

## REVIEW PAPER

# Sweet bakery products for diabetic's diet and analysis of risk associated with selected ingredients

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**Abstract**

Diabetes is a complex, chronic illness that demands a healthy diet. The overall quality of consumed food is important for diabetics, but benefits are expected from whole grains and lower-energy food. Choice of appropriate sweet bakery product may present the problem for diabetics in meal planning. The aim of this research is to provide an overview of some opportunities for new food product development for persons with diabetes and to analyze the risks associated with selected food ingredients, which can be used. It includes identification of special requirements for controlled nutrition. Quality parameters and food product composition are determined on a formulation for muffins modified to contain ingredients recommended and safe for diabetics' diet with lower energy value, but keeping prescribed and acceptable product quality. The research focuses on assessment of the risks analysis associated with selected ingredients on an example of muffin-like cake formulation modelling and use of wheat flour, sugars, fats, salt and some additional ingredients, milk, eggs and cocoa powder, based on experience, insight into recommendations for diabetics' nutrition and scientifically identified indicators aimed at health protection. Methodology for the selection of the ingredients for energy-reduced muffin-like cakes with whole-grain wheat flour and cocoa, suitable for diabetics' diet presented in the paper, can be used as a model for developing other products aimed to improve nutrition of persons with healthy food preferences or diseases. In addition, it presents an opportunity for the food industry contribution to healthy lifestyle by developing products adapted to modern dietary recommendations and target consumers group.

**Keywords:** diabetics' diet, sweet bakery products, ingredients selection, risks analysis

## 1. INTRODUCTION

The food industry offers on the market numerous products, which may differ in the content of basic ingredients, several nutrients or their concentrations, when compare them in one product category or between several products. Numerous factors continuously have impact on the changes in working and living conditions, which then change consumers' habits and requirements in terms of the type, quantity and nutritional quality of preferred and consumed food. Identified changes in consumers' interest in some food product category or its specific quality characteristic can be used as an indicator for the food industry to search for solutions and introduce in-

novations in production program. Today, special attention is given to products that can contribute to preserving or improving the general human health, or to persons with some diseases (Horvat, Behdani, Fogliano, & Luning 2019; Sajdakowska, Gębski, Żakowska-Biemans, & Jeżewska-Zychowicz 2019; Sajdakowska, Królak, Zychowicz, & Jeżewska-Zychowicz 2018; Soegoto & Walewangko 2020; Steinhauser, Janssen, & Hamm 2019). Studies have shown that the most common risk factors for occurrence of diseases associated with improper diet are food consumption habits, diet and lifestyle, even more than individual genetic predisposition of certain consumer populations. This justifies activities aimed at

the production of food with controlled nutritional quality and providing conditions for the practical application of recommendations for proper, balanced, and varied nutrition of different categories of consumers (Annunziata & Mariani 2019; Neale & Tapsell 2019; World Health Organization 2015a). The main role of food and human nutrition is to ensure the normal functioning of the organism, but also to prevent the development of certain diseases, or to help in remediation if they occur. Increased interest in the food quality, its nutritional composition and their impact on maintaining human health, has led to greater engagement and scientific approach to examine the impact of certain food ingredients on human health (World Health Organization 2015a; 2017; 2018). Consumers try to satisfy the physiological needs of the organism consuming the optimal amount of carbohydrates, proteins, fats, vitamins and minerals on a daily basis. However, everyone has individual habits, someone try to eat properly but sometime happens that favourite products eats in quantities higher than necessary, or do not like to eat important recommended food. That can be a way to obesity, malnutrition or diet-related diseases development (Grujić & Lukajić 2013; Slavica & Božana 2017). Enjoying the culinary specialities and a variety of food products is often associated with good appetite, improper diet, and an increase in the number of overweight people or other risk factors that contribute to the diabetes development, as one of the non-communicable diseases (Houalla et al. 2012; World Health Organization 2018). When consumers chose food, they usually balance between desires, needs and recommendations for proper nutrition, (or) health problems on one side, and choosing among available products on the market, on the other. Diabetes is a complex, chronic illness requiring continuous medical care with multifactorial risk-reduction strategies beyond glycemic control. Because of that, for overweight or obese people, who have a high risk for developing diabetes, it is recommended to change behaviour, lose weight by reducing energy-reach food consumption and increase physical activity. The serious problem for individuals with diabetes can be meal planning and making decision on what to eat. The eating pattern for persons with diabetes is specific because of the fact that it should be individualized, and there is not a "one-size-fits-all" model or an ideal percentage of calories from carbohydrates, proteins, and fats (American Diabetes Association 2020). Food product must have quality characteristics standardised according to the legally prescribed framework and quality parameters selected based on identified demands or expectations of the target category of consumers. A prerequisite for this is integrated knowledge from different scientific fields and related professional fields, as are food laws, food quality and safety standards which have application in food pro-

duction, quality control and human nutrition. In all activities on the development of new products for persons with diabetes, before defining or changing the composition of food, the producer should analyse the recommendations for diabetics' nutrition and analyze risks related to individual food ingredients (Horvat et al. 2019; Steinhauser et al. 2019). The aim of this research was to provide an overview of some opportunities for new food product development for consumers with diabetes and to analyse the risks associated with selected food ingredients, which can be used.

