Chapter

Flour-Based Confectionery as Functional Food

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Abstract

Nowadays, the flour-based confectionery industry is facing different challenges in reducing caloric and increasing nutritive values in order to produce healthier products, given that consumption of flour-based confectionery products has been growing steadily worldwide. In addition to wheat flour, these products include sugar and fat, which contribute to high energy value, but have few micronutrients and are mostly poor in nutritional terms. Due to frequency of consumption, they can harm a balanced diet, especially when it comes to children and young people. Flour-based confectionery is highly suitable for enrichment with ingredients that have pronounced functional properties. In this sense, the text offers some possibilities for improving such products through different approaches and presents new trends in developing functional, flour-based confectionery by using different supplements that could decrease caloric value, improve nutritional and non-nutritional values and develop products with pronounced functional properties.

Keywords: flour-based confectionery, nutritive and non-nutritive improvements, reduction of caloric value

1. Introduction

Confectionery products are concentrated food items that belong to the group of energy-rich foods obtained through treatment of carbohydrate raw materials during industrial or handcraft processing. They are mostly characterised by sweet taste, as the main ingredients are sucrose and other sugars. They are consumed on a daily basis depending on individual desires, habits and customs, regardless of the consumer's age, gender or status and it is food that enjoys great popularity among wide range of population.

According to their ingredients, methods of production, and final product, confectioneries can be divided into three main categories: sugar confectionery (candies, caramels and others), chocolate and chocolate products and flour confectionery (biscuits, cookies, crackers, wafers and others). This is just a rough classification of confectionery. Precise classification is not simple because of overlapping categories and new complex products constantly being created. Today we can find a lot of different products as a combination of these three categories.

The chocolate, biscuits and confectionery industries represent a prominent and dynamic food sector in Europe. The latest Statistical Bulletin demonstrates that the chocolate, biscuit & confectionery industry is a major contributor to the European economy. According to data collected from Eurostat, the production in Europe has increased by 2.3% in 2015, reaching 11,736.975 metric tons. This shows that the passion to create innovative treats and bring pleasure to consumers remains vivid among these sectors [1].

Flour-based products are the most often consumed ones among the confectionery in general and their growth in the market has been boosting per capita consumption around the world.

Due to the popularity and increasing interest in the functional food concept, the relationship between food and health has an increasing impact on food innovation. Nutrition knowledge has been used to improve consumer health which represents the functional food concept in general.

As the role of diet in the prevention of human ailments such as cancer, cardiovascular diseases and obesity has become more evident, many consumers are increasingly seeking functional foods to improve their diets. Consequently, there is a trend to search for natural raw materials rich in dietary fibre and high in antioxidant capacity as functional ingredients for the food industry [2].

Regarding flour-based confectionery, these efforts are especially important, as children and young population consume such products gladly and very often, and sometimes without control. Uncontrolled consumption of high-calorie products in unnecessary amounts, especially confectionery, can harm balanced diet and consequently lead to obesity.

Therefore, confectionery manufacturers are facing two different challenges. New products need to develop with improved health-promoting properties and at the same time they should be tasty and look like conventional confectionaries that are popular and regularly widely consumed.

2. Definition of flour-based confectionery

Confectionary products with flour as the main ingredient include a great number of different products that vary not only in their formula but also in the way they are manufactured. They are generally made of soft wheat flour. Understanding the common terms is sometimes rather difficult because of numerous kinds of such products and their different names. For example, *cookie* is a term used in the USA, defined by a formula high in sugar and shortening and relatively low in water. Similar products made in Europe and the United Kingdom are called *biscuits*. The biscuits made in USA are more accurately defined as chemically leavened bread. In addition, a number of products do not fit to this definition of cookies but are still called cookies mainly because they do not fit elsewhere [3].

Cakes are characterised by a high level of sugar in the formula. The difference between cookies and cakes is that cakes also contain relatively high levels of water. Because the molar sugar concentration is much lower in cakes than in cookies, the starch gelatinises during baking. Therefore, cakes set when baked, giving a light product. The specific structure of the cakes is obtained by incorporating air into the batter in form of small air cells during mixing. As with cookies, the definition of crackers must be quite broad, as there are many types of crackers. In general, crackers contain little or no sugar but moderate to high levels of fat (10–20%), based on flour weight. The doughs generally contain low levels of water (20–30%) [3].

In addition to flour, main ingredients incorporated during flour-based confectionery manufacturing are sugar and fat. The other ingredients such as milk, eggs, salt, aerating agents, emulsifiers, flavour and colour can be included as well. Water is added in different amounts to connect ingredients and to make dough. The water acts as a solvent, too. The main technology operations in flour-based confectionary are: mixing and moulding, baking and cooling. Within these basic operations, a great number variations and different regimes can exist. This is why we can find a great number of different kinds of products on the market today.

