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Effect of onion waste powder on the rheological characteristics, sensory attributes, and antioxidant properties of mayonnaise

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Abstract: The recovery and utilization of onion processing waste would contribute to the solution of environmental problems. This research presents the way of successful supplementation of onion processing waste in mayonnaise. Different levels (0, 1, 2, and 3%) of onion waste powder (OWP) were used as an additive to mayonnaise, based on sunflower oil. The final mayonnaise formulations were evaluated for sensory properties, rheological behaviour, oxidative stability, total phenolic content, total flavonoids, and antioxidant activity. The results indicated that OWP could be used as a potential health-promoting functional ingredient in amounts of 2% to produce mayonnaise enriched with total phenolic compounds and flavonoids, having high antioxidant activity, acceptable quality, and overall consumer preference.

Keywords: food; emulsion; health ingredient; quality

Consumer demand for nutritious, healthy, and fresh-like food products, with high organoleptic quality is increase (Zinoviadou et al. 2015). Evaluation of food products by consumers is not only in terms of nutritional needs, but also regarding the effect on their health. On the other side, in the new era of the COVID-19 pandemic, it is foreseen that consumers will increasingly seek products to boost their immune system in the future (Galanakis 2020). Supplementation of the food is one of the most used techniques for quality improvement of the products (Świeca et al. 2014; Prokopov et al. 2018a). Food waste is today considered a low-cost source of food additives with high added value, and significant efforts are being made to valorise it because of the environmental problems associated with its treatment and because of the great potential for the development of new products (Galanakis et al. 2018a,b). Different non-traditional extraction methods for nutraceuticals and techniques were proposed by several authors (Nagarajan et al. 2019; Sarfarazi et al. 2020). Onion processing waste (OPW) consists mainly of the top and bottom of onion bulbs and the two outer fleshy

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scales together with the brown skins. In our previous study, it was found that OPW powder could be potentially used as a value-added low-calorie functional food ingredient rich in dietary, mainly insoluble, fibre, and in total phenols and total flavonoids, mainly quercetin, with good antioxidant activity. The recovery and utilisation of OPW would also contribute to the solution of some environmental problems (Prokopov et al. 2018b).

Mayonnaise is one of the most widely consumed products worldwide for use in condiments or sauces (Alu'datt et al. 2017). Its structure, creaminess, appearance, and rheological behaviour are of outstanding importance for the sensory properties and perceived texture and also the physical stability parameters, which are the key factors for consumers' choice and satisfaction (Mattia et al. 2015). The addition of spices, pureed or dried vegetable pieces into food emulsions, improved their consumer acceptance and the overall flavour (Mihov et al. 2012).

Many types of research have been reported in the literature concerning the incorporation of different plant waste by-products and extracts for the enhancement of physicochemical properties, rheological behaviour, and lipid oxidation stability of mayonnaise (Park et al. 2019; Flamminii et al. 2020). To the best of our knowledge, there is no research, reported in the literature, on the effects of onion waste powder (OWP) addition on mayonnaise quality and consumer acceptability of such product. The importance and novelty of this research is the addition of OWP, like a health-promoting functional ingredient in mayonnaise with the objective of optimization and reduction of environmental pollution. Therefore, this research was carried out to find a way to successful supplementation of OWP in mayonnaise. The aim of this study is to use different concentrations of OWP to find out which one is most appropriate and will give the most successful results.

MATERIAL AND METHODS

Material

The industrial onion waste, used in this study, was obtained from a Bulgarian canning factory (Bulcons Parvomay JSC, Bulgaria). OWP was prepared as by Prokopov et al. (2018b). The ingredients, used in the preparation of mayonnaise, included 70% sunflower oil, 12% dry egg yolk, 1% salt, 0.5% sugar, 4% vinegar, 0.5% citric acid, purchased from the local market, and the remaining water.

