JAP&T
TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2021, *27*(3), 271-276

Journal of Agroalimentary Processes and Technologies

Determination of some nutritional parameters of dark chocolate

Ariana-Bianca Velciov[1], Adrian Riviș[1*], Dacian Lalescu[1], Georgeta – Sofia Popescu[1], Antoanela Cozma[1], Andreea – Annemarie Kiss[1], Andrei – Marius Gherman[1], Iasmina Madalina Anghel[2], Roxanda Elena Simescu[1], Maria Rada[3*]

[1]*Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" Timisoara, Calea Aradului, 300-645, Timisoara, Romania*
[2]*Politehnica University of Timișoara - Faculty of Mechanical Engineering, Mihai Viteazu Street, No. 1, 300222 Timisoara Romania*
[3]*University of Medicine and Pharmacy "Victor Babes", 2 Efimie Murgu Sq., 300041, Timisoara, Romania*

Abstract

This paper presents the results obtained in determining nutritional parameters from three local varieties of dark chocolate with the addition of cocoa mass, recognized as a tradition on the local market. The total contents of fats, proteins, carbohydrates, minerals and moisture were determined from three brands of local dark chocolate, with different contents of cocoa mass: 40, 70 and 80%, sold in Timisoara markets (Romania). The results obtained: 4.27 - 11.32% protein, 39.12 - 43.61% fats, 26.8 - 59.2% carbohydrates, 1.22 - 1.39% moisture and, 1.72 - 2.24% minerals, dark chocolate brands contain significant amounts of nutritional facts, which provides a large part of the body's nutritional and energy needs. In addition, due to the high content of cocoa, this dessert has increased amounts of antioxidants and other biologically active substances with beneficial effects on aging, oxidative stress, regulation of blood pressure, atherosclerosis, etc. The beneficial effects of dark chocolate consumption are influenced by increasing the cocoa content in chocolate.

Keywords: dark chocolate, nutritional parameters, health benefit

1. Introduction

Chocolate is one of the most popular and enjoyed sweets approved by consumers of all ages [1]. This dessert is consumed not only because of its unique taste, texture and aroma, but also because of the high nutritional and energy content of proteins, carbohydrates, fats, minerals and vitamins with a fast metabolism and good digestibility [2]. In addition, cocoa, the basic ingredient in chocolate, which contains a significant amount of fat (cocoa butter, with about 33% oleic acid, 25% palmitic acid and 33% stearic acid) and dietary polyphenols (especially catechins, anthocyanidins and proanthocyanidins), is associated with several health benefits [3, 4, 5]. Interest in chocolate has increased, due to its physiological and health-enhancing effects, on the regulation of blood pressure, insulin levels, vascular functions, oxidation processes, prebiotic effects, glucose homeostasis and lipid metabolism [3, 5].

The food industry produces different types of chocolate with well-defined ingredients and characteristics, classified according to the proportion of cocoa used in a given formula. The different types of chocolate: dark chocolate, milk chocolate, white chocolate, etc., are produced by varying the amounts of different ingredients [6, 7].

Dark chocolate, also known as "plain chocolate" or "black chocolate", is produced using higher percentages of cocoa (usually 35 – 85%), traditionally with cocoa butter instead of milk, but there are also dark milk chocolates and many degrees of forms [7]. The name Dark chocolate is synonymous with semisweet chocolate, and extra dark with bittersweet chocolate, although the ratio of cocoa butter to solids may vary [6]. This type of chocolate, whose quality depends on the percentage of cocoa has an intense, persistent cocoa aroma, melts in the mouth, leaving a pleasant, bitter taste.

Corresponding authors: adrianrivis@usab-tm.ro, radamariam@gmail.com

The health benefits of chocolate are mainly due to the content of cocoa flavonoids and theobromine. [8]. Therefore, dark chocolate with high cocoa content and low sugar content has much obvious beneficial effects compared to normal chocolate or milk chocolate. In addition, due to its higher sugar content or other high-fat ingredients to make it taste better, milk chocolate could be associated with side effects such as obesity, cardiovascular disorders and cancer [5, 6].

