conditions and validation of the model

Optimal extraction conditions on TPC of AP and GS sample crude extracts were obtained using the predictive equations generated by

TABLE 1 Total phenolic yield (mg GAE/100 g DW) of apple peels and grape seeds resulted from single-factor experiments

Apple peels									
Particle size (μm)		Solvent type		Ethanol concentration (%)		Extraction time (min)		Solvent-to-solid ratio (mL/g)	
>250	7.01 ± 0.2[b]	EtOH50%	86.6 ± 0.5[a]	10	12.41 ± 0.63[d]	5	9.12 ± 0.47[f]	10	11.18 ± 0.91[e]
> 500	7.72 ± 0.3[b]	MeOH50%	84. 6 ± 0.6[a]	30	17.17 ± 0.08[b]	10	14.29 ± 0.67[d]	20	13.17 ± 0.78[d]
>1,000	13.12 ± 0.9[a]	Ace50%	73.7 ± 0.7[b]	50	20.60 ± 0.72[a]	15	16.46 ± 0.33[c]	30	22.04 ± 0.76[a]
				70	17.27 ± 0.38[b]	30	17.57 ± 0.57[b]	40	17.10 ± 0.11[b]
				90	13.77 ± 0.51[c]	60	21.96 ± 0.55[a]	50	16.92 ± 0.44[c]
						90	11.78 ± 0.29[e]		
Grape seeds									
Particle size (mm)		Solvent type		Acetone concentration (%)		Extraction time (min)		Solvent-to-solid ratio (mL/g)	
> 250	44.41 ± 1.53[a]	EtOH50%	58.23 ± 2.17[c]	10	53.69 ± 1.53[d]	10	24.44 ± 1.93[e]	10	67.69 ± 0.44[e]
> 500	29.47 ± 0.72[b]	MeOH50%	127.11 ± 0.94[b]	30	76.43 ± 0.90[c]	15	24.69 ± 0.18[e]	20	109.97 ± 1.35[b]
>1,000	19.93 ± 1.14[c]	Ace50%	169.9 ± 1.16[a]	50	90.72 ± 2.27[b]	30	40.24 ± 0.89[b]	30	159.89 ± 3.79[a]
				70	109.31 ± 1.17[a]	60	26.55 ± 1.04[d]	40	101.02 ± 3.01[c]
				90	71.26 ± 1.39[c]	90	76.37 ± 5.32[a]	50	74.32 ± 3.15[d]
						120	30.45 ± 1.41[c]		

Note: EtOH: ethanol, MeOH: methanol.

Values in the same columns by each by-product with different letters are significantly different ($p \leq .05$).

RSM. TPC was tested using Folin-Ciocalteu method after solvent extraction under specific optimal conditions. Each set of experiments was conducted in three replicates, and the experimental and predicted values were compared in order to examine the validity of the model.

2.6 | Determination of total phenolic content (TPC)

The TPC was determined using Folin–Ciocalteu reagent (FCR) as described in our previous study (Brahmi et al., 2014). Methanolic gallic acid solutions (1–10 μg/ml) were used as standards. 100 μl of the appropriately diluted sample extract, 6 ml distilled water, 500 μl FCR, and finally 1,500 μl Na_2CO_3 (20%, *w/v*) were added together and vortexed. The mixture was incubated for 2 hr in the dark, and at room temperature. After incubation, the absorbance was measured at 760 nm by a UV-Vis spectrophotometer (Rayleigh UV-1800, Beijing, China) against the reagent blank prepared without extract. The TPC was expressed as mg GAE/100 g DW.

2.7 | Determination of total flavonoids content (TFC)

The TFC was measured using the method of aluminum chloride as reported in our previous work (Brahmi et al., 2014). An aliquot (1 ml) of extract was mixed with 1 ml of aluminum chloride (2%, *w/v*). After incubation at room temperature for 15 min, absorbance of the reaction mixture was measured at 430 nm against the prepared blank containing all reagents except the extracts. The data were expressed as milligram quercetin equivalent per 100 gram dry weight of the sample (mg QE/100 g DW).

2.8 | Antioxidant activity

2.8.1 | DPPH• radical scavenging activity (RSA)

In the RSA assay, the extracts of AP or GS were diluted, and then 2 ml was added to 0.15 ml of a DPPH• methanolic solution (1.10^{-3} mM). The mixture was shaken vigorously and left standing at room temperature for 60 min. The absorbance of the resulting solution was then measured at 517 nm. The percent inhibition of the free radical DPPH• was calculated based on the following equation:

$$\%\,\text{inhibitionofDPPH} = \frac{(\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}})}{\text{Abs}_{\text{control}}} \times 100 \quad (2)$$

where $\text{Abs}_{\text{control}}$ is the absorbance of the control reaction (containing all reagents except the test compound), and $\text{Abs}_{\text{sample}}$ is the absorbance of the test compound (Brahmi et al., 2014).

The capacity of free radical scavenging was expressed by IC_{50} (μg/ml) value, which represents the concentration required to scavenge 50% of DPPH• radicals.

TABLE 2 Measured and predicted results for the optimization of total phenolic content (TPC) extraction from apple peels and grape seeds

				Apple peels				Grape seeds				
					Actual levels				Actual levels			
Factors				Unit	−1	0	+1	Unit		−1	0	+1
Solvent concentration			(X_1)	%	30	50	70	(X_1)	%	50	70	90
Time			(X_2)	min	30	60	90	(X_2)	min	60	90	120
Ratio			(X_3)	mL /g	10	25	40	(X_3)	mL /g	20	30	40
No.	X_1	X_2	X_3	Measured		Predicted		X_1	X_2	X_3	Measured	Predicted
1	50	30	25	18.10		18.41		70	90	30	145.90	159.78
2	50	60	10	14.57		14.13		70	90	30	151.89	159.78
3	30	90	40	18.31		18.33		50	60	20	143.15	150.89
4	50	60	25	15.9		16.27		70	120	30	180.41	176.28
5	50	60	25	16.43		16.27		70	90	30	146.76	159.78
6	30	90	10	14.76		14.09		50	90	30	170.00	169.14
7	30	60	25	14.76		14.64		90	60	40	168.32	178.34
8	70	30	10	13.82		14.44		50	120	20	129.17	126.54
9	70	30	40	16.29		15.60		50	120	40	127.48	133.73
10	50	60	40	16.95		16.83		70	90	30	157.86	159.78
11	50	60	25	15.68		16.27		70	60	30	163.78	159.37
12	50	60	25	14.82		16.27		90	90	30	193.24	190.56
13	70	90	10	13.35		13.04		70	90	40	134.41	142.99
14	30	30	10	14.9		14.71		70	90	30	154.05	159.78
15	30	30	40	16.93		16.89		90	120	20	127.87	126.88
16	70	90	40	16.42		16.26		50	60	40	144.32	135.83
17	50	60	25	15.59		16.27		70	90	30	157.43	159.78
18	50	60	25	16.05		16.27		70	90	20	90.00	95.71
19	70	60	25	13.92		13.47		90	60	20	88.83	90.97
20	50	90	25	18.32		18.44		90	120	40	235.86	236.50

2.8.2 | Total antioxidant activity (TAA)

The TAA was evaluated by phosphomolybdenum method. An aliquot of 0.1 ml of sample solution was combined with 1 ml reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate). The tubes were capped and incubated in boiling water for 90 min. After the mixture had cooled, its absorbance was measured at 695 nm against a blank.