## 2. MATERIALS AND METHODS

Development of a new food product intended for consumers with diabetics is a complex task due to the special requirements for the quality of their diet. The aim of this research was to provide an overview of general dietary recommendations for diabetics, and to give a methodology for selecting food ingredients suitable for their diet, as well as an analysis of risks associated with selected ingredients on an example of a sweet bakery-product, energy-reduced muffin-like cake. Before defining the composition and quality parameters of the product, it will be examined which ingredients are recommended for diabetics' diet. Based on that, basic ingredients, suitable for energy-reduced muffin-like cake manufacturing will be identified. The new product should have acceptable quality characteristics in order to secure its position on the market and keep it. That is why, based on personal knowledge and available published results of other authors scientific work, possible impacts of certain product ingredients on technological and sensory quality of the product will be examined and analysed risks associated with their use in diabetics diet. Methodology for the selection of ingredients for a muffin-like cake suitable for diabetics' diet, adapted to modern dietary recommendations and target consumers, presented in the paper, could be used as a model for selected food products development. It could be a contribution of the food industry to consumers' healthy lifestyle or improving nutrition of persons with some food preferences and/or diseases.

## 3. RESULTS AND DISCUSSION

### 3.1. General dietary recommendations for diabetics' diet

The rapid spread of diet-related diseases animated nutritionists around the world to give more attention to searching solutions or models that would reduce the risk of further development of non-communicable diseases associated with malnutrition. It is clear that the economic aspect of human health protection also should be considered regarding costs of sick person's treatment (Houalla

et al. 2012; Neale & Tapsell 2019; World Health Organization 2015a; 2018). The biggest causes of health problems in developed and in developing countries have been identified and they are most often related to improper diet, insufficient physical activity, obesity, smoking, and alcohol consumption (Krömker, Stolberg, Müller, Tian, & Parlesak 2015; Sanders 2009; World Health Organization 2015a). An active, positive consumer's attitude towards individual diet contributes to a better health and physical status of the body (Min, Li-Fa, Dong, Jing, & Ming-Jie 2017; Stewart-Knox et al. 2013). Information regarding healthy diet is available to consumers and professionals in the form of Dietary Guidelines of the World Health Organization (WHO) and other responsible institutions, which offer science-based recommendations, as opportunities for improving nutrition and making appropriate food choices. Recommendations for healthy diet are based on the controlled intake of energy, fat, sugar, salt, protein, micronutrients, and energy in the daily meal provided through food, which is balanced with energy consumption. That also means that among other recommended nutrients, fruits, vegetables, and whole grains should be consumed in larger quantities in daily meal, to contribute to healthy lifestyle. For the practical application of the recommendations, it is essential that food should be delicious and with acceptable sensory quality (Layman 2014; World Health Organization 2015a; 2015b). People with diabetes could use evidence-based guidance for easier healthy food choice aimed to meet their individual needs and improve overall health. The consumed food quality is important, but benefits are expected from whole foods, whole grains, non-starchy vegetables, legumes, nuts, and fruits. In addition, added sugars and refined grains should be minimized in the diet. A commonly used visual guide for basic meal planning for patients with diabetes, known as diabetes plate method, is modified for the practical application of the American Diabetes Association nutritional guidelines (American Diabetes Association 2020; Bowen et al. 2016). Today, there is no longer an officially separated category of food on the market intended exclusively for diabetics. Competent scientific authorities concluded that food for some sensitive categories of consumers, as are persons with carbohydrate metabolism disorder (known as diabetes), could eat food intended for normal (conventional) diet, providing that they strictly control food quality and quantity. Competent authorities analysed the quality of food available on the market, as well as the food regulations regarding food quality, safety and mandatory information labelling. They concluded that there was no scientific evidence to justify the need for further existence of three special food categories intended for special nutritional purposes, among which was food category for diabetics' nu-

trition (European Parliament 2006; 2011; 2013). The quality of diet composition of people with diabetes can affect their health in the long term, and the recommendations for their diet are similar to those given for healthy people. That means that people with diabetes can create and control individual balanced diet that will meet their needs, choosing and combining usual foodstuffs, which they want and should consume (Annunziata & Mariani 2019; European Parliament 2013; Grujić & Grujić 2016; Grujić & Grujić 2017; Grujić, Grujić, Petrović, & Gajić 2013; Grujić, Grujić, Petrović, Gajić, et al. 2013). Professional recommendations promote and support healthful eating patterns, including different nutrient-dense foods in appropriate portion sizes, in order to improve overall health, achieve and maintain body weight and delay or prevent the complications of diabetes. Individual nutrition needs should be based on personal and cultural preferences, including access to healthful foods. However, consumers' willingness and ability to make behavioural changes are very important for a successful implementation of recommended diet, (American Diabetes Association 2020). Information about the composition and nutritional composition of the product is available on the packaged food as mandatory information, and diabetics must learn to use it and determine what quantity and nutritional quality of certain foodstuffs should be an integral part of the meal and the overall daily meal. At this time, there is still not enough adequate research and evidence about dietary patterns for diabetics to support one eating plan over another. For example, available studies examining the ideal amount of carbohydrate intake, monitoring carbohydrate intake and considering the blood glucose response for people with diabetes are inconclusive. Due to this, children and adults with diabetes are encouraged to minimize intake of refined carbohydrates and added sugars and focus on carbohydrates from vegetables, legumes, fruits, dairy (milk and yogurt) products, and whole grains, keeping total calorie (energy) intake and metabolic goals in mind (American Diabetes Association, 2020).

