Joanna KOBUS-CISOWSKA[1], Agnieszka ZAWADZKA[1], Aleksandra TELICHOWSKA[2], Piotr SZULC[3]
[1] Poznan University of Life Sciences, Faculty of Food Science and Nutrition, Department of Gastronomy Science and Functional Foods, Poznań, Poland
[2] Foundation for the Education of Innovation and Implementation of Modern Technologies, Poznań, Poland
[3] Poznan University of Life Sciences, Department of Agronomy, Poznan, Poland
e:mail: joanna.kobus@up.poznan.pl

Received: 2021-11-08; Accepted: 2021-12-03

AN EFFECT OF PASTEURIZATION OF FUNCTIONAL PRODUCTS ON THE BASIS OF A MOUSSE-TYPE COCONUT WATER ON THE STABILITY OF BIOLOGICALLY ACTIVE COMPOUNDS AND ANTI-OXIDATION POTENTIAL

Summary

Coconut water is an increasingly popular raw material, mainly due to its hydrating and health-promoting properties. The aim of the work was to develop exemplary model fruit mousses with coconut water and to evaluate the effect of thermal fixation processes on the stability of polyphenols and antiradical activity, which were pasteurized and stored for 6 months in real conditions. The nutritional value of the mousses, i.e. the content of vitamins and minerals, was determined, and the influence of storage on the content of polyphenols and antioxidant properties measured with the DPPH radical and ABTS$^{\bullet+}$ radical cation methods was assessed. It has been shown that coconut water can be an ingredient in mousses, which allows for the creation of new dessert products. It was found that the developed products contained compounds of antioxidant nature. The highest content of phenolic compounds was found in the sample with the addition of protein 178.43^b±11.39 µg gallic acid/mL. The content of polyphenols in the tested samples was stable during storage. In the test with the use of ABTS$^{\bullet+}$ radicals, the highest activity was shown by mousse with the addition of caffeine tested one day after preparation (4.43^a±0.24 TE/g dw), while in the test with the use of DPPH radicals, the sample tested one day after preparation with the addition of almond protein had the highest activity anti-radical (6.87^a±0.37 TE/g dw). The highest total acidity was recorded in the case of mousses with the addition of almond protein (MPr - 0.84^a±0.03 g / 100 g).

***Key words**: coconut water, mousses, caffeine, collagen, almond protein, DPPH, ABTS*

WPŁYW PASTERYZACJI PRODUKTÓW FUNKCJONALNYCH NA BAZIE WODY KOKOSOWEJ TYPU MUS NA STABILNOŚĆ ZWIĄZKÓW BIOLOGICZNIE AKTYWNYCH ORAZ POTENCJAŁ PRZECIWUTLENIAJĄCY

Streszczenie

Woda kokosowa jest coraz bardziej popularnym surowcem, głównie ze względu na swoje właściwości nawadniające i prozdrowotne. Celem pracy było opracowanie przykładowych, modelowych musów owocowych z udziałem wody kokosowej oraz ocena wpływu procesów utrwalania termicznego na stabilność polifenoli i aktywność przeciwrodnikową, które poddano pasteryzacji i przechowywano przez 6 miesięcy w warunkach rzeczywistych. W musach ustalono wartość odżywczą, tj. zawartość witamin i składników mineralnych, a także oceniono wpływ przechowywania na zawartość polifenoli i właściwości przeciwutleniające mierzone metodami z rodnikiem DPPH oraz kationorodnikiem ABTS$^{\bullet+}$. Wykazano, że woda kokosowa może być składnikiem musów, co pozwala na uzyskanie nowych produktów deserowych. Stwierdzono, że opracowane produkty zawierały związki o charakterze przeciwutleniaczy. Najwyższą zawartość związków fenolowych stwierdzono w próbie z dodatkiem białka 178.43^b±11.39 µg kwasu galusowego/mL. Zawartość polifenoli w badanych próbach była stabilna w czasie przechowywania. W teście z wykorzystaniem rodników ABTS$^{\bullet+}$ najwyższą aktywność wykazał mus z dodatkiem kofeiny poddany badaniom jeden dzień po przygotowaniu (4.43^a±0.24 TE/g s.m.), natomiast w badaniu z zastosowaniem rodników DPPH próba zbadana jeden dzień po przygotowaniu z dodatkiem białka migdałowego wykazała najwyższą aktywność przeciwrodnikową (6.87^a±0.37 TE/g s.m.). Najwyższą kwasowość ogólną odnotowano w przypadku musów z dodatkiem białka migdałowego (MPr - 0.84^a±0.03 TE/g s.m.).