Methods

Preparation of the mayonnaise. Dry egg yolk or partially replaced dry egg yolk with OWP at the 1, 2, and 3% levels, salt and sugar were blended in the water and homogenized for 1 min. The oil was then carefully mixed with the water phase. Finally, the dissolved in vinegar citric acid was added to the emulsion. Four samples were prepared – control sample with 0% OWP, mayonnaise with 1% OWP, mayonnaise with 2% OWP, and mayonnaise with 3% OWP. The mayonnaise was transferred to sterile 500 mL glass beakers and left at 4 °C before testing. Samples were taken after 1, 22, 43, and 64 days in three replications for analysis.

Determination of total phenolic and flavonoid contents and in-vitro antioxidant activity. For the extraction of phytochemical compounds (phenols and flavonoids), a sample (1 g) was extracted with methanol in a solid-to-liquid ratio of 1 : 25 (*w*/*v*). The extraction procedure was performed in temperature-controlled water bath on a magnetic stirrer (500 rpm) for 60 min at 60 °C. The obtained extract was twice vacuum filtered, through filter paper with anhydrous Na_2SO_4.

The total phenolic content of the extract (TPC) was determined using Folin-Ciocalteu's reagent according to Stintzing et al. (2005). Gallic acid was used as a calibration standard and the results were expressed as mg gallic acid equivalents (GAE)·g^{-1} on a dry weight basis (d.w.) as described by Prokopov et al. (2018a,b).

The total flavonoid (TF) content of the extract was determined using an $Al(NO_3)_3$ reagent and measuring the absorbance at 415 nm according to Kivrak et al. (2009). The results were presented as mg quercetin equivalents (QE)·g^{-1} d.w. (Prokopov et al. 2018a,b).

The antioxidant activity was evaluated by two methods: DPPH (1,1-diphenyl-2-picrylhydrazyl) radical based on mixed hydrogen atom transfer (HAT) and FRAP (ferric reducing antioxidant power) based only on the single electron transfer mechanism (Benzie and Strain 1996). The results were expressed as mM Trolox® equivalents (TE)·g^{-1} d.w. (Prokopov et al. 2018a,b).

Determination of oxidative stability. For the determination of the oxidative stability of mayonnaise samples, the Soxhlet extraction of lipids was carried out. Acid and peroxide values (AV and PV) were determined according to ISO 660 (2009) and ISO 3960 (2007), respectively. p-Anisidine value (p-AV) was determined according to AOCS (1998).

Rheological properties. The rheological measurements of the samples were carried out at a temperature of 20 °C with a rotational rheometer (Reotest 2,

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Germany) using a system of coaxial cylinders (Dolz et al. 2007). The flow curves (shear stress *vs.* shear rate and viscosity *vs.* shear rate) were fitted at increasing shear rates: 0.17–72.9·s^{-1}. The apparent viscosity was measured, i.e. the shear stress as a function of the rotation velocity.

Sensory analysis. The Quantitative Descriptive Analysis (QDA) was performed by a trained sensory panel consisting of 12 trained assessors (Carpenter et al. 2000). The mayonnaise samples of 5 g were placed on white plastic glass and labelled with a three-digit code. The performance conditions were standard, during daytime and under regular room temperature (20 °C). The temperature of the samples was 4 ± 1 °C.

The list of specific attributes and sensory descriptors was defined and focused on appearance: colour (intensity of yellow colour), brightness (mat to bright), emulsion stability (separate oil – stability); texture: consistency (thin to thick), adhesion (stickiness), oiliness (watery to oily), homogeneity (homogenous to heterogeneous); smell (weak to strong): onion, rancid; taste (weak to strong): salty, sour, bitter, onion, rancid; aftertaste (weak to strong): bitter, onion; overall acceptability: bad to very good. The analysis was performed by scoring attributes on a structural scale from 0 to 9 points, where a higher score means more expressed attributes.

Statistical analysis. All data were statistically evaluated by means of one-way analysis of variance (ANOVA) and Tukey's test ($P < 0.05$) to establish the statistical significance of the differences between the mayonnaise samples.