### 3.2. Methodology for selection of food product ingredients for diabetics' diet

The quality and safety of food in production and trade are prescribed by numerous international and national regulations. The legislation on informing consumers on food quality and labelling plays an important role in food choice, based on individual needs or preferences. These set of regulations include prescribed indication of mandatory and specific information on food packages and labels in a standardized, uniform, simple, and understandable way. They are intended for consumers or product

users, to make their choice of the desired product easier, comparing quality regarding food ingredients, nutritional composition or some other product quality characteristics (European Parliament 2011; Grujić & Grujić 2016; Grujić & Grujić 2017; Grujić, Grujić, Petrović, & Gajić 2013; Grujić, Grujić, Petrović, Gajić, et al. 2013; Savjet ministara BiH 2011; 2013; Slavica & Božana 2017). The food industry can have an important role in supporting healthy diets by developing new products with quality in line with dietary recommendations for balanced nutrition (Horvat et al. 2019; Min et al. 2017; World Health Organization 2015a; 2015b). The composition and nutrient profile of processed food may be changed depending on which food category is the subject of modification. It could be energy-reduction in food, in order to reduce the content of sugars and/or fats, trans-fatty acids, and saturated fat. Reduction of salt is also recommended in a healthy diet. However, food quality management requires knowledge from various areas of food technology, food quality and safety control, as well as food nutritional quality and human nutrition, and to integrate them with practical application as modelling of new product quality. In line with the modern active approach to the healthy lifestyle at the international level, the Republic of Srpska has made an action plan for the prevention and control of non-communicable diseases for the period from 2019 to 2026. Following the recommendations of the World Health Organization (WHO), measures were defined that should contribute to discouraging consumption of high-energy foods, or foods with high-saturated content of fats, trans fats, free sugars and/or salts. At the same time, it emphasized that the promotion of food consumption should be according to the nutritionists' recommendations, contributing to human health protection (Vlada Republike Srpske 2018). It is important to ensure that all changes in products and ingredients quantity are made in order to keep technological and sensory quality on an acceptable level. The main goal of nutrition (diet) planning on an individual level is a practical application of the principles of proper nutrition and health care as a method for reducing the probability for unacceptable deviations in terms of particular nutrient insufficiency or excessive intake (European Food Safety Authority 2017; World Health Organization 2017; 2018). Following that, it is important to find a solution and connect recommendations for diet and individual nutrients daily needs of target consumer groups to the food available in their local market. One of the solutions lay in opportunity to indicate special properties of the food product on its package, in the form of nutritional and health claims, which must be in accordance with the prescribed conditions for their labelling the same as the mandatory information (Annunziata & Mariani 2019; European Parliament 2006; Schwingshackl, Bogensberger,

& Hoffmann 2018; Springfield, Cunanan, Heaney, Peng, & Gardner 2020). The nutritive data on a food include the energy value and the content of some nutrients in the food, which could connect scientific recommendations for nutrition and support informed food choices as part of public health policy. The general public has an interest in the relationship between diet and health, at the same way as consumers with diabetes may use labelled information as the basis for selecting and combining different food products type as ingredients for an appropriate diet, suitable for their individual needs.

### 3.3. Basic ingredients for muffin-like cakes and risk analysis associated with them

The assessment of the risks analysis associated with selected ingredients on an example of sweet bakery-product formulation modelling in this research was performed based on experience, insight into recommendations for diabetics' nutrition and scientifically identified indicators aimed at health protection. Each production system can make a creative approach to the new food products development, using unlimited space to combine different ingredients and processing methods and at the same time secure competitive status in the market (Grujić & Grujić 2016; Grujić & Grujić 2017; Grujić & Grujić 2012; Horvat et al. 2019). The development of new health-focused food products demands integrating of different contemporary knowledge in the areas of food science and technology, food physics, methods of foods fortification and nutrients preservation. The food industry can use the recommendations of the World Health Organization (WHO) as a guide for modifying its own business policy, production program and product quality parameters. For example, there is an opportunity to improve the overall nutritional quality of food products modifying the ratio of saturated and unsaturated fats and eliminating trans-fats in food products, offering energy-reduced products, or reducing the amount of free sugars and salt in processed food. It is known that different ingredients can be used for cakes production, enabling creativity in production. Usually, the following ingredients are used: wheat flour, eggs, sugar, butter, margarine, oil, cocoa, chocolate, nuts, coconut flour, spices and flavours, as well as numerous other ingredients suitable for use in cakes and bakery products (Baixauli, Salvador, & Fiszman 2007; Sajdakowska et al. 2019; 2018; Schwingshackl et al. 2018). There are various ways to analyse risks, using professional and scientifically established indicators. In selecting the most appropriate ingredients, it is necessary to perform a risk analysis based on recommendations given for the diet of diabetics. A sweet bakery product, muffin-like cake, was selected for development as a new energy-reduced food product, which is

safe for use in the diabetics' diet. It used as a model for presenting a methodology for the selection of food ingredients recommended for nutrition of consumers with diabetes, and analyse the risks associated with selected food ingredients. The guide for clinical practice for diabetes mellitus (Popović-Pejić et al. 2016), emphasizes the importance of a controlled diet, harmonised with the principles of proper, balanced and varied diet. The total daily energy intake of each meal should provide 50-55% carbohydrates, 10-15% protein and 30-35% fat or less by combining selected meal ingredients. Each meal should contain 2-5 parts of carbohydrates, up to a maximum of 60 g, one part of protein and the appropriate amount of fat. It is recommended in meal planning to select products made with wholemeal flour, rich in dietary fibres, to control sugar intake and to use fructose. The meal should provide the required amount of protein, while fats should be of vegetable origin and in lower content. Various chocolate muffins are available on the market, and the following basic ingredients are typically used for their production: wheat flour, milk, sugar, eggs, margarine or oil, chocolate and/or cocoa powder (Baixauli et al. 2007; Karp, Wyrwicz, Kurek, & Wierzbicka 2016; Sanz, Salvador, & Fiszman 2007; Song, Li, & Zhong 2019; Springfield et al. 2020; Steinfurth, Koehler, Seling, & Mühling 2012). The manufacturer's specification and formulation determine the cakes ingredients, their quality, production method and final product quality parameters, as well as packaging and storage conditions. The muffin-like cake production process includes selecting and combining the basic ingredients in different quantities, according to the formulation for basic dough (Grujić & Lukajić 2013) modified to include measuring and preparation of the ingredients according to the formulation, mixing, and fermentation in mass, followed by dosing and fermentation in cups of muffin pan, baking and cooling to room temperature. The average weight of baked cookies was determined to be 60 g, as a portion. Baked products are suitable for consuming warm or cold, depending on consumers' preferences. Results of the chemical and sensory analysis are also important in product quality control and evaluation, product non-compliance identification and formulation modelling when it is required.