***Słowa kluczowe**: woda kokosowa, musy, kofeina, kolagen, białko migdałowe, DPPH, ABTS*

1. Introduction

The chemical composition of coconut is influenced by several factors such as geographic location, age, variety, seasons, and environmental conditions, mainly rainfall and temperature in the area. Fresh coconut pulp contains about 47% of water, 34% of fat, 15% of carbohydrates, and about 4% of wholesome protein. Carbohydrates include fiber (11%) as well as starch and sugars (4%) [1–3].

The flesh is fit for consumption when it obtains a soft, jelly-like consistency. This happens about 7 months after flowering, in the following months, the endosperm hardens and turns into fennel. During this time, the coconut fruit can contain up to 1 liter of water. As the flesh hardens, the water content decreases, while the fat content increases [4–8].

Coconut water is a transparent liquid that is obtained from coconut in 5-7 months of maturity. In 1998, coconut water was recognized by the United Nations Food and Agriculture Organization (FAO) as a natural isotonic drink. It contains more potassium than most sports drinks and significantly less sodium. Coconut water has a positive effect on the bioavailability of many nutrients and digestion, while the minerals contained in it, such as magnesium and potassium, have a positive effect on blood pressure and heart function, while the ballast substances and amino acids in coconut water optimize insulin [3, 9].

Most of the processing processes used in the food industry negatively affect the stability of bioactive ingredients and the antioxidant potential of plant raw materials. As antioxidants in food, polyphenols act in several directions: they bind free radicals, quench singlet oxygen, terminate free radical chain reactions, chelate metals catalyze oxidation reactions, and inactivate oxidase enzymes [10]. On the other hand, they can influence the stabilization of plant hormones, e.g. kinetins, or cause a protective effect against each other. Coconut water is a functional drink popular in Asia [11–13]. In Poland, its popularity is growing intensively, which results from consumer awareness of its functional and isotonic properties. Coconut water has many benefits, mainly due to its composition and effect, not only in terms of effective hydration but also in stimulating metabolic processes in the body. Due to the growing popularity of coconut water, the range of products made with its participation should be increased.

The aim of the work was to develop exemplary model fruit mousses with coconut water and to evaluate the effect of thermal fixation processes on the stability of polyphenols and antiradical activity, which were pasteurized and stored for 6 months in real conditions.

2. Material

The research material was "Coconaut" brand coconut water obtained directly from the manufacturer Quest Food (Poland). The water after pasteurization came from Vietnam and was obtained from young coconuts (7 months old). The liquid was colorless, clear, slightly cloudy with a characteristic coconut flavor and odor. The research material was also anhydrous microcapsule caffeine (BEAN'ERGY - BEA 90°C), produced by Comercial Química Massó, S.A. Its energy value was 4.7 kcal per 100 g, including 1.2 g of carbohydrates, 19 mg of sodium, and 7 mg of potassium Another research material was hydrolyzed fish collagen, brand "Pure Gold Collagen", and almond protein, organic (All Organic Treasures GmbH) with a protein content of 53%. Single ingredients were used, such as apple puree, mango puree, cupuacu puree, cashews, banana puree, almond milk, maca, apple juice, guava puree, pitaya puree, orange juice, passion fruit juice and puree, graviola puree, and acai fruit puree purchased in the retail chain of the city of Poznań.

3. Methods

3.1. Development of the composition and technology to produce mousses

To develop the composition of individual samples, the available literature data on issues related to the technology of developing functional food of this type was used. The recipes, proportions, and composition of all obtained mousses have been developed to obtain products with the best sensory values and functional properties. The proportions of the components were formulated according to theoretical calculations in Microsoft Office Excel. The main goal was to obtain recipes that are characterized primarily by high content of coconut water and the addition of functional ingredients (almond protein, caffeine, and collagen), as well as other individual ingredients enhancing the sensory properties of the obtained products. The obtained mousses were pasteurized (temperature 85°C, 5 min). In this way, three variants of the tests were obtained: protein mousse (MPr), caffeine mousse (MCaf), and collagen mousse (MCol), which were stored under real conditions, i.e. at 21°C, until the analyzes were performed. Before the tests, the mousses were centrifuged in a centrifuge (2697 x g, 10 min), and a clear supernatant solution was used for the tests.