The TAA was expressed as IC_{50} (μg/ml) that is the effective concentration at which the absorbance was 0.5 and was obtained by interpolation from linear regression analysis (Brahmi et al., 2014).

RSA and TAA of the tested samples were compared to that of BHA and BHT.

2.9 | Formulated yogurts

Yogurt was prepared from skimmed milk powder and afterwords we add sugar, AP, and GS powders. The mixture was then mixed using a hand whisk to form coarse emulsions and was then homogenized. All batches of milk were heated to 90°C for 10 min and cooled to 43°C. The processed milk was inoculated with lactic acid bacteria (*Streptococcos thermophilus* and *Lactobacillus bulgaricus*). After homogenization, it was dispensed into plastic cups fitted with press-on lids and incubated for 4 to 5 hr at 43°C. The yogurts were then transferred to a cold store at 4°C. A control was prepared following the same steps without AP and GS powders.

2.9.1 | Characterization of the formulated yogurts

Physico-chemical and microbiological analyses were carried out; the pH, viscosity, and acidity were determined. Total coliforms, fecal coliforms, yeasts and molds and total germs were searched.

The hedonic and sensory analysis of the stored yogurt samples (48 hr at 4°C after their formulation) were realized at the sensory analysis laboratory of the Department of Food Sciences (University of Bejaia, Algeria).

TABLE 3 Analysis of variance for the total phenolic content on parameter effect for apple peels and grape seeds

	Apple peels					Grape seeds				
Source	Df	Sum of Squares	Mean Square	*F*-value	*p*-value Prob> F	Df	Sum of Squares	Mean Square	*F*-value	*p*-value Prob> F
Model	9	38.23	4.25	17.99	<.0001	9	19,972.21	2,219.13	59.50	<.0001
X_1-Ethanol concentration	1	3.43	3.43	14.54	.0034	1	1,000.00	1,000.00	26.81	.0004
X_2-Time	1	0.13	0.13	0.53	.4828	1	853.59	853.59	22.89	.0007
X_3-Ratio	1	18.22	18.22	77.19	<.0001	1	5,353.21	5,353.21	143.52	<.0001
$X_1{}^*X_2$	1	0.31	0.31	1.32	.2770	1	2,359.85	2,359.85	63.27	<.0001
$X_1{}^*X_3$	1	2.000E−004	2.000E−004	8.471E−004	.9774	1	4,418.00	4,418.00	118.45	<.0001
$X_2{}^*X_3$	1	0.56	0.56	2.38	.1540	1	82.18	82.18	2.20	.1685
X_1^2	1	9.41	9.41	39.84	<.0001	1	1532.76	1532.76	41.09	<.0001
X_2^2	1	11.23	11.23	47.55	<.0001	1	545.46	545.46	14.62	.0034
X_3^2	1	0.51	0.51	2.15	.1734	1	5,770.11	5,770.11	154.70	<.0001
Residual	10	2.36	0.24			10	372.99	37.30		
Lack of Fit	5	0.89	0.18	0.61	.7021	5	240.88	48.18	1.82	.2629
Pur Erreur	5	1.47	0.29			5	132.11	26.42		
Cor Total	19	40.60				19	20,345.20			
R^2	0.9418					0.9817				
Adj. R^2	0.8895					0.9652				

The sensorial analysis was performed by nine experts jury (four males, five females) aging from 30 to 50 in order to assess the sensory characteristics of the developed products. This analysis was based on 5-points scale, ranging from 5 (extremely liked) to 1 (extremely disliked), for each sensory attribute: flavor (odor), consistency, fruity taste, texture, acidity, sweetness, fragrance, and color.

On the other hand, hedonic analysis (preference test) was undertaken by 82 naive subjects (41 males and 41 females), aging from 18 to 50 years with an evaluation of the overall acceptability on a scale of 1–9.

Water and bread were supplied between samples to cleanse the palates.

2.9.2 | Statistical analysis

All measurements assay were conducted in triplicate. The experimental results were mentioned as means ± standard deviation (*SD*) of three measurements.

Data analysis was performed by analysis of variance (ANOVA) by STATISTICA (version 10.0) to show significant differences at 5% probability level ($p \leq .05$).

Statistical analysis was done with JMP software (Version 7.0) to find the response surfaces. The processing of the sensory analysis data was carried out by XL STAT (version 9.0).

3 | RESULTS AND DISCUSSION

3.1 | Preliminary experiments

A preliminary attempt with different solvents and particle sizes was carried out to determine the factors influencing the extraction of the TP from the AP and GS, considerably reducing the number of experiments needed for the results presented in the next section.

In order to extract the phenolic compound from different samples, water, methanol, ethanol, and acetone separately or mixed with water are usually used (Medina-Torres et al., 2017). In this study, aqueous ethanol was an effective solvent for extracting AP. It gave the highest TPC, followed by aqueous methanol and aqueous acetone. However, the best extraction solvent for TP from GS is aqueous acetone with a significant difference at $p \leq .05$ compared with aqueous methanol and ethanol (Table 1). Consequently, ethanol and acetone were selected as the appropriate extraction solvents for AP and GS, respectively.

Some researchers revealed that ethanol is efficient in extracting phenolics from AP (Radenkovs et al., 2020; Zalazar-García et al., 2020). Regarding GS, the preliminary assays carried out by Yalcin et al. (2017) demonstrated that aqueous acetone was the best solvent for the extraction of phenolic compounds from GS. Furthermore, other researchers proposed a procedure using the mixture of acetone/water to extract the GS phenolics (Baydar et al., 2007; Hwang et al., 2008; Yemis et al., 2008; Yilmaz & Toledo, 2006). Bosso et al. (2016) have found that mixing acetone with water improves almost five times the efficiency of extraction of phenolics from GS than the ethanol/acetone mixture.

The content of phenolics was also influenced by variations in the sample particle size. A higher amount of TP was obtained with a particle size of ≤1 mm for AP and ≤250 μm for GS (Table 1).

The size obtained after the powdering of the sample was not always specified. According to Bucić-Kojić et al. (2007), the TPC extracted from GS was the highest upon using the smallest particle class (0.16–0.125 mm), and the lowest when the biggest particle size (>0.63 mm) were used. Da Porto and Natolino (2018) after testing different particles sizes (<0.5, 0.8–1.0, 1.0–1.25, 1.25–1.50, 1.50–1.75, 1.75–2.0 > 2.0 mm) adopted an average particle diameter of 0.83 ± 0.05 mm to extract phenolic compounds from red grape marc. Small particle size had high connection surface which allows the increase in mass transfer (Ćujić et al., 2016).

However, Silva et al. (2007) reported that the use of very small particles may lead to technical difficulties related to the permeability of the solid bed during the filtration.

In the present research, assays were carried out in AP with particle size ≤1 mm and in GS with particle size ≤250 μm.