RESULTS AND DISCUSSION

Effect of OWP addition on the total phenolic and total flavonoids content and the antioxidant activity of mayonnaise. For the evaluation of the OWP effect on the antioxidant activity of the resulting mayonnaise, the total phenolic and total flavonoids content, the DPPH and FRAP values in mayonnaise samples with different levels of added OWP were determined and the results presented in Table 1. Data indicated increases in TPC, TF, and antioxidant activity, evaluated by DPPH and FRAP methods, with increasing added OWP levels. The TPC, TF, and antioxidant activity of mayonnaise samples with added OWP were significantly higher compared to the control sample. The obtained results for antioxidant activity are comparable to those obtained by Shabbir et al. (2015) for the addition of sesame sprout powder in mayonnaise. The addition of an OWP level of 2% led to significant increases in TPC, TF, DPPH, and FRAP values of approximately 2.7, 2.0, 2.8, and 3.1-fold, respectively in comparison with the control mayonnaise sample.

The levels of antioxidant activity (Table 1) were close to the recommended values of 5–15 mM TE as necessary to cover the human daily antioxidant needs (Denev et al. 2013). The results suggested that a daily intake of two tablespoons (28 g) of mayonnaise with 21.22% moisture content and 2% OWP could deliver approximately 37.81 mg GAE of total phenols and 20.78 mg QE of total flavonoids which could render additional health benefits to the human body. Similar results were reported in a study for white bread (intake of 50 g) incorporated with 3% OWP (Prokopov et al. 2018a). In another study, Lim et al. (2011) also observed that a daily intake of 50 g or two slices of bread having 4% turmeric powder could deliver 40.12 mg GAE of total phenolic compounds. Data in Table 1 indicated the possible application of OWP to the formulation of mayonnaise with health-promoting ingredients.

Effect of OWP addition on oxidative stability of mayonnaise lipid phase. To test the effect of OWP addition on the oxidative stability of mayonnaise samples, the AV, PV, and p-AV were determined during the investigated storage period. The AV of extracted lipids

Table 1. Total phenolic content, total flavonoids, and antioxidant activity of mayonnaise with different levels of added OWP

Levels of added OWP (%)	Total phenolic content (TPC) (mg GAE·g^{-1} d.w.)	Total flavonoids (TF) (mg QE·g^{-1} d.w.)	Antioxidant activity (mM TE·g^{-1} d.w.)	
			DPPH	FRAP
0 (control)	0.641^{a}	0.476^{a}	1.12^{a}	ND
1	0.817^{b}	0.579^{b}	1.88^{b}	2.64^{a}
2	1.714^{c}	0.942^{c}	3.17^{c}	3.05^{b}
3	2.442^{d}	1.640^{d}	5.28^{d}	4.03^{c}

* mean ± SD of three independent measurements; $^{a-d}$ significantly different values ($P < 0.05$); OWP – onion waste powder; GAE – gallic acid equivalents; QE – quercetin equivalents; TE – Trolox® equivalents; DPPH – 1,1-diphenyl-2-picrylhydrazyl; FRAP – ferric reducing antioxidant power; ND – not detected

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is an indicator for lipid hydrolysis and the formation of free fatty acids, while the PV and p-AV indicated primary and secondary oxidation stages of mayonnaise, respectively (Kishk and Elsheshetawy 2013). The oxidative stability of the lipid phase of mayonnaise samples with different levels of added OWP during storage at 4 °C is presented in Table 2.

The results indicated that the AV, PV, and p-AV of all samples significantly increased during the storage period. Similar trends were reported by Kishk and Elsheshetawy (2013) for mayonnaise with added ginger powder. However, in our study, we found that the AVs and p-AVs of samples with added OWP were higher than the control sample after 64 days of storage at 4 °C. While the PVs of OWP-added samples were not statistically different ($P > 0.05$) or close to the control for the same storage period. On the other side, the results for PVs of the mayonnaise enriched with 1% and 2% OWP after 22 and 43 days of storage were lower than that of the control.