3.2. Nutritional value designation

The nutritional value of the obtained mousses was calculated using the Aliant program. Information on the nutritional value of individual products was taken from the USDA database (U.S. Department of Agriculture). In addition, the energy value of the tested products was calculated in accordance with the Regulation of the Minister of Health of 25 July 2007 on labeling food with nutritional value (Journal of Laws of 2007, No. 137, item 967). According to the regulation, the energy value should be specified in kilojoules (kJ) and kilocalories (kcal), considering the relevant conversion factors: 17 kJ / g and 4 kcal / g (proteins and carbohydrates) and 37 kJ / g and 9 kcal / g (fat).

3.3. Determination of total acidity

Titratable acidity (potential) is a measure of the content of acidic chemicals, organic and inorganic acids and their acid hydrolysable salts. The acid-base titration consisted of titration of acids with a standard sodium hydroxide solution against the indicator - bromothymol blue, the color change of which from yellow to blue indicated the end of the titration. The total acidity was determined, which refers to the total content of acids and acid salts in 100 g of the product, and the result is expressed in degrees of acidity. The degree of acidity is the number of cm^3 of 1 M sodium hydroxide solution used to neutralize the free acids and hydrogen salts contained in 100 g of the product.

3.4. Determination of the total content of compounds reactive with the Folin-Ciocalteu reagent

A volume of 0.2 mL of the sample was mixed with 0.8 mL of acetonitrile and centrifuged (12000 g, 20 min.). Supernatant after centrifugation (0.01 mL) was mixed with 0.04 mL of DDI water, 750 µl of F-C reagent, and after 5 min, with 750 µl of 7.5% Na_2CO_3 water solution. After 2 h, the absorbance was read at 760 nm against the reagent sample (containing water, F-C reagent, and Na_2CO_3 [14]. The calibration curve was prepared using 0.34 mg of gallic acid dissolved in 0.5 mL DDI water and 0.5 mL of acetonitrile. Fifteen solutions (1.12-24 µg gallic acid/50 µl) were prepared. To these solutions, 750 µl of F-C reagent and, after 5 min, 750 µl of 7.5% Na_2CO_3 water solution were added followed by the measurement.

3.5. Determination of antioxidant activity using the ABTS and DPPH radicals

The DPPH procedure was based on the reduction of DPPH solution absorbance (2,2-diphenyl-1-picrylhydrazyl) at wavelength 517 nm in the presence of free radicals [15]. Measurements were performed using SP-830 Plus apparatus (Metertech, Taiwan). The percentage of DPPH radical scavenging was evaluated based on the standard curve for $y = 321.54x + 21.54$ ($R^2 = 0.986$) and presented as mg TE/1 g d.w. of extract.

The $ABTS^{\bullet+}$ cation radical scavenging activity was measured according to the TEAC (Trolox Equivalent Antioxidant Capacity) test according to the methodology described by Kobus-Cisowska et al. [15]. Spectrophotometric measurement of the ability to scavenge $ABTS^{\bullet+}$ formed from ABTS (2,20-azinobis-(3-ethylbenzothiazoline-6-sulphonic acid) by oxidation with potassium persulphate was carried out at a wavelength of 414 nm using SP-830 Plus apparatus (Metertech, Taiwan). The percentage rate of ABTS$^{\bullet+}$ scavenging was calculated from the standard curve for y = 121.63x +26.33 (R^2 = 0.96) and expressed as mg TE/g d.w. of extract.

3.6. Statistical analysis

Statistical analysis of all results was performed using Microsoft Excel 2013 software (USA) and Statistica 13 software (StatSoft, Poland). All assays were conducted in triplicates and results were expressed as mean ± SD. One-way ANOVA testing was used to analyze statistical differences. The *p* value less than 0.05 was assumed as a level of significance.

4. Results

4.1. Product recipe development

Proper preparation of the product recipe is of great importance not only for the producer but also for the consumer. Properly selected ingredients of processed products determine the popularity of the product on the market, and those belonging to the group of functional products, being popular, may affect human health. As part of the research, 3 products were developed in which coconut water was the basic ingredient, then the mousses were supplemented with a second ingredient determining the functionality of the product (almond protein, caffeine, collagen) and other recipe ingredients were included. The description of the recipes for each trial is presented in Tab. 1-3.