### 3.3.1. *Wheat flour as ingredient of muffin-like cakes*

Bakery products are the basic component of human nutrition worldwide. This is important because of the fact that cereal-derived food products are highly recommended as a fundamental part of a healthy and balanced diet. Depending on the formulation for production, they contain carbohydrates, fat, fibre, protein and micronutrients in proper quantities, which are important for hu-

man health. Muffins are sweet bakery products made with cereal flours, but they also contain a high amount of sugars and fats, which are partially responsible for overweight, obesity and health-related diseases. This is a cake, which all gourmets love to eat, regardless of their age. However, its nutritional quality is not in line with current dietary recommendations, so it would be good to use it as a basis for the development of a new product that has a quality modified according to the principles of a healthy diet, as it was the aim of this research. Changing the composition of food products could be an effective method for improving healthy food availability on the market. Some researches aimed to modify the nutritional profile of muffins and similar products, based on the key ingredients selection and making the cake healthier, for example the use of low-energy sweeteners instead of sucrose or cake enrichment with dietary fibre produced from different raw materials. It was found that low dietary fibre intake is a result of an insufficient amount of wholemeal products in the diet (Baixauli et al. 2007; Doménech-Asensi, Merola, López-Fernández, Ros-Berruazo, & Frontela-Saseta 2015; Gębski, Jezewska-Zychowicz, Szlachciuk, & Kosicka-Gębska 2019; Grujić, Odžaković, & Božić 2020). Whole grain or other functional ingredients are becoming more important in the bakery industry due to a higher awareness of a healthy lifestyle. Bakery products are a source of high amounts of starch, vitamins, minerals, trace elements, and dietary fibre. Production of whole-grain products can offer additional variety of bakery products with a positive impact on health, among other, regarding fermentable soluble fibre content. However, such type of bakery products will only have a chance to survive in the marketplace, if they also have a good texture and a good taste at the same time (Hotchkiss & Trius 2016; Steinfurth et al. 2012). Dietary fibre is the edible part of plants that are resistant to digestion and absorption in the human small intestine, with complete or partial fermentation in the large intestine (Baixauli et al. 2007). Bakery products, especially with wholemeal flour, similar to cereals, contain different types of dietary fibres, which are important because of the numerous physical and physiological properties that are in line with consumers' willingness to maintain health. Consumers often make the mistake of thinking that they will gain more weight by consuming bread and potatoes than from some other food products. The energy-value of starch from these foods is 16 kJ (3.8 kcal) energy per gram, which is significantly less than from fat, 38 kJ (9.1 kcal) energy per gram. That confirms the importance of planned nutrition and including nutritional fibres as ingredients of daily meal. Fresh fruits and vegetables, as natural sources of fibres are also recommended to eat whenever is possible (Doménech-Asensi et al. 2015; Euro-

pean Food Safety Authority 2017; Houalla et al. 2012). In an attempt to replace white flour with whole-grain flour it is necessary to adjust the production process and the ratio of ingredients to their technological quality. Particle size of the flour is a key parameter for the technological quality of wholemeal flour. Flour milling and small bran particles may reduce adverse effects of fibre and bran on loaf volume. Wholemeal flour has higher water absorption than white flour, fermentation time with wholemeal flour is reduced compared to the white flour, but the effect of bran particles on loaf volume seems to be larger than the effect of dough consistency on loaf volume (Steinfurth et al. 2012). Starch is a component of wheat flour and depending on the type, quantity and its functional characteristics may affect the technological and sensory quality of bakery products. Starch can be divided into rapidly digestible starch, slowly digestible starch and resistant starch. Resistant starch is interesting for control and improvement of bakery products quality, as a source of dietary fibre. It has significant functional properties in the human body, such as the interaction with dietary macronutrients, fats and protein, and with micronutrients such as minerals. It also has a positive physiological effect of reducing the glycemic index and acting as a functional prebiotic for some probiotic microorganisms, increasing the production of short chain fatty acids in the large intestine (Sanz et al. 2007). In addition to the above-mentioned characteristics, it can also contribute to better technological quality, as for example muffins produced with higher concentrations of resistant starch have softer texture, they were less hard, with an elastic and more tender structure. During a storage period, they remain softer than control samples, made without resistant starch (Baixauli et al. 2007). In defining the formation and parameters for manufacturing bakery products with wholemeal flour and yeast, it is important to know the effect of different treatments on ingredients and dough quality. In the process of production, dough is subjected to different shear, large extensional deformations and fracture during mixing, fermentation and baking, which are dependent on the temperature and water hydration. Gas cell nuclei are incorporated into the dough by occlusion of air during mixing and processing should generate as much gas cell nuclei as possible, while the yeast is incapable of forming new gas cells. During wholemeal product processing, the fibre and bran particles in the flour cause discontinuities and inhomogeneities of strands, films and membranes, and decrease gluten strength and gas-holding capacity, leading to a lower loaf volume. The detrimental effect of bran on loaf volume gas cell processes during mixing, proofing and baking, is explained by the fact that gas cells are surrounded by a starch-protein matrix at advanced stages of proofing, so the homogeneity of protein strands and

protein films plays a crucial role in gas-holding capacity (Steinfurth et al. 2012). Therefore, components relationships modelling with the inevitable experimental production is important for achieving the desired goal in a given complex food system and making products of acceptable quality.