Therefore, added OPW might retard oxidation in the early stage. Similar results were reported by Park et al. (2019). Generally , the results obtained in the study for oxidative stability of the mayonnaise lipid phase could be explained by the fact that quercetin, which is the main antioxidant consisted in OWP (Prokopov et al. 2018b), did not show a significant antioxidant effect in sunflower oil containing natural tocopherols with added citric acid (Roeding-Penman and Gordon 1998). Nevertheless, the data in Table 2 indicated that AVs, PVs, and p-AVs of the mayonnaise with 1% and 2% added OWP were below the set limits for such type of product (Codex Alimentarius) after 43 days of storage and was oxidative stable and suitable for consumption.

Effect of OWP addition on rheological properties of mayonnaise. Rheological behaviour is of considerable importance for the physical stability of the food emulsion system. Flow curves of mayonnaise with different levels of OWP are presented in Figure 1. They showed non-Newtonian, pseudo-plastic flow.

The control sample (0% OWP) exhibited the highest rate of non-Newtonian properties, followed by the sample with 1% OWP. All the mayonnaises studied exhibited non-ideal plastic behaviour. The Herschel-Bulkley model described this rheological behaviour of products most accurately and the addition of OWP did not influence the rheological properties of newly developed products.

Flow behaviour curves (apparent viscosity/shear rate) of mayonnaise samples containing different levels of OWP are shown in Figure 2.

Mayonnaise samples with OWP have high viscosity or visco-elastic properties. Control sample and the mayonnaise with 1% OWP had high viscosity, particularly for high values of shear rate. With the increase

Table 2. Oxidative stability of lipids extracted from mayonnaise with different levels of added OWP

Levels of added OWP (%)	Period of storage (days)			
	1	22	43	64
Acid value (AV), mg KOH·g^{-1} oil				
0 (control)	0.28 ± 0.01^{aA}	0.39 ± 0.01^{bA}	0.53 ± 0.01^{cA}	0.66 ± 0.01^{dA}
1	0.31 ± 0.01^{aB}	0.42 ± 0.01^{bB}	0.55 ± 0.01^{cB}	0.77 ± 0.03^{dB}
2	0.33 ± 0.02^{aB}	0.45 ± 0.02^{bC}	0.59 ± 0.01^{cC}	0.76 ± 0.01^{dB}
3	0.36 ± 0.01^{aC}	0.55 ± 0.01^{bD}	0.75 ± 0.01^{cD}	0.89 ± 0.02^{dC}
Peroxide value (PV), meq O$_2$·kg^{-1} oil				
0 (control)	0.12 ± 0.02^{aA}	0.45 ± 0.03^{bA}	0.57 ± 0.03^{cA}	0.71 ± 0.03^{dA}
1	0.13 ± 0.03^{aA}	0.24 ± 0.02^{bB}	0.41 ± 0.03^{cB}	0.67 ± 0.03^{dA}
2	0.21 ± 0.03^{aB}	0.34 ± 0.03^{bC}	0.53 ± 0.03^{cC}	0.81 ± 0.03^{dB}
3	0.39 ± 0.03^{aC}	0.51 ± 0.03^{bD}	0.62 ± 0.03^{cD}	0.88 ± 0.03^{dC}
p-Anisidine value (p-AV)				
0 (control)	2.22 ± 0.03^{aA}	2.92 ± 0.03^{bA}	3.30 ± 0.04^{cA}	3.79 ± 0.03^{dA}
1	2.28 ± 0.03^{aB}	3.06 ± 0.03^{bB}	3.50 ± 0.03^{cB}	3.99 ± 0.03^{dB}
2	3.09 ± 0.03^{aC}	3.36 ± 0.04^{bC}	3.88 ± 0.03^{cC}	4.55 ± 0.03^{dC}
3	3.20 ± 0.03^{aD}	3.58 ± 0.03^{bD}	3.78 ± 0.03^{cD}	3.96 ± 0.04^{dD}