3.2 | Optimization of the extraction conditions

The impact of the factors: solvent concentrations (X_1), extraction time (X_2), and solid/liquid ratio (X_3) on the extraction of TPC was evaluated and the measured and predicted results of TPC are shown in Table 2. TPC of AP varied from 13.35 to 18.32 mg GAE/100 g DW, and for GS from 88.83 to 235.86 mg GAE/100 g DW.

The mathematical models related the TPC of AP (Y_{AP}) and GS (Y_{GS}) and the factors studied are presented by second-order polynomial equations according to the following relations:

$$Y_{AP} = 15.92 - 0.59X_1 + 0.11X_2 + 1.35X_3 - 0.20X_1X_2 - 5.000e^{-003}X_1X_3 + 0,27X_2X_3 - 1.85{X_1}^2 + 2.02{X_2}^2 - 0.43{X_3}^2 \quad (3)$$

$$Y_{GS} = 154.59 + 10.00X_1 + 9.24X_2 + 23.14X_3 + 17.18X_1X_2 + 23.5X_1X_3 + 3,21X_2X_3 + 23.61{X_1}^2 + 14.08{X_2}^2 - 45.81{X_3}^2 \quad (4)$$

Table 3 described the analysis of variance (ANOVA) for response surface quadratic polynomial models. The F assay was employed to verify the statistical significance of the regression equations. The two models possessed a high f values (17.99 and 59.5 for AP and GS, respectively) and a low p value ($p < .0001$), stated that the two produced models were highly significant. The coefficients of determination ($R^2 = 0.9418$ and 0.9817 for AP and GS, respectively) are approaching 1, that means existence of a good correlation between the measured and the predicted results, and stipulated that each model could describe 94.18% and 98.17% of the fluctuation in the TP yield in AP and GS, respectively.

The fitness of the models was examined by the lack of fit assay. The *F* values of 0.61 and 1.82 followed by p values of 0.7021 and 0.2629 for AP and GS, respectively, designated the relevance of models to precisely predict the changing. All of these findings proposed that the models were suitable for predicting in the range of the parameters used.

The regression analysis of the data revealed that all variables (solvent concentration (X_1), extraction time (X_2), and solid/liquid ratio (X_3)) have a significant impact ($p < .05$) on AP and GS TPC extraction. Likewise, solid/liquid ratio indicated the principal impact on TP yield, come after that the solvent concentration and then extraction time. All the interactions X_1X_2, X_1X_3, X_2X_3, X_1^2, X_2^2, and X_3^2 displayed also a significant impact ($p < .05$).

The extraction time (X_2), solid/liquid ratio (X_3), their interaction (X_2X_3), and time quadratic interaction (X_2^2) showed a positive linear effects on TPC of AP extract, but ethanol concentration (X_1), and its interaction with time (X_1X_2), and ratio (X_1X_3), its quadratic interaction (X_1^2), and ratio quadratic interaction (X_3^2) possess significant negative effects (Equation 3). Regarding, GS (Equation 4), all the variables and their quadratic interaction, except ratio quadratic interaction (X_3^2), showed a significant positive effects on TP yield.

The relationships between the solvents (ethanol or acetone) concentration, extraction time, and the solid/liquid ratio on TPC were illustrated in the response surface and contour plots (Figure 1).

The analysis of the results demonstrated that the TPC values increased at a low concentration of ethanol and then decreased with further increase of its concentration. However, the TPC in the GS extracts increased with increasing of acetone concentration.

According to Casazza et al. (2020), the highest TPC of the AP extracts was recorded when the ethanol concentration varied between 40% and 60% (*v*/*v*). A similar trend was occurred in the extraction of TP from sunflower seed cake by Zardo et al. (2019); the increase in

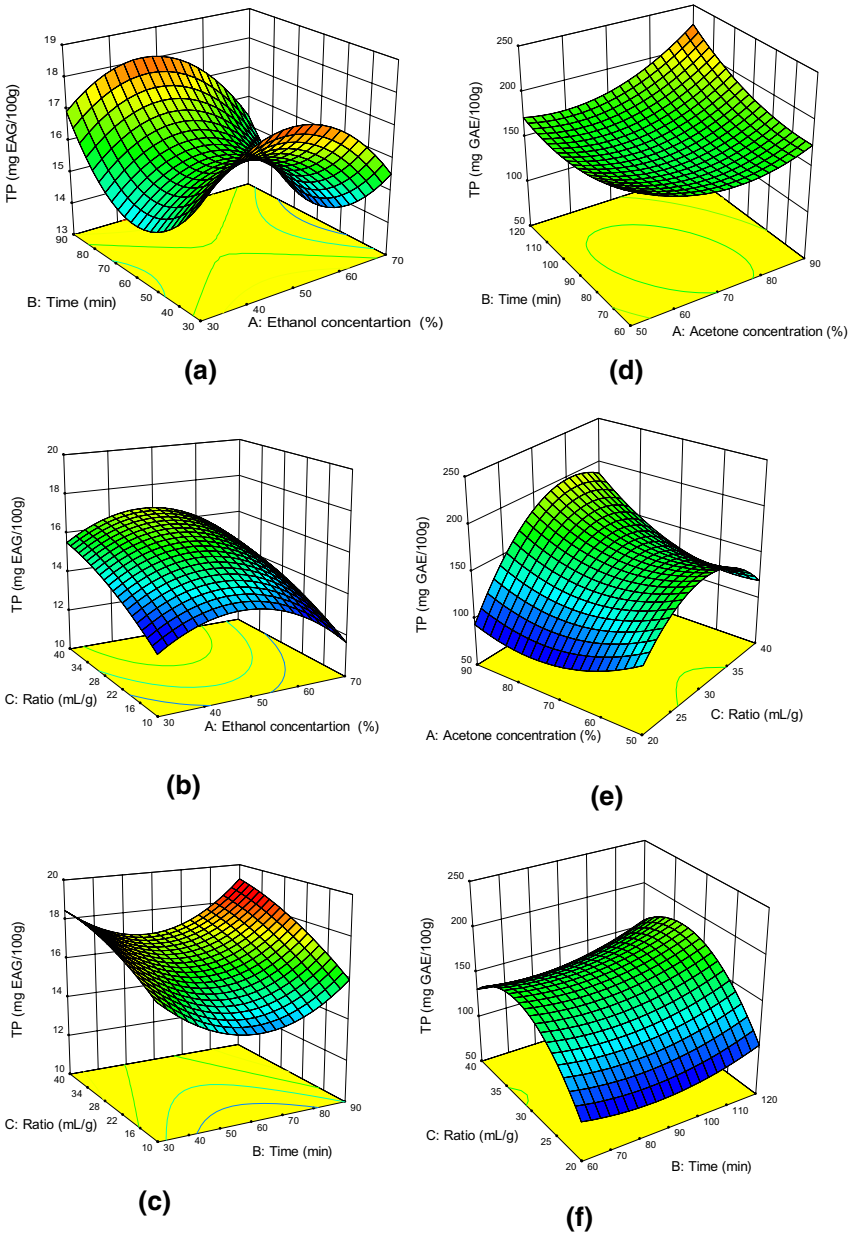


FIGURE 1 Responses surface of the interaction solvent-time (a), solvent-ratio (b), ratio-time (c) of AP and solvent-time (d), solvent-ratio (e), ratio-time (f) for GS extracts

ethanol concentration from 0 to about 45% increased the TP yield but higher ethanol concentrations induced a decrease in TP amount. Ćujić et al. (2016) also reported that the utilization of medium concentration for ethanol/water combination (50%) generated in higher TP yield compared with other ratios of the ethanol/water mixture.