### 3.3.2. *Energy-reduction and sugars as ingredients of muffin-like cakes*

The high sugar content in certain food products and the significant variation in composition within product categories and among different countries, indicate that there is an opportunity for reducing the amount of added sugar to foods, as one of the major challenges in line with the healthy diet promotion. The amounts of added sugars consumed in Europe exceed recommended levels and a significant part of sugars in the diet comes from sweet food products, increasing the risk of weight gain and diet-related noncommunicable diseases (World Health Organization 2017). Reducing the food product energy value depends on its basic composition. Muffin is a sweet product, rich in sugars and relatively high in fat content. Intensity of sweet taste can be reduced successfully in the sucrose content by 30 % of primary formulation and keep acceptable sweetness level. Carbohydrates include thousands types of compounds, differing in composition and size. The classification based on size or molecular weight, divides simple carbohydrates into monosaccharides (single carbon chain with 3 to 9 carbons), disaccharides (composed of 2 monosaccharides), oligosaccharides (3 to 10), and polysaccharides (more than 10 monomer units bound by glycosidic bonds). Sugars are water-soluble carbohydrates with a sweet taste. There are a few specific terms used for indication the type of sugar in a food product. The term sugar in chemistry is used for indicating mono-, di-, and the lower oligosaccharides. They are usually crystalline. Sugars represent mono- and disaccharides that give sweet taste to food. Some studies revealed that with the increase in the number of monosaccharide units in a molecule, the sweet taste is considerably less pronounced (Clemens et al. 2016). Sugars are very important ingredients for the food industry. The two main categories of sugars are interesting for food processing, namely monosaccharides, which are simple sugars, and disaccharides, which consist of two monosaccharide molecules joined together. The term added sugars is used to indicate sugars added to foods and beverages (World Health Organization 2017). In food product development and defining amount of ingredients responsible for specific modalities of food taste, it is important to know that humans are the most sensitive to bitter and the least sensitive to sweet taste if compare quantities of

different taste-inducing compounds. Sensation of sweetness may not be directly proportional to the concentration of sugar in different complex food products. Sugar is often used in food and beverages to achieve a sweet taste, and for taste balance with sour, salty, and bitter tastes in less sweet products. Some researchers have confirmed that it is not possible to connect sweetness and structure of sugars and their analogues directly, as it depends on many factors. Therefore, for example, sweetness of sugars depends on the degree of polymerization of respective monomers, thermal environment, and concentration (Clemens et al. 2016). The gold standard for sweetness is sugar. It provides essential functional properties as ingredient of food products, important to maintain competitiveness on the market and retain consumers' confidence (World Health Organization 2017). Fructose, or fruit sugar, is a monosaccharide found in many plants, often bonded to glucose forming the disaccharide sucrose. Fructose is important regarding ability to be absorbed directly into the blood during digestion, the same as glucose and galactose, which is the reason why it is recommended for use as sucrose replacement in food products suitable for diabetics (Popović-Pejičić et al. 2016; Song et al. 2019). However, sugars as high-energy components can be partially or completely substituted with one or more low-energy ingredients to achieve specific energy-reduction. Intense sweeteners are in use for replacing sweetening function of sugar, but low-molecular-weight polyols (bulking agents), also known as sugar alcohols are good substitute for the mass provided by sucrose or other sugars. In some products, complex carbohydrate bulking agents could also be an appropriate partial substituent (El & Simsek 2011; Karp et al. 2016). Non-energy intense sweeteners and polyols are food additives that can be natural or produced artificially (World Health Organization 2017). Natural sweeteners provide sweetness and bulk to food and drinks, but artificial sweeteners have no bulk property. Some of artificial sweeteners, also known as "high-intensity" sweeteners, are up to 3000 times sweeter than sugar (sucrose). Their use in food products is limited, and the use in some bakery products is prohibited (European Parliament 2008; 2011; Grujić 2018; Savjet ministara BiH 2018; World Health Organization 2017). Sucrose could be partially replaced with polyols in bakery products. Polyols or sugar alcohols are a group of artificial and natural sweeteners that retaining bulk in food, they contain fewer calories than sugar (2.4 kcal/g), but most of them have a lower sweetness index if compared with the same concentration of sucrose. They are acceptable for use in diabetics' nutrition. Polyols can replace sucrose in foods, but only in small quantities as they have a laxative side effect (Karp et al. 2016; World Health Organization 2017). Polyols are used in baking as humectants,