* mean ± SD of three independent measurements; $^{A–D}$ significantly different values within each column and individual indicator ($P < 0.05$); $^{a–d}$ significantly different values within each row ($P < 0.05$); OWP – onion waste powder

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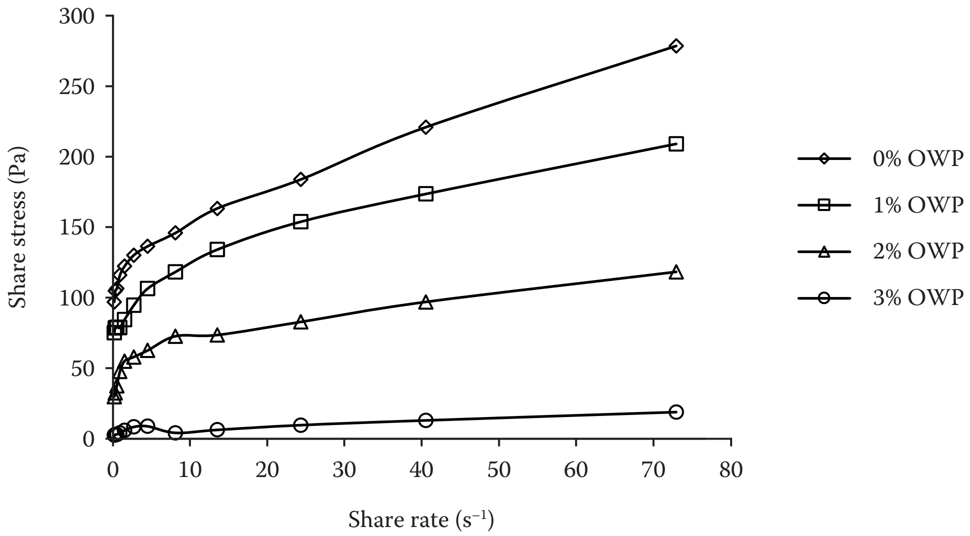

Figure 1. Flow curves of the mayonnaise with different levels of OWP

OWP – onion waste powder

in shear rate a decrease in the apparent viscosity of all samples occurred. The apparent viscosity of samples decreased with increasing the content of the OWP. The increase OWP influenced emulsifying capacity and emulsions stability of the food system because of the reduced egg yolk content.

Effect of OWP addition on sensory quality of mayonnaise. The results of sensory analysis of mayonnaise samples with different levels of added OWP are presented in Table 3. For all samples, there were no statistical differences in colour. Using OWP up to 3% did not influence the mayonnaise colour considerably. According to the brightness, the control sample was evaluated as the brightest one and the powder made the product more turbid. The emulsion stability and consistency were different. The samples with 3% OWP were perceived as the most unstable and thin. This could be due to the percentage of OWP used instead of egg yolk. Thus, the emulsifying activity of the yolk lecithin was decreased. The panellists evaluated the sensory attribute adhesion with a lower score. The perception of mayonnaise's oily texture decreased with the increasing content of OWP. Regarding homogeneity of the sample, the control (0% OWP) was perceived as the product with more homogenous consistency. The descriptive analysis of mayonnaise samples with OWP showed