On the other hand, our results are in accordance with those of Yalcin et al. (2017) who determined the TPC of five different GS. They noted that the acetone 90% extracts showed the best TPC in all samples.

As regards extraction time, the TPC yield diminished then augmented for AP and increasing continuously for GS extracts. Generally, a maximum content of TP was attained at an extraction time of 60 and 90 min for AP and GS extracts, respectively.

Hernández-Carranza, Ávila-Sosa, Guerrero-Beltrán, Navarro-Cruz, Corona-Jiménez, and Ochoa-Velasco (2016) recorded similar results, where the best contents of antioxidants were extracted by maceration from AP at 60 min. In line with Shi et al. (2003) study, an extraction time only of 90 min gave the highest extraction yield of TP from GS. Our results are also in accordance with those of Medouni-Adrar et al. (2015), who revealed that the extraction efficiency of TPC from grape skin was enhanced as the period of the extraction increased up to 90 min.

Vural et al. (2018), demonstrated in their investigation that more time allows the liberation of the bioactive substances from vegetables, but more augmentation in extraction time did not exhibit any increase in the TPC of GS. Longer extraction time reduced the extraction of TP, probably due to the degradation by oxidation of some compounds and their products might polymerize into insoluble compounds (Shi et al., 2003).

Concerning the solute/solvent ratio (X_3), the high ratios enhanced the TP extraction. For AP extract, the increase in the ratio led to an increase in TPC, reaching a maximum at the highest one tested (1/40 ml/g). Nevertheless, for GS extract we noted a diminution in the TP yield beyond the ratio of 1/35 ml/g.

The sample-to-solvent ratio is one of the most important variable throughout mass transfer, since a substantial volume of solvent affect the diffusion procedure (Medina-Torres et al., 2017). Higher the solute/solvent ratio generated in larger concentration gradient over the diffusion from solid into the solution and in utmost swelling of the herbal material growing the contact surface area between the solid and the liquid (Drevelegka & Goula, 2020). The results agree with those of the previous findings which indicate that higher solid–solvent ratio conducts to the higher TPC. Da Porto et al. (2018) and Iglesias-Carres et al. (2018) established an increase of TPC of the whole edible parts of red grapes when the sample-to-solvent ratio increased. A ratio of 1:40 g/ml is best to offer the content of solvent needed to penetrate the cells hence ameliorating the permeability of the phenolic components (Sousa et al., 2016).

Optimum conditions were established by RSM and comparison between the predicted results and the measured values were done by experimental rechecking using those presumed optimal conditions. The optimal extraction conditions of TPC acquired using the models were as follows: for AP: ethanol concentration, 45.74% (*v/v*), extraction time of 90 min, and 1 g/40 ml solid/liquid ratio. Under these optimal conditions, the model predicted a maximum response of 19.32 ± 0.91 mg GAE/ 100 g DW. The optimal conditions for the extraction of TP from the GS according to the model are the acetone 90% (*v/v*), 120 min, and 1 g/35.44 ml solid/liquid ratio that gave the highest response of 242.26 ± 11.08 mg GAE/ 100 g DW.

The measured results were well related to the predicted ones, affirming the validity and adequacy of the predicted models.

The TP and TF contents, and antioxidant activity of the extracts which gave the highest predicted TPC were determined.

3.3 | Total phenolic and total flavonoid contents

The TPC of the extracts prepared using optimal conditions, yielded 19.33 ± 2.33 and 240.59 ± 4.77 mg GAE/g 100 DW for AP and GS, respectively. These contents belong to those of the prediction interval of the CCD experience.

The AP extract has a significantly ($p \leq .05$) lower content comparing to GS one.

Peschel et al. (2006) reported that apple by-products were among the vegetable and fruit wastes with the highest TPC (48.6 ± 0.9 mg GAE/g dry extract). However, the concentration of phenolic compounds dependent on several factors such as cultivar, harvest, storage conditions, and processing (Karaman et al., 2013).

The differences between growing seasons in phenolic quantity in AP amounted to 57% (Łata & Tomala, 2007). Wolfe et al. (2003) have specified that AP of four varieties possess high TPC which ranged from 309.1 ± 32.1 to 588.9 ± 83.2 mg GAE/100 g of peels. Among the fruit peels studied by Leontowicz et al. (2003), AP have the highest TPC (107.4 ± 9.6 mg/100 g fresh weight (FW)). The TPC (mg GAE/100 g) of AP of 11 apple cultivars varied from 304.6 to 712.6 (Vieira et al., 2011). Massini et al. (2013) appointed that the AP contains up to 27 mg GAE/g DW of TPC. By applying cellulase enzymolysis extraction with ultrasonic-assisted extraction (UAE) method, the model predicted a maximum response of 771.62 mg/100 g of TPC in AP (Junjian et al., 2013). Extracts of dried and frozen AP have an important TPC of 830.9 and 3,370.1 mg chlorogenic acid equivalents /L, respectively (Sekhon-Loodu et al., 2013).

The maximal yield of TPC was 26.81 (mg GAE/g FW) in sugar AP using UAE process (Deng et al., 2015). Jusoh et al. (2017) adopted a novel extraction method (radio frequency assisted extraction), established that the highest recovery of TPC was from AP (121.87 mg GAE/ g DW). The TP quantified in AP by El-Messery et al. (2019) was 1,141.92 ppm. Ahmad et al. (2020) by studying five varieties of apple revealed a level of TP ranging from 1.39 (gacha) to 3.43 g GAE/100 g DW (red delicious) in their peels.

Regarding GS, Gómez-Mejía et al. (2020), stated that the GS have a considerable TPC. According to literature, this content depends on several factors, mainly the variety.

In the GS extracts, the TPC was found to be 627.98 mg GAE/g using acetone: water: acetic acid (90:9.5:0.5) and 667.87 mg GAE/g using ethyl acetate: methanol: water (60:30:10) (Baydar et al., 2007).

Yilmaz et al. (2006) revealed that acetone–water mixtures at 50% recorded the highest TPC (40 mg GAE/g DW) in GS. In an another study, 50% aqueous ethanol for 200 min gave a TPC that varied from 14.72 to 66.81 mg GAE/g (Bucić-Kojić et al., 2007). TPC extracted from GS by 70% acetone solution for 12 hr ranged from 16.71 to 28.60 mg/100 g (Hwang et al., 2008). The TPC values of three varieties of GS varied between 7.107 and 13.992 mg GAE/100 g DW (Karvela et al., 2009). By adopting the optimal conditions resulted from UAE, the maximum TPC of GS was 5.44 mg GAE/100 ml (Ghafoor et al., 2009). Among the samples studied by Babbar et al. (2011), GS exhibited the highest TPC which is 37.4 ± 0.15 mg GAE/g DW. In the same year, by using microwave assisted extraction (MAE), the TPC from GS of *Vitis vinifera* cultivars fluctuated between 47.2 and 86.6 mg GAE/g of powder (Li et al., 2011).