Table 1. The recipe composition of coconut mousse as a source of protein (MPr)
Tab. 1. Skład recepturowy musu kokosowego będącego źródłem białka (MPr)

Mousse MPr	In 100 g of the product	In a portion of 120 g
Apple puree	23.5	28.2
Coconut water	21.4	25.7
Mango puree	18.8	22.6
Cupuacu	15	18
Cashew	12.4	14.9
Banana puree	4.2	5
Almond protein	3.4	4.1
Maca	0.8	1
Apple juice	0.5	0.6

Source: own study / Źródło: opracowanie własne

Table 2. The recipe composition of coconut mousse as a source of caffeine (MCaf)
Tab. 2. Skład recepturowy musu kokosowego będącego źródłem kofeiny (MCaf)

Mousse MCaf	in 100 g of the product	In a portion of 120 g
Apple puree	43.3	52
Coconut water	26.1	31.3
Guava puree	9.9	11.9
Banana puree	5.4	6.5
Pitaya puree	4.9	5.9
Papaya puree	4.9	5.9
Orange juice	3.3	4
Passion fruit juice	1.1	1.3
Apple juice	1.1	1.3
Caffeine	0.02	0.02

Source: own study / Źródło: opracowanie własne

Table 3. The recipe composition of coconut mousse as a source of collagen (MCol)
Tab. 3. Skład recepturowy musu kokosowego będącego źródłem kolagenu (MCol)

Mousse MCol	in 100 g of the product	In a portion of 120 g
Apple puree	24.2	29
Coconut water	22	26.4
Mango puree	19.4	23.3
Passion fruit puree	13.2	15.8
Graviola puree	8.8	10.6
Cupuacu puree	4.4	5.3
Banana puree	4.4	5.3
Acai puree	2.2	2.6
Collagen	0.9	1.1
Apple juice	0.5	0.6

Source: own study / Źródło: opracowanie własne

The resulting mousses can be considered functional products due to their composition. The mousse with the addition of protein derived from almond flour - almond protein met the assumptions for its source products, in which the energy value from the protein must be at least 12% of the total energy value. In this product, the energy value from protein is 13%, so the assumption was met. The energizing mousse was supplemented with micronized caffeine at a level of over 20 mg per serving, while the collagen mousse was supplemented with this product at the level of 1100 mg per serving (Tab. 4-6). Both the addition of caffeine and collagen determine the functional properties of the resulting mousses.

The coconut mousse with the addition of almond protein (MPr) contained mainly a high protein content (4.4 g) (Tab. 4). Among the minerals, the highest content was found for potassium (190.2 mg), phosphorus (72.6 mg), sodium (50.3 mg), and magnesium (40.8 mg). In the case of vitamins, the sample with the addition of almond protein contained the highest content of vitamin A (74 µg), vitamin C (8 mg), and folate (7.2 µg). In the case of this mousse, the lowest values were found for copper (0.3 mg), vitamin D (0 mg), vitamins B2 and B12 (0 mg).

The nutritional value of the obtained mousses depended on the recipe ingredients of the proposed desserts. Considering key ingredients such as an increased proportion of protein, the addition of caffeine or collagen, these products can be considered functional. Referring to the nutritional value, it was found that in the dessert sample with the addition of caffeine (MCaf), carbohydrates (12.1 g), including sugars (8.5 g), accounted for the highest share. Among the minerals, potassium (128.8 mg) and calcium (56.3 mg) were the dominant ones. Among vitamins, the highest content was found for vitamin C (26 mg), vitamin A (6.8 µg), and folates (8 µg) (Tab. 5).

The last mousse tested was a product with added collagen (MCol) (Tab. 6). It was characterized by a good, balanced nutritional value. Potassium (129.2 mg), calcium (48 mg), and phosphorus (34.4 mg) were the predominant minerals. The dominant vitamins were vitamin A (106.8 µg), vitamin C (12.3 mg), and folates (9.3 µg).