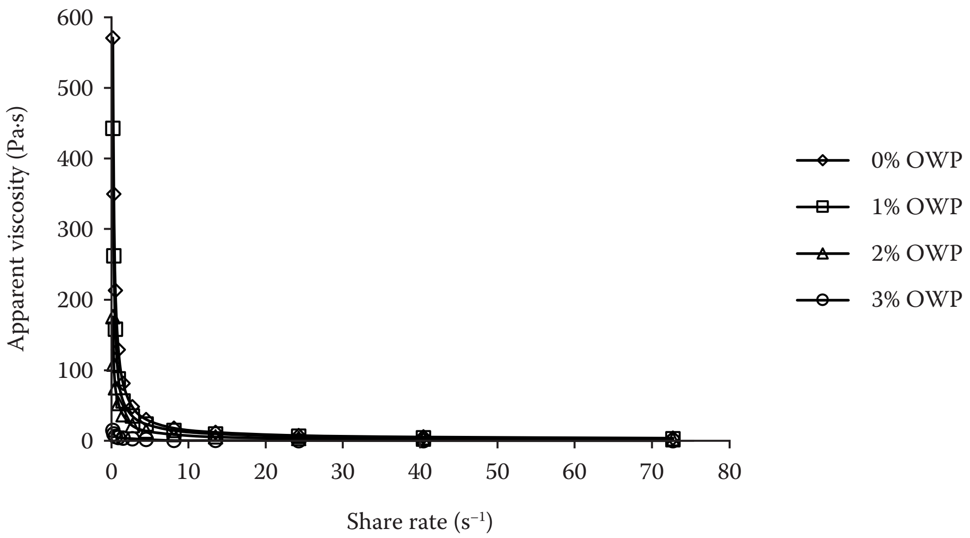

Figure 2. Apparent viscosity of the mayonnaise with different levels of OWP

OWP – onion waste powder

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Table 3. Sensory evaluation of mayonnaise with different levels of added OWP

Sensory descriptors	Levels of added OWP (%)			
	0 (control)	1	2	3
Yellow colour	4.27 ± 1.3^{a}	4.23 ± 0.8^{a}	4.38 ± 0.5^{a}	4.41 ± 0.4^{a}
Brightness	7.55 ± 1.0^{a}	5.45 ± 0.6^{b}	6.27 ± 0.5^{c}	5.00 ± 0.6^{b}
Stability	8.05 ± 0.9^{a}	7.14 ± 1.2^{b}	7.59 ± 0.9^{b}	5.00 ± 1.0^{c}
Consistency	7.64 ± 0.4^{a}	6.50 ± 0.5^{b}	5.64 ± 0.5^{c}	2.91 ± 0.7^{d}
Adhesion	1.00 ± 1.3^{a}	2.27 ± 0.8^{b}	1.18 ± 0.7^{a}	2.18 ± 0.7^{b}
Oiliness	8.05 ± 0.4^{a}	6.27 ± 0.5^{b}	5.82 ± 0.5^{c}	4.82 ± 0.6^{d}
Homogeneity	7.95 ± 1.0^{a}	6.45 ± 0.9^{b}	6.09 ± 0.8^{b}	5.00 ± 0.8^{c}
Onion smell	0.18 ± 0.02^{a}	4.82 ± 0.8^{b}	6.36 ± 1.0^{c}	6.51 ± 1.1^{c}
Rancid smell	0.47 ± 0.1^{a}	0.50 ± 0.2^{a}	0.46 ± 0.1^{a}	0.58 ± 0.1^{a}
Salty taste	5.85 ± 1.0^{a}	6.00 ± 1.1^{a}	6.00 ± 0.7^{a}	6.43 ± 0.9^{a}
Onion taste	0.18 ± 0.02^{a}	5.36 ± 0.6^{b}	6.50 ± 0.8^{c}	7.73 ± 0.8^{d}
Sour taste	6.50 ± 0.8^{a}	6.91 ± 0.7^{b}	7.32 ± 0.7^{b}	7.00 ± 1.0^{b}
Rancid taste	0.00^{a}	0.27 ± 0.01^{b}	$0,18 \pm 0.01^{b}$	$0,26 \pm 0.02^{b}$
Bitter aftertaste	0.18 ± 0.01^{a}	0.50 ± 0.1^{b}	0.46 ± 0.1^{b}	0.45 ± 0.1^{b}
Onion aftertaste	0.09 ± 0.01^{a}	4.45 ± 0.7^{b}	5.09 ± 0.9^{c}	6.36 ± 1.1^{d}
Overall acceptability	$4,95 \pm 0.7^{a}$	$7,05 \pm 1.1^{b}$	$8,45 \pm 0.9^{c}$	$5,55 \pm 0.5^{d}$

* mean ± SD (n = 12); $^{a-d}$ significantly different values (*P* < 0.05); OWP – onion waste powder

that there were no significant differences in the sensory characteristics including salty and sour taste, and bitter aftertaste. For all samples, there were no statistical differences in rancid smell and taste due to the high quality of the sunflower oil. The mayonnaise with 2% OWP obtained the highest score in overall acceptability compared to the control and the other samples.