In 2013, Chouchouli, Kalogeropoulos, Konteles, Karvela, Makris, and Karathanos determined TPC of 76.1 ± 6.7 and 151.6 ± 3.6 mg GAE/g dry extract in the GS belonging to two varieties Agiorgitico and Moschofilero, respectively. Furthermore, Krishnaswamy et al. (2013) after the optimization of MAE of phenolic antioxidants from GS, deduced a predicted TPC of 13 ± 0.89 mg GAE/g.

Garcia-Jares et al. (2015) noticed that the TPC were from 99 to 121 mg GAE/g DW in the GS of 11 Spain grape varieties. Likewise, Pantelić et al. (2016) have determined that the TPC oscillated from 38.02 ± 0.46 to 102.98 ± 0.58 mg GAE/g in the seeds of 13 grapevine varieties from Serbia.

Zhou et al. (2016) calculated the contents of TP of 23.5 ± 0.3 and 22.97 ± 0.14 mg GAE/g DW in GS from China, using two methods of extraction. Based on the work of Yalcin et al. (2017), the highest TPC (583.03 mg GAE/g dry extract) was recorded in the GS of the variety Cabernet, while the lowest amount (130.17 mg GAE/g dry extract) was assigned to the GS of the variety Gamay.

The TPC measured in the extracts of ten GS varieties ranging between 34.628 ± 2.435 and 71.244 ± 0.762 mg GAE/g FW with a twofold difference (Tang et al., 2018). Vural et al. (2018) by using UAE, stated that the TPC of GS resulted from optimum conditions was 25.96 ± 0.70 mg/g.

The TFC quantified in the AP and GS extracts prepared following the optimal conditions were 11.61 ± 1.76 and 6.89 ± 0.23 mg QE/100 g DW. The AP extract gave a significantly (≤ 0.05) higher concentration of flavonoids (Table 4).

A very good positive correlation ($R^2 = 0.98$) was found between TP and FC. This means that flavonoids are the predominant phenolic compounds in the studied samples.

According to Issa et al. (2016) and Massini et al. (2016), AP phenolics composed mostly of flavonoids (> 50%), especially flavan-3-ols consisting of monomers such as catechins, and dimers (namely procyanidin B2), while anthocyanin constitute 9.76%.

Wolfe et al. (2003) reported that the TFC in AP extract was 3.061 mg catechin equivalents (CE)/g and among the fruits peel studied by Leontowicz et al. (2003), the AP possess the highest TFC (45 ± 3.9 mg/100 g FW). The TFC of the peels of five apple cultivars passed from 1.15 to 2.04 g QE/100 g (Ahmad et al., 2020).

Łata et al. (2007) predominantly quantified as flavonols different glycosides of quercetin in the external layer of AP (about 40%). Whereas, the total flavanol content from 11 apple cultivars varied from 32.4 to 147.7 mg CE/100 g FM (Vieira et al., 2011).

As regards GS, Tang et al. (2018) established that the TFC of ten GS cultivars fluctuated between 1.130 ± 0.054 and 3.957 ± 0.213 mg QE/g FW with a fourfold difference. The flavonoids are displayed ats a lower amount compared with proanthocyanidin. The only characterized flavonoid at low concentration (0.382 ± 0.008 mg/g of extract) was the glucoside flavanonol taxifolin-*O*-rhamnoside (Gómez-Mejía et al., 2020). The flavan-3-ol derivatives group was the preponderant one and represent 98%–99% of the TP composition (Garcia-Jares et al., 2015; Gómez-Mejía et al., 2020; Pantelić et al., 2016). The total flavanols determined in the seeds of three grape cultivars were 5,679 ± 665 ; 4,134 ± 839, and 4,688 ± 1,001 mg CE/ 100 g DW, respectively (Karvela et al., 2009). In accordance with Chouchouli et al. (2013), flavanols contents were 35.5 ± 0.43 and 58.1 ± 0.68 mg CE/g dry extract and flavones contents were 1.89 ± 0.23 and 1.28 ± 0.10 mg Rutin equivalents/g dry extract in two varieties of GS.

The total content of flavanols was 611 mg/100 g of FM (Di Lecce et al., 2014), while the content of flavonols reported by Garcia-Jares et al. (2015) was 3.190 mg /g DM.

The results obtained by the current study seem to be different from those reported in the literature. Dissimilarities can be explained by the influence of several factors such as the method and condition of extraction, the geographic origin of the sample as well as the degree of maturity of the products used (Salvador et al., 2001).

TABLE 4 Phenolic content and antioxidant activity of the optimal extracts of apple peels (AP) and grape seeds (GS)

	Phenolic contents		Antioxidant activity		
	TPC (mg GAE/g DW)	TFC (mg QE/g DW)	TAA (IC_{50} µg/mL)	RSA (IC_{50} µg/mL)	ARP (1/ IC_{50}). 10^{-3}
AP extract	19.33 ± 2.33^{b}	11.61 ± 1.76^{a}	837.9 ± 35.9^{d}	97.3 ± 4.3^{c}	10.3 ± 0.7^{c}
GS extract	240.59 ± 7.77^{a}	6.89 ± 0.23^{b}	225.5 ± 7.1^{c}	12.2 ± 0.9^{b}	83.3 ± 3.3^{b}
BHA	-	-	10.3 ± 0.4^{a}	6.6 ± 0.1^{a}	151.5 ± 5.2^{a}
BHT	-	-	27.2 ± 0.7^{b}	12.2 ± 1.5^{b}	81.9 ± 2.8^{b}

Abbreviations: ARP, Anti-radical power; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; RSA, Radical scavenging activity; TAA, Total antioxidant activity; TFC, Total flavonoid content; TPC, Total phenolic content.

The different letters on the numbers show that there are significant differences ($p \leq .05$).

3.4 | Antioxidant activity

3.4.1 | DPPH• radical scavenging assay

The results obtained (Figure 2) showed that the two samples studied have the capacity to scavenge the DPPH• radical. In addition, the scavenging effect of 50% of this radical was recorded at low concentrations. The concentrations required to scavenge 50% of the free radical DPPH• (IC_{50}) were 97.34 ± 4.30 and 12.22 ± 0.89 µg/ml for AP and GS extracts, respectively. The anti-free radical powers (ARP = $1/IC_{50}$) were $10.27 \times 10^{-3} \pm 0.7$ and $83.33 \times 10^{-3} \pm 3.33$ for AP and GS extracts, respectively.

GS extract showed a better ability to scavenge the DPPH• radical with a significant difference ($p \leq .05$) than AP. This activity was comparable to that of BHT used as positive control (Table 4). The reduction of this radical can be attributed to their phenolic compounds, which gives protons the ability to scavenge DPPH•.

The AP extract at 5 mg/ml quenched 98% of DPPH• radicals (Leontowicz et al., 2003). Wolfe et al. (2003) reported an anti-radical activity of 312.2 ± 9.8 µmol equivalent of vitamin C/ g of AP. Peschel et al. (2006) noticed that the percentages of inhibition of DPPH• by acetone and butanone AP extracts at 10 µg/ml were 77.63 ± 0.42 and 27.41 ± 0.55%, respectively.