Table 4. The nutritional value of coconut mousse as a source of protein (MPr)
Tab. 4. Wartość odżywcza musu kokosowego będącego źródłem białka (MPr)

Nutrient	Unit	In 100 g of the product	In a portion of 120 g	%RWS
Water	g	59.3	71.16	
Energy	kcal	133.9	160.68	8%
Protein	g	4.4	5.28	13%
Fat	g	6.6	7.92	5%
Total carbohydrates	g	16.1	19.32	12%
Fiber	g	2	2.4	-
Sugars	g	7.5	9	-
Minerals				
Sodium	mg	50.3	60.36	3%
Potassium	mg	190.2	228.24	11%
Calcium	mg	13.3	15.96	2%
Phosphorus	mg	72.6	87.12	12%
Magnet	mg	40.8	48.96	13%
Iron	mg	1.3	1.56	11%
Zinc	mg	0.7	0.84	8%
Copper	mg	0.3	0.36	36%
Selenium	µg	2.6	3.12	6%
Vitamins				
Vit. A	µg	74	88.8	11%
Vit. D	µg	0	0	0%
Vit. E	mg	0.2	0.24	2%
Vit. K	µg	4.5	5.4	7%
Vit. B1	mg	0.1	0.12	11%
Vit. B2	mg	0	0	0%
Vit. B3	mg	0.4	0.48	30%
Vit. B6	mg	0.1	0.12	9%
Folates	µg	7.2	8.64	4%
Vit. B12	µg	0	0	0%
Vit. C	mg	8	9.6	12%

Source: own study / Źródło: opracowanie własne

Table 5. The nutritional value of coconut mousse as a source of caffeine (MCaf)
Tab. 5. Wartość odżywcza musu kokosowego będącego źródłem kofeiny (MCaf)

Nutrient	Unit	In 100 g of the product	In a portion of 120 g	%RWS
Water	g	82.1	98.52	
Energy	kcal	52.7	63.24	3%
Protein	g	0.6	0.72	5%
Fat	g	0.7	0.84	12%
Total carbohydrates	g	12.1	14.52	91%
Fiber	g	1.9	2.28	-
Sugars	g	8.5	10.2	-
Minerals				
Sodium	mg	14.7	17.64	1%
Potassium	mg	128.8	154.56	8%
Calcium	mg	56.3	67.56	8%
Phosphorus	mg	11.3	13.56	2%
Magnet	mg	9.1	10.92	3%
Iron	mg	0.3	0.36	3%
Zinc	mg	0.1	0.12	1%
Copper	mg	0	0	0%
Selenium	µg	0.3	0.36	1%
Vitamins				
Vit. A	µg	6.8	8.16	1%
Vit. D	µg	0.3	0.36	7%
Vit. E	mg	0.1	0.12	1%
Vit. K	µg	0.7	0.84	1%
Vit. B1	mg	0	0	0%
Vit. B2	mg	0	0	0%
Vit. B3	mg	0.1	0.12	8%
Vit. B6	mg	0.1	0.12	9%
Folates	µg	8	9.6	5%
Vit. B12	µg	0.3	0.36	14%
Vit. C	mg	26	31.2	39%

Source: own study / Źródło: opracowanie własne

Table 6. The nutritional value of coconut mousse as a source of collagen (MCol)
Tab. 6. Wartość odżywcza musu kokosowego będącego źródłem kolagenu (MCol)

Nutrient	Unit	In 100 g of the product	In a portion of 120 g	% RWS
Water	g	70.4	84.48	-
Energy	kcal	64.7	77.64	4%
Protein	g	1.6	1.92	10%
Fat	g	0.8	0.96	11%
Total carbohydrates	g	14.2	17.04	22%
Fiber	g	2.5	3	-
Sugars	g	9.2	11.04	-
Minerals				
Sodium	mg	16.6	19.92	1%
Potassium	mg	129.2	155.04	8%
Calcium	mg	48	57.6	7%
Phosphorus	mg	34.3	41.16	6%
Magnet	mg	9.7	11.64	3%
Iron	mg	0.6	0.72	5%
Zinc	mg	0.1	0.12	1%
Copper	mg	0.1	0.12	12%
Selenium	µg	0.2	0.24	0%
Vitamins				
Vit. A	µg	106.8	128.16	16%
Vit. D	µg	0.2	0.24	5%
Vit. E	mg	0.2	0.24	2%
Vit. K	µg	0.3	0.36	0%
Vit. B1	mg	0	0	0%
Vit. B2	mg	0	0	0%
Vit. B3	mg	0.4	0.48	28%
Vit. B6	mg	0.1	0.12	9%
Folates	µg	9.3	11.16	6%
Vit. B12	µg	0.3	0.36	14%
Vit. C	mg	12.3	14.76	19%

Source: own study / Źródło: opracowanie własne

4.2. Assessment of the properties and functionality of mousses based on coconut water

Acidity is the main parameter that influences food quality. Typically, the higher the score obtained, the less likely the product is likely to be spoiled by microorganisms in pasteurized products. The acidity is expressed in grams of acid per 100 g of product and is presented in Tab. 7.