CONCLUSION

Quality characteristics of mayonnaise products with added OWP were performed. It was demonstrated utilising the sensory attribute of overall acceptability that the panellists scored the highest in mayonnaise samples with 2% OWP. The use of OWP did not influence the rheological model of mayonnaise. The increase in OWP content decreased the viscosity of the emulsions because of the reduced egg yolk emulsifier. Mayonnaise with 2% added OWP was oxidative stable after 43 days of storage and suitable for consumption. The addition of OWP into mayonnaise increased significantly the TPC, TF, and antioxidant activity of the final product. The data of the analyses showed that OWP in mayonnaise could be successfully supplemented. The addition of 2% OWP has the greatest effect on the quality characteristics of mayonnaise. The results of this study may be used in the commercial development of mayonnaise products with OWP that would appeal to consumers.

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REFERENCES

Alu'datt M., Rababbah T., Alhmad M., Ereifej K., Gammoh S., Kubow S., Tawalbeh D. (2017): Preparation of mayonnaise from extracted plant protein isolates of chickpea, broad bean and lupin flour: Chemical and therapeutic properties. Journal of Food Science and Technology, 54: 1395–1405.

AOCS (1998): Official methods of analysis. American oil chemists' society. Method Cd 18-90. Washington DC. Available at https://www.aocs.org/attain-lab-services/methods?SSO=True (accessed Feb 2, 2023).

Benzie I., Strain J. (1996): The ferric reducing ability of plasma (FRAP) as a measure of antioxidant power: The FRAP assay. Analytical Biochemistry, 239: 70–76.

Carpenter R.P., Lyon D.H., Hasdell T.A. (2000): Guidelines for Sensory Analysis in Food Product Development and Quality Control. Springer, New York: 210.

https://doi.org/10.17221/19/2023-CJFS

Denev P., Lojek A., Ciz M., Kratchanova M. (2013): Antioxidant activity and polyphenol content of Bulgarian fruits. Bulgarian Journal of Agricultural Science, 19: 22–27.

Dolz M., Hernández M., Delegido J., Alfaro M., Muñoz J. (2007): Influence of xanthan gum and locust bean gum upon flow and thixotropic behaviour of food emulsions containing modified starch. Journal of Food Engineering, 81: 179–186.

Flamminii F., Mattia C., Sacehetti G., Neri L., Mastrocola D., Pittia P. (2020): Physical and sensory properties of mayonnaise enriched with encapsulated olive leaf phenolic extracts. Foods, 9: 997.

Galanakis C. (2020): The food systems in the era of the coronavirus (COVID-19) pandemic crisis. Foods, 9: 523.

Galanakis C., Tsatalas P., Charalambous Z., Galanakis I. (2018a): Control of microbial growth in bakery products fortified with polyphenols recovered from olive mill wastewater. Environmetal technology & Innovation, 10: 1–15.

Galanakis C., Tsatalas P., Charalambous Z., Galanakis I. (2018b): Polyphenols recovered from olive mill wastewater as natural preservatives in extra virgin olive oils and refined olive kernel oils. Environmental Technology & Innovation, 10: 62–70.

ISO 3960 (2007): Animal and vegetable fats and oils – Determination of peroxide value – Iodometric (visual) endpoint determination. International Organization for Standardization, Geneva. Available at https://www.iso.org/standard/39158.html (accessed Feb 2, 2023).