Since dark chocolate has substantially higher levels of flavonoids than milk chocolate, and milk proteins may inhibit absorption of flavonoids, it might be preferable to consume dark chocolate than the milk marks [9]. Most health benefits: beneficial effects on the cardiovascular system (regulates blood pressure), improves glucose homeostasis by slowing digestion and absorption of carbohydrates in the intestine, helps prevent and treat cancer, can prevent weight gain by reducing lipid deposition and resistance insulin), has a significant effect on the growth of the intestinal microbiota, has regulatory properties of immune cells involved in both innate and acquired immunity, acts positively on the central nervous system and neurological functions (decreased cognitive and age-related disorders), has several effects on human sexuality (acting mainly as an aphrodisiac) are associated with the consumption of dark chocolate [2, 3, 5, 8].Therefore, chocolate should be consumed as a "nutritional food", which enhances its nutritional and therapeutic abilities [1, 2]. However, it should be borne in mind that chocolate is one of the main potential allergenic foods capable of causing hypersensitivity reactions, which show various clinical symptoms that are manifested by fatigue, irritability, insomnia, headaches, asthma, etc. [10].

The paper aims to determine nutritional parameters: total contents of fats, proteins, carbohydrates, biomineral compounds and moisture in case of three brands of dark chocolate with cocoa contents between 40 - 80%, produced in Romania.

2.Material and method

2.1. Sampling

The three brands of local dark chocolate with 40%, 70% and 80% cocoa, taken in the experiment come from different varieties of chocolate sold in in Timisoara supermarkets (Romania). In order to be able to observe more obviously the changes of the nutritional parameters based on cocoa content, we chose chocolate brands that contain the same ingredients: cocoa mass, sugar, low-fat cocoa powder, cocoa butter, vegetable fats (palm, sea), emulsifier (soy lecithin, polyglycerol, polyricinoleate), flavor, other vegetable fats, in addition to cocoa butter and min. 40-70% dry cocoa mass. Three types of chocolates were analyzed from each brand. Until the time of analysis the chocolate samples were kept in a dry and cool place, boiled by sunlight and frost.

2.2. Analysis

The determination of the nutritional composition for the studied chocolate samples was performed according to AOAC Official Methods of Analysis, 2000 [11] and according to the recommendations of *Aroyeun et al.,* 2019 [12]. Moisture was determined by the oven drying method (100-102°C) until to constant weight. The mineral substances (ash) were determined by the calcination method at 550°C. The protein content was determined by the Kjeldahl method, using a conversion factor for nitrogen of 6.25. The crude fat was determined using the Soxhlet method with hexane as solvent. The carbohydrate content was obtained by difference: 100 - (% moisture +% ashes +% crude nitrogen +% total lipids).

2.3. Statistical analysis

To carry out the statistical analysis was used STATISTICA 10 packages [13]. There were performed descriptive statistics, Duncan's multiple range test and linear correlation analysis. We calculated the mean and standard deviation for studied nutritional characteristics and highlighted the statistical differences between the 3 types of dark chocolates with respect to these nutritional values [14]. We observed relations between values of cocoa mass and the nutritional characteristics taken into consideration, thus we underlined the Pearson's linear correlation coefficients between the nutritional parameters taken in consideration.

3.Results and discussion

The objective of our work was to evaluate some variables (fat, protein, carbohydrates, moisture and minerals) that are influencing nutritional value for three types of indigenous dark chocolate. For the sake of simplicity in our statistical analysis, we used the following abbreviations: (DC40) for dark chocolate with 40% cocoa mass, (DC70) for dark chocolate with 70% cocoa mass, and (DC80) for dark chocolate with 80% cocoa mass.

The results obtained are presented in Table 1.The data presented in Table 1 show that the chocolate samples taken in the experiment have important contents of nutritional factors: 4.27 - 11.32% protein, 39.12 - 43.61% fats, 26.8 - 59.2% carbohydrates, 1.22 - 1.39% moisture and 1.72 - 2.24% minerals, depending on the type of chocolate and the nature of the nutritional parameter analyzed. These values can provide a great deal of energy and nutritional needs of the body.

The highest values were recorded for carbohydrates, which were determined in the range of 26.80 ± 2.48 (in DC80) and 59.2 ± 3.50% (in DC40). The average values of the carbohydrate content determined in the three types of chocolates show statistically significant differences ($p<0.05$), these following the decreasing trend DC40 (59.20%) > DC70 (35.20%) > DC80 (26.80%) which means that with the increase of the percentage of cocoa mass, the carbohydrate content decreases (Table 1).

The fat content has values between 30.12 ± 3.645% (in DC40) and 43.61 ± 3.73% (in DC80) and increases in direct proportion to the increase in cocoa mass content (Table 1). Taking into account the average values of the fat content in case of the three types of chocolate, it can be stated that CD40 is chocolate with the lowest fat content (30.12%), statistically different ($p<0.05$) compared to CD70 and CD80 which have approximately equal contents (41.06%, respectively 43.61%). No statistically significant differences were noticed between the CD70 and CD80 chocolate types ($p<0.05$).