The developed products differed in terms of acidity. The highest total acidity was noted in the case of mousses with the addition of almond protein (MPr - 0.84a±0.03 g/100 g). On the other hand, the lowest total acidity was found in mousses with added collagen (MCol - 0.61a±0.06 g/100 g). It was shown that the 6-month storage did not cause any statistically significant changes in the acidity of the products. It can therefore be concluded that the product is very stable during storage.

4.3. Determination of the total content of compounds reactive with Folin-Ciocalteu reagent in mousses based on coconut water

Table 7. Analysis of the total acidity of the prepared mousses
Tab. 7. Analiza kwasowości ogólnej opracowanych musów

Sample / Storage	General acidity (g/100 g)		
	After preparation/1 day	After 3 momnths	After 6 months
MPr	0.84^{a}±0.03	0.82^{a} ±0.02	0.81^{a} ±0.02
KCaf	0.77^{a} ±0.04	0.75^{a} ±0.02	0.78^{a} ±0.05
KCol	0.65^{a} ±0.04	0.62^{a} ±0.02	0.61^{a} ±0.06

Results are mean values of three determinations ± standard deviation. Values sharing the same letter in a line are not significantly different ($P \leq 0.05$).

Source: own study / Źródło: opracowanie własne

The total content of phenolic compounds was determined using the Folin-Ciocalteu reagent. All prepared samples were tested 1 day after preparation, then 3 months from preparation and 6 months after storage in real conditions. The results are expressed as gallic acid and are presented in Tab. 8.

All tested mousses contained polyphenols, the content of which differed depending on the sample (Tab. 8). It was found that during the six-month storage, the content of polyphenols in the products decreased statistically significantly. A decrease was observed compared to the directly prepared sample ranging from 9.6% to 12.7%. In the protein mousse (MPr) immediately after preparation, the total polyphenol content was 178.43±11.39 µg gallic acid / mL, while after six-month storage it was 161.31±6.43 µg gallic acid / mL. In the mousse with the addition of caffeine (MCaf), a similar relationship was found, where the content of polyphenols after preparation was 173.22±6.50 µg gallic acid / mL and then decreased by 12.7% after six months. Only mousse with added collagen (MCol) did not show any significant differences in the total polyphenol content during the entire storage period.

Table 8. The content of phenolic compounds in the prepared mousses stored for 6 months
Tab. 8. Zawartość związków fenolowych w opracowanych musach przechowywyanych przez 6 miesięcy

Sample / Storage	Total polyphenols (µg gallic acid/mL)		
	After preparation/1 day	After 3 months	After 6 months
MPr	178.43 ^{b}±11.39	156.43 ^{a} ±9.22	161.31 ^{b} ±6.43
MCaf	173.22 ^{b} ±6.50	163.54 ^{ab} ±2.82	151.6 ^{a} ±5.71
MCol	143.54 ^{a} ±7.71	155.51 ^{a} ±2.65	152.54 ^{a} ±1.33

Results are mean values of three determinations ± standard deviation. Values sharing the same letter in a line are not significantly different ($P \leq 0.05$).

Source: own study / Źródło: opracowanie własne

4.4. Determination of antioxidant activity using the ABTS and DPPH radicals

The method used to determine the antioxidant capacity of the extracts was the method using the radical $ABTS^{•+}$. All prepared mousses were tested as in the previous test, 1 day after preparation, then 3 months after preparation, and in the last stage, 6 months after preparation. The results are presented in Tab. 9.

In the conducted study on the evaluation of antioxidant activity, all tested trials showed similar antioxidant activity regardless of the storage time. The mousse with added caffeine (MCaf) showed the highest activity a few hours after preparation (4.43±0.24 TE / g d.w.), and the lowest mousse with the addition of collagen (MCol), tested 6 months after preparation (3.45±0.09 TE / g d.w.).

The last method to assess the antioxidant activity was the method using the DPPH radical. The prepared samples, as in the previous experiments, were tested 1 day after preparation, 3 months, and 6 months after preparation. The results are presented in Tab. 10.