ISO 660 (2009): Animal and vegetable fats and oils – Determination of acid value and acidity. International Organization for Standardization, Geneva. Available at https://www.iso.org/standard/44879.html (accessed Feb 2, 2023).

Kishk Y., Elsheshetawy H. (2013): Effect of ginger powder on the mayonnaise oxidative stability, rheological measurements, and sensory characteristics. Annals of Agricultural Science, 58: 213–220.

Kivrak I., Duru M., Öztürk M., Mercan N., Harmandar M., Topçu G. (2009): Antioxidant, anticholinesterase and antimicrobial constituents from the essential oil and ethanol extract of *Salvia potentillifolia*. Food Chemistry, 116: 470–479.

Lim H., Park S., Ghafoor K., Hwang S., Park J. (2011): Quality and antioxidant properties of bread containing turmeric (*Curcuma longa* L.) cultivated in South Korea. Food Chemistry, 124: 1577–1582.

Mattia C., Balestra F., Sacchetti G., Neri L., Mastrocola D., Pittia P. (2015): Physical and structural properties of extra-virgin olive oil based mayonnaise. LWT – Food Science and Technology, 62: 764–770.

Mihov R., Nikovska K., Nenov N., Slavchev A. (2012): Evaluation of mayonnaise like food emulsions with extracts of herbs and spices. Emirates Journal of Food & Agriculture, 24: 191–199.

Nagarajan J., Krishnamurthy N., Remaron R., Raghunandan M., Galanakis C., Ooi C. (2019): Afacile water-induced complexation of lycopene and pectine from pink guava byproduct: Extraction, characterisation and kinetic studies. Food Chemistry, 296: 47–55.

Park B., Kim J., Lee K., Him T., Hwong K. (2019): Flavonoids in common and tartary buckwheat hull extracts and antioxidant activity of the extracts against lipids in mayonnaise. Journal of Food Science and Technology, 56: 2712–2720.

Prokopov T., Chonova V., Slavov A., Dessev T., Dimitrov N., Petkova N. (2018a): Effects on the quality and health-enhancing properties of wheat bread of the addition of industrial onion waste powder. Journal of Food Science and Technology, 55: 5091–5097.

Prokopov T., Slavov A., Petkova N., Yanakieva V., Bozadzhiev B., Taneva D. (2018b): Study of onion processing waste powder for potential use in food sector. Acta Alimentaria, 47: 181–188.

Roeding-Penman A., Gordon M. (1998): Antioxidant properties of myricetin and quercetin in oil and emulsions. Journal of American Oil Chemists' Society, 75: 169–180.

Sarforazi M., Jafari S., Rajabzadeh G., Galanakis C. (2020): Evaluation of microwave-assisted extraction technology for separation of bioactive components of saffron (*Crocus sativus* L.). Industrial Crops & Products, 145: 111978.

Shabbir M., Iftakhar F., Khan M., Murtaza M., Saeed M., Mahmood J., Siraj N. (2015): Effect of sesame sprouts powder on the quality and oxidative stability of mayonnaise. Journal of Food and Nutritional Research, 3: 138–145.

Stintzing F., Nerbach K., Mosshammer M., Carle R., Yi W., Sellappan S., Acoh C., Bunch R., Felker P. (2005): Color, betalain pattern and antioxidant properties of cactus pear (*Opuntia* spp.) clones. Journal of Agricultural and Food Chemistry, 53: 442–451.

Świeca M., Sęczyk Ł., Gawlik-Dziki U., Dziki D. (2014): Bread enriched with quinoa leaves – The influence of protein-phenolics interactions on the nutritional and antioxidant quality. Food Chemistry, 162: 54–62.

Zinoviadou K., Galanakis C., Brnĉić M., Gimi N., Bousetta N., Mota M., Saravia J., Patras A., Tiwari B., Barba F. (2015): Fruit juice sonication: Implementations on food safety and physicochemical and nutritional properties. Food Research International, 72: 743–752.

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