The concentration of proteins in the analyzed chocolate brands increases with the increase of the percentage of cocoa in chocolate. The richest in protein is CD80 chocolate (11.32%), followed by CD70 and CD40 chocolates (4.27% and 11.32%, respectively) (Table 1.). The statistical calculation performed shows that there are significant differences ($p<0.05$) between the percentage of proteins in CD40 chocolate and CD70 and CD80 chocolates. There are no statistically significant differences between the protein contents of these chocolate assortments.

The average humidity of the types of chocolate shows relatively close values (Table 1), this increasing slightly with the increase of the percentage of cocoa in chocolate: 1.22 ± 0.50% (CD40), 1.31 ± 0.40% (CD80) and 1.39 ± 0.37% (CD80%). The statistical calculation showed that the differences between these values are statistically insignificant ($p<0.05$).

The total mineral content, as in the case of humidity, increases slightly with the increase of the cocoa percentage, so that the differences between the total concentrations of minerals in the analyzed chocolates: 2.24±0.64% (CD80), 2.11±0.61% (CD70) and 1.72± 0.61% (CD40) are statistically insignificant ($p<0.05$ Table 1). As previously observed, with the increase in cocoa mass content (from 40% to 80%), protein, fat and mineral concentrations increase and carbohydrate content decreases. This fact led us to study the linear correlations between the concentration values of these nutritional factors and the cocoa concentration. As can be seen from Table 2 there are strong correlations between the contents of cocoa mass, protein, fat, minerals (ash) and carbohydrates present in the three types of chocolate analyzed.

The experimental results obtained in the analysis of dark chocolate brands studied are comparable to those reported in the literature, obtained in the analysis of similar products [15, 16, 17, 18]. From what has been presented, it can be stated that the increase of the cocoa content from the chocolate brands taken in the experiment has the effect of increasing the content of fats, proteins and even minerals, and the decrease of the carbohydrate contents. In the case of humidity, the differences between chocolate brands are much less pronounced. The changes in the nutritional parameters of the three brands of chocolates are due to changes in the ratios between the quantities of ingredients used in the preparation of chocolates, which are due to the increase in cocoa content It is recommended to consume chocolate assortments with a high percentage of cocoa and a low content of sugar and fat.

Table 1. Proximate composition (%, mean values) of some tipes of Dark chocolate*

Samples	Protein	Fat	Carbohy-drates	Moisture	Minerals
Dark chocolate with 40% cocoa mass (DC40)	4.27± 0.48[a]	30.12± 3.64[a]	59.20± 3.50[a]	1.22± 0.50[a]	1.72± 0.61[a]
Dark chocolate with 70% cocoa mass (DC70)	9.82± 1.56[b]	41.06± 4.14[b]	35.20± 2.47[b]	1.31± 0.40[a]	2.11± 0.61[a]
Dark chocolate with 80% cocoa mas (DC80)	11.32± 2.54[b]	43.61± 3.73[b]	26.80± 2.48[c]	1.39± 0.37[a]	2.24± 0.64[a]

**Results given as mean ± standard deviation of triplicate analyses of three different samples. Different letters in the same column indicate a significant difference by Duncan test at (p <0.05) confidence level.*

Table 2. Linear correlation coefficients of nutritional parameters of dark chocolate analyzed

	Correlations					
Variable	**Cocoa**	**Protein**	**Fat**	**Carbohydrates**	**Moisture**	**Ash**
Cocoa	1,000000	0,999231	0,997972	-0,999951	0,969629	1,000000
Protein	0,999231	1,000000	0,999700	-0,998794	0,959294	0,999231
Fat	0,997972	0,999700	1,000000	-0,997293	0,952092	0,997972
Carbohydrates	-0,999951	-0,998794	-0,997293	1,000000	-0,972002	-0,999951
Moisture	0,969629	0,959294	0,952092	-0,972002	1,000000	0,969629
Ash	1,000000	0,999231	0,997972	-0,999951	0,969629	1,000000