As in the previous study, the storage time of the prepared mousses did not significantly reduce or increase the antioxidant activity. The highest antioxidant activity in this study was shown by the MPr test, i.e. coconut water with the addition of almond protein (6.87±0.37 TE / g d.w.), tested immediately after preparation, while the lowest activity regarding the ability to scavenge DPPH radicals was determined for a mousse with added caffeine (MCaf), stored for 3 months (5.42±0.12 TE / g d.w.).

5. Discussion

Coconut water has many beneficial properties resulting from the content of many different vitamins and minerals, the proportion of which determines the isotonic properties of coconut water. The sodium-potassium balance is important for the proper functioning of the body, including the prevention of hypertension and cardiovascular diseases. Sodium and potassium - these elements are almost completely absorbed in the small intestine and excreted in the urine, which is their main method of regulation in the body [16]. Coconut water also contains water-soluble vitamins, these are thiamin, riboflavin, niacin, pantothenic acid, B6, folic acid, ascorbic acid.

In vitro studies by scientists in Singapore have shown that kinetin (N-6-furfuryl adenine), one of the cytokines, a plant hormone found in coconut water, slows down the aging process and prolongs cell viability. Kinetin delays the aging of endothelial cells, increases their proliferation and metabolic capacity [17]. In addition to its anti-aging and anti-cancer properties, kinetin has effective thrombosis prevention properties. It has been shown to inhibit platelet aggregation and therefore may help prevent blood clot formation [17].

Table 9. Antioxidant capacity of mousses determined by the ABTS cation method
Tab. 9. Pojemność przeciwutleniająca musów oznaczona metodą z kationorodnikiem ABTS

Sample / Storage	ABTS method (TE/g d.w.)		
	After preparing/1 day	After 3 months	After 6 months
MPr	4.26^{b}±0.06	4.03^{a}±0.11	4.02^{a}±0.04
MCaf	4.43^{a}±0.24	4.41^{a}±0.33	4.40^{a}±0.21
MCol	3.65^{b}±0.04	3.55^{a}±0.04	3.45^{b}±0.09

Results are mean values of three determinations ± standard deviation. Values sharing the same letter in a line are not significantly different ($P \leq 0.05$).

Source: own study / Źródło: opracowanie własne

Table 10. Antioxidant capacity of mousses determined by the DPPH radical method
Tab. 10. Pojemność przeciwutleniająca musów oznaczona metodą z użyciem rodnika DPPH

Sample / Storage	DPPH method (TE/g d.w.)		
	After preparing/1 day	After 3 months	After 6 months
MPr	6.87^{a}±0.37	6.43^{a} ±0.08	6.56^{a} ±0.18
MCaf	5.46^{a} ±0.29	5.22^{a} ±0.11	5.31^{a} ±0.09
MCol	5.65^{a} ±0.36	5.42^{a} ±0.12	5.48^{a} ±0.12

Results are mean values of three determinations ± standard deviation. Values sharing the same letter in a line are not significantly different ($P \leq 0.05$).

Source: own study / Źródło: opracowanie własne

Functional food, innovative and exotic products appearing on the market are quickly gaining popularity. At the same time, the consumer's interest in the properties of these products is increasing. Functional drinks and mousses are an interesting assortment group. There is a growing tendency to eat them not only among athletes, but also among inactive people, as well as children and adolescents. Coconut water has a distinctive flavor and aroma different from that of a coconut kernel. Over 30 compounds responsible for this unique aroma have been identified in its composition, including: nonanal 14.2%, ethyl octanoate 6.2%, heptanal 8.2%, 2-nonanol 5.1% , heptanol 5.3%, alcohols, thiols, ketones, carboxylic acids, phenols, short carbon chain esters (n-propyl ethanoate). The content of these compounds and the proportion of their occurrence result from the stage of maturity (the older ones are less aromatic), the variety, and the conditions in which the coconut was grown [18].

The research carried out at work shows that the mousses are characterized by good antioxidant properties, which are stable in pasteurized products stored for 6 months. When examining the antioxidant capacity against $ABTS^{\bullet+}$ cation radicals, the highest content was found for a mousse based on coconut water with the addition of caffeine. In the case of testing the capacity measured with the DPPH reagent, the protein mousse based on coconut water was characterized by the highest content of antioxidant compounds. A large percentage of fruit in the recipe composition of mousses can be of great importance because they are rich in vitamin C, i.e. a strong antioxidant, as well as in such oxidants as carotenoids and anthocyanins. Mousses were characterized by better antioxidant properties when their composition included fruits richer in polyphenolic compounds and vitamin C, which are responsible for antioxidant properties.