contributing to better tenderness, juiciness and elasticity of the biscuit during storage. The WHO Nutrition Guide (World Health Organization 2015b) recommends reducing the intake of free sugars in the diet throughout life, to reduce the risk of problems associated with weight gain and the development of dental caries in humans. The negative attitude towards consuming sugar in larger quantities is based on the knowledge that it is usually associated with weight gain, obesity, and a higher risk of dental caries and the diabetes development. It is recommended that the sugar amount should be less than 10% of the total daily energy intake through food in the body of adults and children, and it is going to further reduce it to 5%. Larger amounts of sugars are added in the beverages, fruit nectars, jams, chocolates and chocolate-related products, candy products, and they are all ingredients of cakes and certain fine bakery products. Muffin baking performance depends on the ingredients with an impact on the flow and viscoelastic behaviour of the raw batter and batter during heating. Fat and sucrose concentrations have a significant effect on the mechanical properties of the biscuit. Depending on the concentration, fat can modify the structure of the biscuit and the rate of hydration during eating, as well as the pattern and rate of aroma release (Burseg, Linforth, Hort, & Taylor 2009). Sugars bind water, increase viscosity, alter the texture of food products, provide bulk, provide energy for fermentation, and serve as precursors for flavour and colour development, etc. (Clemens et al. 2016). Rheological properties such as height, volume and number of air bubbles in muffins could be controlled and improved by adding of resistant starch (Baixauli et al. 2007). Therefore, it is not simply to replace sugars without affecting the quality and stability of food products, because of their multifunctional and technological properties.

### 3.3.3. *Energy-reduction and fats as ingredients of muffin-like cakes*

Fat is a food ingredient with the highest energy value and different important functional properties in processing. It participates in texture forming, provides higher volume and softness, flavour, and mouth feel in baked cakes (Sa, Hega, Ka, & Sale 2018). Recommended reduction or substitution of fats content with other ingredients, aimed to reduce the energy-value of bakery products, as in muffin-like cakes with whole-grain wheat flour, can decrease overall quality and acceptability of products. Some research has confirmed that consumer expressed increased interest in energy-reduced food as obesity-related health risks are spreading at an alarming rate (Lee & Puligundla 2016). However, for some consumers, lower sensory quality may decrease the acceptance of these food prod-

ucts, different from classic products, and if appropriate information is limited or unavailable. The ideal amount of dietary fat for individuals with diabetes is controversial. New evidence suggests that there is not an ideal percentage of energy from fat for people with or at risk for diabetes and that macronutrient distribution should be individualized, according to the individual eating patterns, preferences, and metabolic goals. The percentage of total energy from saturated fats should be limited in diet of people with diabetes, but they should follow the general guidelines for healthy people for the recommended intakes of saturated fat, dietary cholesterol, and trans-fat ([American Diabetes Association 2020](#)). Research has shown that an excessive intake of saturated fat (> 10% of total energy intake) can be associated with an increased risk for cardiovascular diseases. It is recommended that the food products development and appropriate technological solutions should enable the replacement or reduction of saturated fats as food ingredients, but not with sugars used as a substitute ([American Diabetes Association 2020](#); [Hotchkiss & Trius 2016](#); [Martínez-Cervera, Salvador, Muguerza, Moulay, & Fiszman 2011](#)). In cereal-based solid foods, as a relatively dry matrix, numerous factors may be in relation to aroma release. It depends on the matrix composition and extent of hydration during eating. The problem appears to be the fact that starch can bind some aroma compounds and many cereal foods also contain significant amounts of fat, which affects aroma perception and mouth-feel. The flavour perceived during food eating is often the result of interactions between different stimuli, such as taste and aroma or potential aroma–taste–viscosity interactions. Physical properties of liquid and semisolid systems undergo minimal oral processing and do not change markedly, as the main oral process is dilution of the system with saliva. However, on perceived flavour in biscuits is affected by the interactions between ingredients at the molecular and receptor levels, during sensory evaluation of the product quality or eating, and requires deeper analysis of each complex food matrix ([Burseg et al. 2009](#)). Dietary fibres are available on the market as an innovative, healthy and multi-functional ingredient for food industry. There is an interest in recovering and use of by-products as an alternative source of fibre. For example, cocoa husks, as a the waste product from the chocolate industry, are an underutilized source of insoluble dietary fibre and antioxidant compounds ([Martínez-Cervera et al. 2011](#)). Substituting animal fats or oils with ingredients that have similar technological functions and retain the sensory characteristics of foods is important for healthier nutrition ([El & Simsek 2011](#)). It is possible to use some ingredients as fat replacers in low-energy sweet bakery products, for example rice starch used in reduced-fat muffins and reduced-fat

cookies ([Lee & Puligundla 2016](#)). Dietary fibres are recommended as a healthy ingredient, but their addition to the dough as a partial replacement of usual fat contents (25%, 50% and 75%) – for example, with soluble cocoa fibre in low fat chocolate muffins results in lower sensory quality. Analyses show that muffins have lower quality when higher levels of cocoa fibre are added. They are increasingly more cohesive and more difficult to chew and swallow ([Martínez-Cervera et al. 2011](#)).

### 3.3.4. Sodium as ingredient of muffin-like cakes

The healthy diet recommendations are, among other things, based on the controlled intake of salt in the daily meal provided through food regarding risk of hypertension and other non-communicable diseases ([World Health Organization 2015a](#); [2015b](#)). People with diabetes, the same as the general population, are advised to limit sodium consumption to 2,300 mg/day and restriction below 1,500 mg, even for those with hypertension, is generally not recommended ([American Diabetes Association 2020](#)). When compared to the concentrations of compounds eliciting bitter, sour, or salty taste, it is noticeable that the taste threshold is the highest for concentrations of sugar in food (1.5% sucrose for sweet taste), somewhat lower for the salty taste (0.17% with NaCl), and 0.002% for bitter (tested with quinine) ([Clemens et al. 2016](#)). The basic function of sodium in the human body is to participate in the control of the total amount and systematic distribution of water, while enabling the cells to resorb dissolved substances. Deficiency of sodium intake through diet rarely occurs in residents of the European Union. Based on the available data, it was concluded that 2.0 g of sodium per day could be considered a safe and appropriate intake for the adult population in the EU. This amount reduces the risk of cardiovascular diseases in adults and provides a physiological balance of sodium ([European Food Safety Authority 2017](#)). The optimal salt amount gives a more pleasant taste and affects the dough quality of bakery products or biscuits. The decrease in the salt content in food can have a significantly positive effect on consumers' health status, but it changes or decreases the quality of flavour, texture, and other food attributes ([Gębski et al. 2019](#)). Its omission is not recommended, as completely unsalted dough seems bland, even in a sweet product. Daily meal plan should consider recommended sodium intake: 1.1 g/day for children 1–3 years of age, 1.3 g/day for children 4–6 years, 1.7 g/day for children 7–10 years and 2.0 g/day for children 11–17 years of age. For neonates aged 7–11 months, the recommended intake is 0.2 g/day. It is considered as safe and adequate intake, and defined values are based on the established sodium intake for the observed age. The WHO has recommended