The calculated anti-free radical power ($1/IC_{50}$) by Plaza et al. (2013) of industrial apple by-products ranged between 0.26 and 8.51, this result is comparable to that obtained in this study. The phenolic compounds of dried and frozen AP extracts exhibited strong RSA toward DPPH• radical with IC_{50} of 1.65 and 2.52 µg/ml, respectively (Sekhon-Loodu et al., 2013).

Massini et al. (2016) demonstrated that neutral extract of AP had significantly higher DPPH• RSA than the acidic extract with IC_{50} of 0.90 ± 0.05 and 0.51 ± 0.09 mmol/ × L, respectively. Jusoh et al. (2017) specified a maximum value of DPPH• inhibition (94.54%) by the AP extract obtained by radio frequency assisted extraction. Recently, Radenkovs et al. (2020) reported using HPLC-DPPH• that the main contributors to the RSA of apple by-products were cyanidin-glucoside, luteolin-glucoside, and B-type (-)-epicatechin with EC_{50} values of 0.65, 0.70, and 0.80, respectively.

Concerning GS, the anti-free radical activity has been found to be more important in terms of seed extracts than in those of the skin (Tang et al., 2018). Baydar et al. (2007) recorded IC_{50} values ranging from 22.9 to 32.90 µg/L and Bozan et al. (2008) from 2.71 to 4.52 µg/ml. Yemis et al. (2008) have specified potent scavenger activity of the DPPH• radical by GS extracts. They exhibited activities that ranged from 3.55 to 5.76 mg/L Trolox® equivalent (TE) antioxidant capacities. Babbar et al. (2011) established that scavenging activity toward DPPH• radical was 77 ± 0.4% for GS extract.

The extracts from the seeds of two varieties of grapes have a scavenging capacity toward a DPPH• radical of 58.9 ± 6.9 and 94.8 ± 5.8 mg TE)/g dry extract (Chouchouli et al., 2013). Garcia-Jares et al. (2015) identified an activity which depends on the varieties, it passed from 19.7 ± 0.6 to 41.3 ± 1.9 mmol TE/g of DW. Pantelić

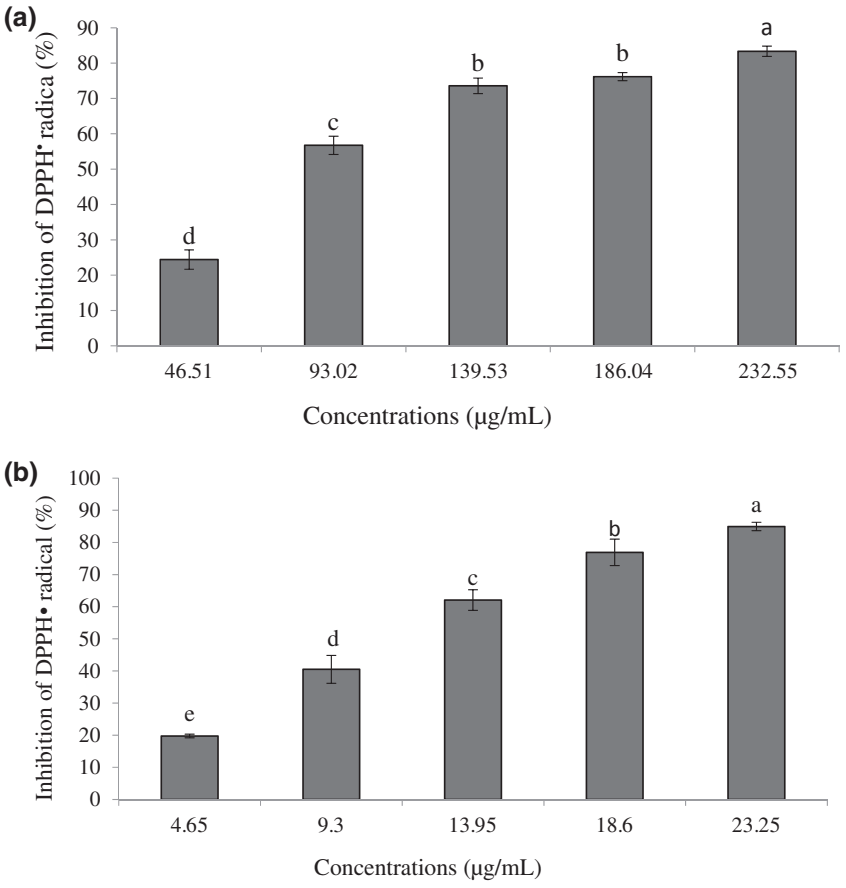


FIGURE 2 Anti-DPPH• radical capacity of AP (A) and GS (B) extracts. The vertical bars represent the standard deviation. The different letters on the bars show that there is significant differences ($p \leq .05$). The values denoted by the identical letters do not show significant differences ($p \leq .05$). The results are listed in descending order a>b> c > d>e

et al. (2016) revealed that RSA of GS varies from variety to another; the highest RSA was recorded in sample 'Prokupac' (967.90 mol TE/g DW), while in the seeds of white varieties, the highest RSA was assigned to 'Pinot Gris' (1,039.92 mol TE/g DW). As stated by Yalcin et al. (2017), grape variety and extraction solvent practiced an important impact on DPPH scavenging capacity. The methanol extract of Okuzgozu variety showed the best anti-DPPH effect (93.66%), while the ethanol extract of Gamay variety exhibited the lowest (20.34%). The extract of GS obtained after the optimization of the conditions of the UAE have an important effect to scavenge DPPH$^{\bullet}$ radical with a value of 93.78% ±0.42 (Vural et al., 2018).

Although the RSA of AP and GS is extremely studied, it is relatively difficult to compare data from the literature. Indeed, there is a difference of varieties, stages of maturity, climatic conditions and storage of the fruits and their waste, a fairly large variation in extraction processes and the type of solvents (water, ethanol, methanol, acetone, ethyl acetate), temperature (20°C–60°C) and extraction time (from 5 min to 24 hr) have an important impact (Popovici et al., 2010).

3.4.2 | Total antioxidant assay

From the results obtained (Figure 3), the absorbances increased significantly by increasing the concentrations of the extracts at $p \leq .05$.

The concentrations which reduce 50% of the molybdate (VI) were 837.91 ± 35.94 and 225.47 ± 7.10 µg/ml for AP and GS extracts, respectively. Therefore, GS extract showed better reducing activity with a significant difference at $p \leq .05$.

The TAA of AP from Irak using the phosphomolybdate assay ranged between 160.36 and 185.15 µmole/mL (Issa et al., 2016).

The maximum TAA of GS extract obtained by UAE was 12.3 mg/ml (Ghafoor et al., 2009). In the phosphomolybdenum reduction assay performed by Yalcin et al. (2017) for the various GS extracts, the highest activity was attributed to the ethanolic extract of the Okuzgozu variety (419.43 ± 60.06 mg Ascorbic Acid Equivalent/g dry extract).