6. Summary

Pasteurized fruit mousses based on coconut water can be classified as functional foods. Variants containing protein, collagen, and caffeine may have additional beneficial effects on health and well-being. The study showed that pasteurized coconut water-based products are stable in terms of the content of antioxidant compounds. The products can add variety to your diet. Coconut water can therefore be used for other purposes than just a drink intended for direct consumption. In addition to the high content of minerals and vitamins, as well as low energy value, coconut water is a very attractive raw material. Its consumption is recommended primarily to people suffering from hypokalemia (potassium deficiency). Coconut water contains kinetin, which slows down the aging process, is an antioxidant and helps prevent thrombosis.

7. References

[1] The Encyclopedia of fruit & nuts. Choice Rev., Online 2009, 46: 46-5375-46–5375.

[2] Ribeiro M. de M., Valdramidis V.P., Nunes C.A., de Souza V.R.: Synergistic effect of thermosonication to reduce enzymatic activity in coconut water. Innov Food Sci. Emerg. Technol., 2017, 41: 404–410.

[3] Resende N.M., Félix H.R., Soré M.R., Neto A.M.M., Campos K.E., Volpato G.T.: The effects of coconut oil supplementation on the body composition and lipid profile of rats submitted to physical exercise. An Acad Bras Cienc., 2016, 88: 933–940.

[4] Prades A., Dornier M., Diop N., Pain J.P.: Coconut water uses, composition and properties: A review. Fruits, 2012, 67: 87–107.

[5] Mcclatchey W, Manner HI, Elevitch CR (2006) IN BRIEF Species Profiles for Pacific Island Agroforestry www.traditional-tree.org Metroxylon species (sago palm).

[6] Commercial Crops Technology - Alice Kurian, Peter K.

[7] Kurian A.: Commercial crops technology. Peter KV (Ed.), 2007, New India Pub. Agency.

[8] Phoeurk C., Somana J., Sornwatana T., Udompaisarn S., Traewachiwiphak S., Sirichaiyakul P., Phongsak T., Arthan D.: Three novel mutations in α-galactosidase gene involving in galactomannan degradation in endosperm of curd coconut. Phytochemistry, 2018, 156: 33–42.

[9] Hruby A., Hu F.B.: Saturated fat and heart disease: The latest evidence. Lipid Technol., 2016, 28: 7–12.

[10] Hemingway R.W., Laks P.E.: Plant Polyphenols: Synthesis, Properties, Significance. 1992.

[11] SABA A.D, M., S. Y, K. C, N. K, H. G (2016) Low cost, high performance supercapacitor electrode using coconut wastes: eco-friendly approach. J. Energy Chem., 25: 880-887.

[12] Karmakar S., De S.: Cold sterilization and process modeling of tender coconut water by hollow fibers. J. Food Eng., 2017,200:70–80.

[13] Syafriani R., Sukandar E.Y., Apriantono T., Sigit J.I.: The Effect of Coconut Water (Cocos Nucifera L.) and an Isotonic Drink on the Change of Heart Rate Frequency in the Rats Induced Hypertension. Procedia Chem., 2014, 13: 177–180.

[14] Meda A., Lamien C.E., Romito M., Millogo J,. Nacoulma O.G.: Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity. Food Chem., 2005, 91: 571–577.

[15] Kobus-Cisowska J., Szulc P., Szczepaniak O., Dziedziński M., Szymanowska D., Szymandera-Buszka K., Goryńska-Goldmann E., Gazdecki M., Telichowska A., Ligaj M.: Variability of Hordeum vulgare L. Cultivars in Yield, Antioxidant Potential, and Cholinesterase Inhibitory Activity. Sustainability, 2020, 12: 1938.

[16] Brzozowska A.: Składniki mineralne. W: Żywienie Człowieka, Podstawy nauk o żywieniu (red. Gawęcki J.). Wydawnictwo Naukowe PWN, Warszawa, 2012.

[17] Yong J.W.H., Ge L., Ng Y.F., Tan S.N.: The chemical composition and biological properties of coconut (Cocos Nucifera L.) water. Molecules, 2009, 14: 5144-5164.

[18] Dahanukar S.A., Kulkarni R.A., Rege N.N.: Pharmacology of medicinal plants and natural products. Indian J. Pharmacol., 2000, 32:

Research carried out as part of the project (RPWP 01.02.00-30-0124 / 17)