that less than 5 grams of salt or 2 grams of sodium per day should be ingested, and, by gradually changing habits, the salt intake should be reduced by 30% by the year 2025 (European Food Safety Authority 2017).

### 3.3.5. Fresh eggs as ingredient of muffin-like cakes

Different foods and ingredients, with different metabolic effects, combining during the dishes preparation result in diversity of the daily meal and their nutritional composition (Houalla et al. 2012; World Health Organization 2015a). Daily meal prepared for diabetics should provide the required amount of protein. Dietary protein intake is important as a source of nitrogen and essential amino acids, necessary for tissue growth and maintaining the function of the human body. The basic role of amino acids is in protein synthesis. Proteins are usually consumed with meat and meat products, cereals and products based on cereals, milk and dairy products in the countries of the European Union (European Food Safety Authority 2017). Protein intake should be determined individually for each person with diabetes, based on current eating patterns. However, slightly higher levels of protein may contribute to increased consumers satiety (American Diabetes Association 2020). The protein content of flour is important for the technological quality of the product. Whole-meal flour has higher protein concentration and its protein composition differs from that of white flours. Regarding technological and sensory quality of bakery products, important is finding that the loaf volumes for wholemeal flour are usually smaller than for white flour, because of different protein types and functional properties. During flour and water mixing to form a dough, the protein matrices in the individual cells are brought together and form a continuous network, giving the viscoelasticity and high-quality bread dough, with a light porous crumb structure of a well-leavened loaf. Gliadins and glutenins are storage proteins that are only present in the endosperm. They have a major impact on the bread-making performance and there are more impact in white flour comparing to wholemeal flour. Instead of gliadins and glutenins, the bran and aleurone layers contain albumin- and globulin-like proteins (Steinfurth et al. 2012). Nutritional value of food with eggs as ingredient is appreciated. Eggs are considered as one of the best foods in terms of "wholesomeness." The functional properties of eggs, when used as a food ingredient, come from their unique composition. They participate in binding, leavening, tenderizing and emulsifying the mixtures, as well as in flavour and colour forming. Eggs are commonly used as important ingredients in the production of sweet baked products, because of their solubility, emulsification and coagulation properties and the ability to form a foamy structure, giving desir-

able volume, texture and colour in finished food products (Ratnayake, Geera, & Rybak 2011).

### 3.3.6. Additional ingredients of muffin-like cakes

Recommendations for healthy nutrition emphasise the importance of achieving the right balance in protein intake from foods of plant and animal origin. Dairy products are a source of proteins, but they should contain less fat. Since animal fats are mostly saturated, a very small amount is needed to meet daily needs. They must not be left out of the diet, because the consumption of fats is necessary, as a source of energy and essential fatty acids, but also for the absorption of fat-soluble vitamins (A, D, E and K). However, amounts should be optimal, when it is known that higher amounts of certain fats can increase the risk of obesity (World Health Organization 2018). Milk is an important ingredient of some formulations for cakes, biscuits or bakery products fermented with yeast. Caution is advised when choosing the type and amount of this ingredient. According to the recommendation for diabetics' nutrition, it is better to use skimmed milk than full-fat milk regarding risk of higher animal fat intake. It is also possible to replace part of milk with water, with appropriate formulation modelling, to keep technological and sensory quality standards of muffin-like cakes. Various ingredients, such as chocolate crumbs, dried fruit, coconut flour, nuts, aromatic and spicy herbs, can be used in the production of muffins to expand the product range. However, producers must choose these additional ingredients carefully, as some of them may be allergenic or carry some other risk. Dried fruit, for example, is a product with a high content of natural sugars, so they are not suitable for use as cake ingredients for diabetics. Changes in the basic composition with the aim to improve nutritive quality usually result in a decrease of the sensory quality, sometimes to unacceptable quality levels. Changes in the formulation, such as using fresh yeast instead of a dough rising agent, can modify the structure of dough with whole-grain wheat flour and provide increased bubbles forming during the process of fermentation and baking (Grujić & Lukajić 2013). Energy-reduction can be achieved by fats-reduction and using using the available methods for increasing the air and/or water content in emulsion-type dough, where two immiscible phases (water and fat) are present. It is possible to overcome the impacts of reduced sugar and fat quantities on sensory quality using the available knowledge in the food science and technology regarding the impact of food ingredients on the final product structure. The energy-reduced muffin-like cake, with whole-grain wheat flour and cocoa, used for modelling in this research, is a type of food rich in valuable nutrients, containing vegetable oil and naturally contained fi-