A very good correlation ($R^2 = 0.99$) was recorded between the TPC and the antioxidant capacity measured by the two techniques of the two samples studied. This means that it is the phenolic compounds which are responsible for this activity of AP and GS extracts. Leontowicz et al. (2003) and Vieira et al. (2011) have raised the same results between the antioxidant potentials determined by DPPH and the TPC of AP with R^2 of 0.9207 and 0.716, respectively.

In addition, Radenkovs et al. (2020) demonstrated that the values of the DPPH assay of different apple by-products revealed a strong positive correlations with TPC.

Our results are also similar to those reported in previous works on antioxidant activity and the phenolic composition of GS. TPC of GS showed that there is a significant correlation with DPPH (R^2 of 0.7974, $p < .001$) (Yemis et al., 2008). A significant correlation of GS TPC with RSA (r = 0.76) was also revealed by Pantelić et al. (2016).

The existence of a high correlation between TFC of AP extract and the RSA ($R^2 = 0.992$) and TAA ($R^2 = 0.984$) was also recorded.

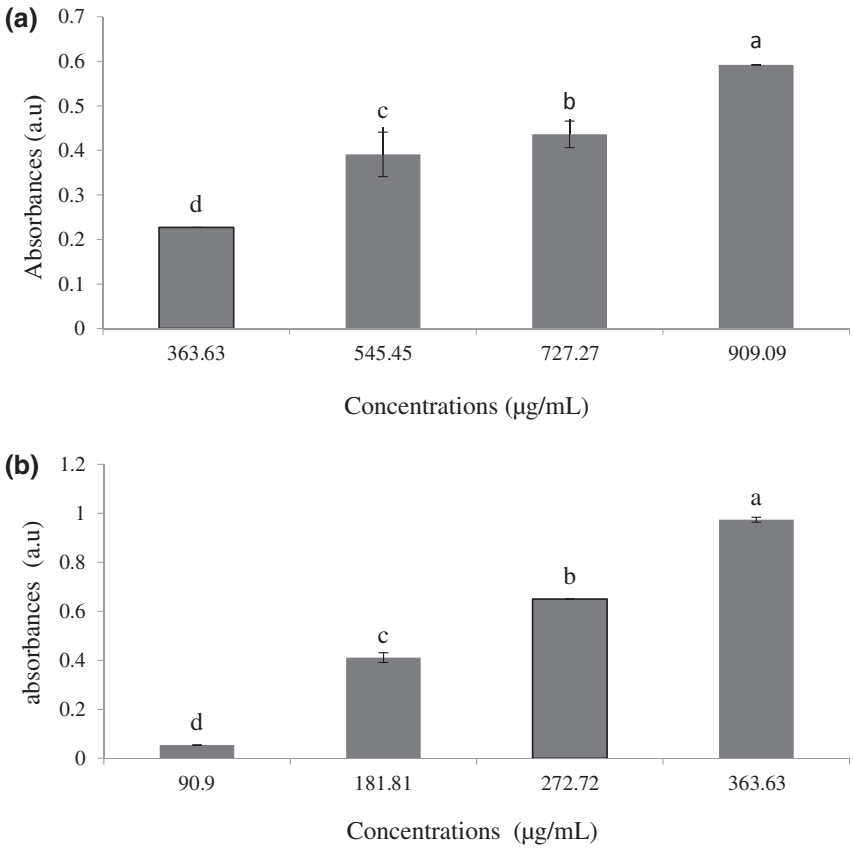


FIGURE 3 Total antioxidant activity of AP (A) and GS (B) extracts. The vertical bars represent the standard deviation. The different letters on the bars show that there is significant differences ($p \leq .05$). The values denoted by the identical letters do not show significant differences ($p \leq .05$). The results are listed in descending order a>b> c > d>e

Sekhon-Loodu et al. (2013) determined that the RSA as IC_{50} values was significantly correlated with flavonols (r = 0.980) content in dried AP. Nevertheless, GS TFC showed lower correlation with antioxidant capacity, this means that other phenolic compounds of GS apart from flavonoids are involved in this activity. Tang et al. (2018) noted that the phenols were the major contributors to the antioxidant activities of seeds and peels from 30 grape varieties, and flavonoids were not the main contributors to these capacities.

3.5 | Formulated yogurts

3.5.1 | Physico-chemical and microbiological analyses

The results of the physicochemical analyses carried out for the fortified yogurts (prepared with AP and GS) and control yogurt are shown in Table 5.

The pH values of yogurts prepared with AP or GS was slightly lower than that of control. This is probably due to the enrichment of the yogurt by the studied by-products. However, these results are in accordance with those cited by the Algerian standard (J O R A D P).

The pH variation of the fortified yogurts relies on the nature of the added component and it was linked to the growth of the bacteria in samples (Demirbüker Kavak & AKdeniz, 2019).

The pH values in yogurt samples containing encapsulated AP (El-Messery et al., 2019) and apple pomace (Wang et al., 2020) was lower than in the control sample. The same trend was demonstrated by Ahmad et al. (2020) where the AP polyphenol extract moderately reduced the pH of yogurt comparatively to control. Similarly, according to Demirbüker Kavak et al. (2019), the pH values of yogurt enriched by GS extract slightly decreased. Phenolic compounds from AP and GS have various hydroxyl and carboxyl groups which can have an impact on pH values.

The total acidity represents the amount of lactic acid produced during fermentation in the yogurt and varied between 36.4 and 38.1 °SH (Tomovska et al., 2016). It gave information about the dominant organic acid content (lactic acid).

According to the results, we noticed that the yogurt enriched by AP was more acidic than one fortified by GS. This could be due to the abundance of organic acid in AP (Catană et al., 2018). In addition, the fortification increased the acidity of yogurts compared with the control sample. However, the acidity of the three produced yogurts complies with the standards given by the Algerian standard (J O R A D P) (80–95 ° D).

A similar results were revealed by El-Messery et al. (2019) and Ahmad et al. (2020) when studying the fortification of yogurts by encapsulated AP and AP extract, respectively. Additionally, the decrease in acidity of yogurts fortified with GS extract at different levels was obvious comparatively to the control sample (Demirbüker Kavak et al., 2019).

The results of the viscosity of the two analyzed products comply with the dairy standards Soummam (27500–32500 Centi Poise (CP)) but the viscosity of AP and GS-enriched yogurts is a little higher compared to the control. In line with Ahmad et al. (2020) results, it was observed that the addition of AP in yogurt reduced the syneresis while increased firmness and viscosity. A similar phenomenon was observed in yogurt with addition of apple pomace (Wang et al., 2020). However, according to El-Messery et al. (2019) encapsulated AP-supplemented yogurts exhibited lower apparent viscosities than non supplemented control yogurts. The decrease in viscosity may be attributed to a lower content of casein, because polyphenolic compounds extract powder encapsulated replaced a part of skimmed milk powder in yogurt. Demirkol and Tarakci (2018) similarly observed that grape pomace powder-fortified yogurts show lower viscosity values compared to non-fortified control yogurts.

Viscosity can be conditioned by the number and power of linkage among casein micelles of yogurt, and also their texture and spatial distribution. Other parameters such as the type of starter culture, type of stabilizer, processing methods, and heat treatment can have impact on the yogurt viscosity (Ahmad et al., 2020).