4.Conclusions

The analyzed Romanian dark chocolate brands present important contents of carbohydrates, fats, proteins and minerals and low water contents, the differences being influenced by the cocoa mass content used in their preparation. The concentration of carbohydrates has values between 26.80% and 59.2% and decreases with the increase of the percentage of cocoa in chocolate. The fat content increases with the increase of the percentage of cocoa in chocolate and was determined in limits between 30.12% and 43.61%. The protein content increases with the increase of the percentage of cocoa in chocolate and has values between 4.27% and 11.32%. The humidity of chocolate brands has relatively close values between 1.22% and 1.39%. The total mineral content increases with the increase in the percentage of cocoa in chocolate, but less pronounced than in the case of fats and proteins and has been identified in concentrations between 1.72% and 2.24%. It can be suggested that analyzed dark chocolate brands contain significant amounts of nutrients that can provide a significant percentage of the daily requirement of carbohydrates, fats, proteins and minerals. In addition, due to the high content of cocoa mass (40 - 80%) these varieties of chocolate have many beneficial effects on the health of the consumer.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

Acknowledgements: The present paper was funded by the Research Project "Research on the use of biologically active substances in order to obtain high-nutrition foods", No 1545/28.02.2019.

References

1. Mehta M., Proximate analysis of branded chocolate, *Global Journal For Research Analysis*, **2017**, 6(7). ISSN 2277- 8- 8160;
2. Patel N., Diwan S., Shukla K., Tomar P., Jain H., Pradhan P., Upadhyay U., Chocolate drug delivery system: A Review, *Indo Am. J. Pharm. Sci*, **2015**, 2(6);
3. Montagna M.T., Diella G., Triggiano F., Caponio G.R., De Giglio O., Caggiano G., Di Ciaula F. and Portincasa P., Chocolate, "Food of the Gods": History, Science, and Human Health, *Int. J. Environ. Res. Public Health*, **2019**, 16, 4960;
4. Kharat V.T. and Deshpande H.W., Studies on proximate analysis and microbial analysis of probiotic chocolate, *Journal of Pharmacognosy and Phytochemistry*, **2017**, 6(5), pp. 407-411;
5. Latif R., Chocolate/cocoa and human health: a review, *The Netherlands Journal of Mrdicine*, **2013**, 71(2), pp. 64-68.

6. Munjal S,. Mathur H., Lodha L., Singh A., The Chemistry Of Chocolate, *International Journal of Innovative Research & Growth*, **2019**, 8(10);
7. Shafi F., Reshi M., Bashir A. and Bashir I., Chocolate processing, *IJABR*, **2018,** 8(3), pp. 408-419;
8. Katz D.,L., Doughty K. and Ali A., Cocoa and Chocolate in Human Health and Disease, *Antioxidants & Redox Signaling*, **2011**,15(10);
9. Lippi G., Franchini M., Montagnana M., Favaloro E.J., Guidi G.C., Targher G., Dark chocolate: consumption for pleasure or therapy?, *J Thromb Thrombolysis*, **2009, 2**8, pp. 482–488.
10. Zukiewicz-Sobczak W.A., Wróblewska P., Adamczuk P., Kopczynski, P. Causes, Symptoms and prevention of food allergy, *Postep. Dermatol. Alergol.* **2013**, 30, pp.113–116;
11. AOAC. Official Methods of Analysis, Association of Official Analytical Chemist. EUA; **2000;**
12. Aroyeun S.O., Okunade A.F., Obatoye A.O. and Olalekan Adeniran M.A., Nutritional Profile and Organoleptic Qualities of Milk Chocolate Incorporated with Different Spices, *AFSJ*, **2019**, 13(4), pp.1-8;
13. John A. Bower, Statistical Methods for Food Science: Introductory Procedures for the Food Practitioner, 2nd Edition, Wiley-Blackwell, 2013;
14. Are Hugo Pripp, Statistics in Food Science and Nutrition, Springer, 2013;
15. De Melo C.W.B., de Jesus Bandeira M., Maciel M.F., da Silva Bispo E., de Souza C.O., SOARES S.E., Chemical composition and fatty acids profile of chocolates produced with different cocoa (*Theobroma cacao L.*) cultivars, *Food Sci. Technol*, **2020**, 40(2), pp. 326-333;
16. Fajardo G.C.C., Arrunategui R.A.V., Rivera C.A.O. and Peralta M.O.U., Assessment of physical and physicochemical quality of main chocolates traded in Peru, *Acta Agronómica*, **2017**, 66(2), pp. 164-171;
17. Robson A.A., Chocolate bars based on human nutritional requirements. *Nutrition and Health*, **2012,** 7, pp. 143–148;
18. Suzuki R.M., Montanher P.F., Visentainer J.V., de Souza N.E., Proximate composition and quantification of fatty acids in five major Brazilian chocolate brands, *Scienc. Tecnol. Aliment., Campinas,* **2011**, 31(2), pp. 541-546.