bres from wheat flour and low-fat cocoa. Chocolate and cocoa are favourite ingredients of sweets, cakes and bakery products for numerous consumers of all ages, so cocoa is better ingredient, than chocolate for achieving desired colour and aroma of whole-grain wheat flour cakes. Chocolate is usually energy-rich and sweated product with different amount and type of fats and sugars. That is why, fat-reduced cocoa powder could be ingredient, which could provide the appropriate chocolate-brown hue of the muffin-like cake colour, enrich the aroma and reduce the coarse nuance of the whole-grain flour aroma. It is interesting that there is no clear evidence of benefits from herbal or non-herbal (i.e., vitamin or mineral) supplementation for people with diabetes. Routine supplementation with antioxidants, such as vitamins E, C and carotene, is not advised due to the lack of evidence of efficacy and long-term safety, the same as for the routine use of herbal supplements and micronutrients, such as cinnamon, curcumin, vitamin D, aloe vera, or chromium (American Diabetes Association 2020). Packed food must contain labelled prescribed mandatory information about food, namely the following (European Parliament 2011; Savjet ministara BiH 2013): product name, list of ingredients, storage conditions, shelf life, name and address of the manufacturer, products net quantity, nutritional composition, and other information important for the proper product storage and safe use. Labelled data about food ingredients and nutritive composition are important for analysis of risk and suitability as products for diabetics. Consumers should be informed about certain product ingredients, particularly those that can cause allergies or intolerances in some people (as are wheat flour, milk, eggs), and some of those allergies or intolerances constitute a risk to their health. That information enables consumers, particularly those suffering from a food allergy or intolerance, to make informed choices, safe for them. Producers in the food industry should be familiar with food safety and good manufacturing practice principles and apply them in food processing, and especially in the raw materials handling. They must be under control, as activity important for safety of food ingredients and finished product regarding risk of different type of deterioration. Perishable food ingredients, such as fresh eggs, fresh yeast, margarine and pasteurised or sterilised milk (in an opened package), must be stored in a cool place, at a prescribed storage temperature (4–8°C), as it could present a biological and/or chemical risk. Other cake ingredients could be stored at room temperature in suitable and hygienic conditions: wheat flour, packaged pasteurised or sterilised milk (if the package is not open), sugar or sweeteners, cocoa powder, vegetable oil and salt. The new product, the low-energy muffin-like cake, should have defined sensory quality, uniform brown colour, proper char-

acteristic shape and volume with uniform distribution of pores, moderate elasticity, and moderate humidity during chewing, pleasant harmonious sweet taste and rich aroma of baked chocolate biscuit. Based on the results of the risk analysis of energy-reduced muffin-like cakes with whole-grain wheat flour and cocoa, with improved health benefits, the following ingredients were selected as suitable for production: whole-grain wheat flour, water, skimmed milk, fructose, sunflower oil, eggs, fat-reduced cocoa powder, yeast and salt. The ingredients are presented in descending order, based on the mass in the product. Certain muffin ingredients (namely wheat flour, milk and eggs) are identified as allergens, because they can cause allergies or intolerances in some people, and constitute a risk for their health. Consumers suffering from a food allergy or intolerance must be informed about the presence of these ingredients, so that they are able to make informed safe choices. Based on the previously stated, appropriate, scientifically proven facts, it could be recommended to producers to analyse the quality and nutritional composition of their products, and determine which ingredients and nutrients can be subject of changes, based on prescribed or recommended quality parameters for diabetics' diet.

#### 4. CONCLUSIONS

Numerous factors affect consumers' individual interest in a particular type or category of food product, and its nutritional and sensory quality. People usually choose food based on their preferences and possibilities, but health problems can limit the choice of products that must or can be consumed. Further, there is interest in food products with increased or decreased content of certain ingredients or products that must not contain some ingredients. Food allergens are among the current high-risk food ingredients. Each production system can make a creative approach to the development of new food products, using unlimited space to combine different ingredients and processing methods and at the same time secure competitive status in the market. Consumers' preferences for a sweet bakery product, with a specified quality modified according to the recommendations for diabetics' healthy nutrition and lifestyle, has been used as a model for new product development. The overall quality of consumed food is important for diabetics, but benefits can be expected from whole-grain wheat flour, lower-energy food produced based on less sugar and fat content. Based on that, the research provides an overview of some opportunities for the development of a new food product intended for persons with diabetes and gives an analysis of the risks associated with selected food ingredients, which can be used in manufacturing. Special requirements for con-

trolled diabetics' nutrition are identified, used for muffin-like cake formulation modelling and quality parameters determination. Cake compositions were modified to contain ingredients recommended and safe for diabetics' diet with lower energy value, but to achieve prescribed and acceptable technological, nutritive and sensory quality of product. The assessment of the risks analysis for selected ingredients used in modelling of the muffin-like cake formulation was performed, after which and as suitable ingredients whole-grain wheat flour was selected instead of white flour, fructose instead of sucrose, vegetable oil instead of margarine and lower salt content. Some additional ingredients were selected as acceptable for use, such as skimmed milk and fat-reduced cocoa powder. Risk analysis indicated that there is a risk with perishable food ingredients, such as fresh eggs, fresh yeast, margarine and pasteurised or sterilised milk (in open package), which should be stored in a cool place, at a prescribed storage temperature. Certain muffin ingredients are identified as risky, because they can cause allergies or intolerances in sensitive consumers. Methodology for selecting the ingredients for energy-reduced muffin-like cakes with whole-grain wheat flour and cocoa suitable for diabetics' diet, presented in the paper, can use as model for the development of some other products, aimed to improve nutrition of persons with healthy food preferences or diseases. It could be an opportunity for the food industry to contribute to a healthy lifestyle, by developing products adapted to modern dietary recommendations and target consumers.

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