The results of the microbiological analyses of the two fortified yogurts (Table 6) showed clearly their perfect compliance with the standards. The total coliform bacteria group can be considered as an extensive group of several kinds of bacteria where there is a marked correlation between yogurt quality and safety (Demirbüker Kavak et al., 2019).

The coliform, yeast, and mould counts for all the yogurts were <10 cfu/g. These results indicate that the yogurts were produced under good sanitary conditions. The total count of the non-lactic acid bacteria in all the yogurt samples tested was <100 cfu/g which is a low and an acceptable target count.

These results stated the raw materials quality, adequate heat treatment applications, or hygienic production (Demirbüker Kavak et al., 2019).

TABLE 5 Results of the physico-chemical analysis of the enriched yogurts by apple peels (AP) and grape seeds (GS)

Parameters	Control	Yogurt with AP	Yogurt with GS	Reference (JORA)
pH	4.36	4.23	4.25	4.3–4.8
Acidity (D°)	79	86	80	78–100
Viscosity (CP)	30,100	30,200	30,180	27500–32500

Abbreviations: CP, centipoise; D, dornic degrees; JORA, Official Journal of the Republic of Algeria.

3.5.2 | Hedonic and sensory analysis

Color, texture, fragrance, acidity, sweetness, consistency, smell, fruity taste properties of fortified yogurts were evaluated as sensory attributes.

As shown in Figure 4, color, texture, and fragrance are the most discriminating attributes. These characteristics differ between the three yogurts with low p-values, they are followed by acidity, then

TABLE 6 Results of the microbiological analysis of the enriched yogurts by apple peels (AP) and grape seeds (GS)

	Researched germs				
	Total germ	Yeasts	Mold	Total coliforms	Fecal coliforms
Control	2. 10^2	00	Absence	00	00
YAP	3.10^2	00	Absence	00	00
YGS	2.10^2	00	Absence	00	00
Reference (JORA)	10^2	<100	Absence	<10	<1

Abbreviations: JORA, Official Journal of the Republic of Algeria; YAP, Yogourt with AP; YGS, Yogourt with GS.

FIGURE 4 Discriminating power by descriptor for the sensorial analysis

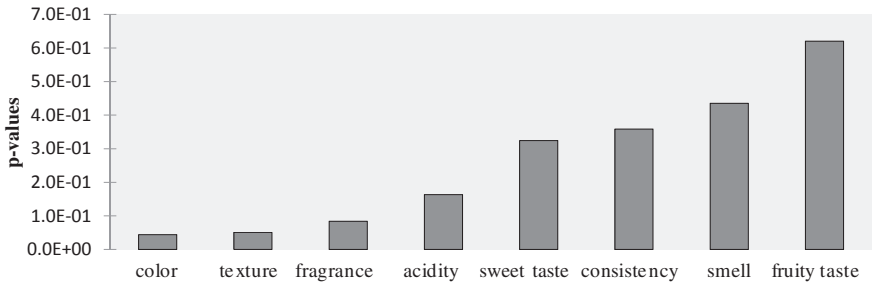
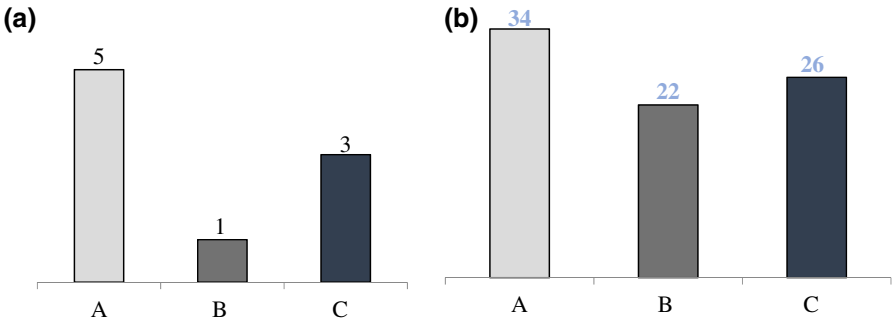


TABLE 7 Averages adjusted values of a different sensory attributes by product

	Consistancy	Fragrance	Sweetness	Fruity taste	Texture	Odor	Color	Acidity
YAP	3.4	3.8	3.0	4.7	3.2	4.6	3.4	4.8
YC	4.6	2.8	4.6	4.9	2.1	4.6	2.7	4.1
YGS	4.8	2.2	4.9	4.4	3.0	3.0	3.9	4.7

Abbreviations: YAP, Yogourt with AP;YC, Control; YGS, Yogourt with GS.

FIGURE 5 General preference of a produced yogurts by expert (a) and naive (b) subjects. A: yogurt made from GS; B: yogurt made from AP; C: control yogurt



sweetness, consistency, odor, and finally by the intensity of the fruity taste. This latter does not vary between the three samples.

Table 7 summarizes the averages adjusted values that were given by the expert panel for the analyzed attributes of the three elaborated samples. These results demonstrated that the texture and color differ between the three yogurt samples and the other attributes are of medium intensity. The yogurt fortified by AP was characterized by its more granulous texture compared to the yogurt fortified by GS, while the control has a smoother texture. Texture is an substantial sensory attribute for yogurt and enrichment with fruits extract affected its textural properties (Mendes et al., 2019). Wang et al. (2020) specified that soluble and insoluble fiber components of AP have impact on the texturizing ability of the enriched yogurt.

The color of the yogurt containing GS was more intense compared to the yogurt fortified by AP and to the control which have a lighter color.

The color measurements indicated that the supplemented yogurts by GS extracts from two different varieties were darker than the controls (Chouchouli et al., 2013).

According to Demirbüker Kavak et al. (2019) the yogurt enriched with GS impacted the sensory scores of quality attributes and the impact of fortification on color was clear. They noted that the

orange-light brown color of the GS extract attributed to its pigments such as anthocyanin which are positively involved to yogurt color.

The results of the hedonic analysis (Figure 5) revealed that the yogurt enriched with the GS powder (YGS) was the more appreciated one followed by the control. The yogurt enriched with AP (YAP) was the least preferred. This can be explained by the fact that the color of the YGS was more appreciated and it has a smoother texture compared to YAP and control. Color has an essential role in the food choice of consumers and it is the first characteristic perceived and thus often influences consumer preference (Mendes et al., 2019).

4 | CONCLUSION

In the current study, our vision was to optimize the extraction of phenolic compounds contained in by-products of apple (peels) and grape (seeds) which are much consumed and widely generated by the food industry worldwide including Algeria. Moreover, in order to valorize them, yogurts were fortified by their powders. It was shown that ethanol and acetone are the adequate solvents for the extraction of a maximum phenolics from AP and GS during 60 and 90 min, respectively.

The analysis of the extracts resulted from optimal conditions of extraction revealed that the studied by-products contained important contents of phenolic compounds and have a potent antioxidant activity.

The classification test demonstrated that yogurt fortified by GS was the most preferred by naive and expert subjects. The composition and the activities of AP and GS give them their beneficial role for health. Consumption of products enriched by these by-products is recommended to prevent certain diseases linked to oxidative stress.

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

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