Ingredients play an important role in creating an acceptable product. Whether alone or together, each ingredient contributes an important quality to the final product. Flour, liquid, sugar, leavening agent, eggs, and fat are present in a proportion that, when properly mixed, make a quality product [4]. Thanks to high amount of carbohydrates and fat, flour-based confectionary products are very rich in caloric value. Caloric values for cookies and other similar products range from 1400 to 2300 kJ/100 g [5].

3. Improvement of flour-based confectionery products

All main ingredients in flour-based confectionery products contribute to high energy value. On the other hand, they are low in micronutrients and generally poor in a nutritive sense. Hence, there are two basic trends in confectionary industry: improving nutritive value and at same time, reducing the energy value.

Nutritive value can be improved by: using wholemeal and flour with high extraction rate instead of white wheat flour, and other cereals with evident considerable nutritive value, adding fruit and other high nutritive ingredients.

In addition, the energy value in confectionery products can be reduced by decreasing the sugar content, substituting sugar partially or completely by different low-energy sweeteners and reducing fat in formula or replacing the fat with some suitable substituents.

Flour-based confectionery products are considered as good material for fortification and nutritional and non-nutritional improvement to make a new product with functional properties.

Flour is a basic ingredient and it is supposed to be of optimum quality appropriate for a certain product. Thus, probably the greatest influence on improving the functionality and nutritive value of flour-based confectionery just involves the replacement of flour in recipes with other kinds of flours, such as wholemeal wheat flour and flours obtained from other cereals and non-cereals with evident nutritive and non-nutritive values like oat, barley, rice, soy, buckwheat, flaxseed etc. Whole grains are rich in dietary fibre, trace minerals, antioxidants, and phenolic compounds, which are important for human health because they reduce risks of different diseases like cancer, diabetes, obesity, and cardiovascular diseases [6]. The importance of dietary fibre in the human diet is widely accepted, and over many years, extensive research has been undertaken on the enrichment of food products with fibre [7].

Some pseudo-cereals like buckwheat, amaranth and quinoa are especially interesting not only because of their high nutritive and non-nutritive value but also because of the fact that they do not contain gluten.

In addition, protein fortification of biscuits is of current interest and they can be prepared from composite flours, such as wheat flour fortified with soy, cottonseed, peanut, corn germ flour or mustard flour [7], and with supplementation of health-promoting ingredients like whey protein concentrate and skimmed milk powdered [8].

Fruits have received much attention recently as a source of biologically active substances because of their anti-oxidant, anti-carcinogenic and antimutagenic properties and they had an important relevance for confectionary industry, especially for biscuits, cakes and the other bakery products.

As mentioned earlier, flour-based confectionery belongs to high calorie food, and a trend to reduce the calorie value of those products has gained considerable importance recently. Reducing or substituting sugar for other sweeteners, reducing fat in recipes and complete elimination of fat could decrease the caloric value in flour-based confectionery in general.

Changing the recipes to improve nutritive and non-nutritive values of products could at the same time lead to decreasing the caloric value and glycaemic index, too. For example, if wholemeal flour is used instead of white flour, the content of fibre in a product will rise, and the starch content will at the same time decrease. So, the content of digestible carbohydrates (4 kcal/g) will be decreased. In addition, using honey in recipes can slightly reduce caloric value and the glycaemic index, as honey is sweeter than sugar and is incorporated in recipes in a lower amount [9].

Nevertheless, microencapsulation should certainly be pointed out as a relatively new technique in improving of flour-based confectionery, as well.

In general, flour-based confectionery is supposed to be of great nutritive and non-nutritive quality, low in caloric value and above all, they should be not just edible, but desirable with attractive sensory properties and texture, and packed in appropriate well-designed packing. All efforts in improving these products are supposed to be followed by sensory evaluations as a kind of final approval to ensure better competitiveness in the market of this kind of food. The texture, flavour and appearance of these products are major attributes that affect their acceptability. In fact, sensory analyses should cover all results of scientific and other researches that investigate improving and promoting food quality.

3.1 Nutritive and non-nutritive improvement of flour-based confectionery

Different cereals, legumes and fruits have been widely recognised as important sources for improvement of flour-based confectionery and provision of functional properties. There are a lot of scientific studies that investigate influences of different plant material on fortification of biscuits, cakes and other bakery products.

3.1.1 Wheat flour replacement and fibre increase

The most common source of dietary fibre in bakery products has been bran from various cereals and non-cereals.

Nevertheless, using only wheat flour of higher extraction rate rather than white flour for biscuit production can have positive effects on the antioxidant activity and general quality of the product due to the incorporation of higher content of external grain components in flour when extraction rate is higher. The flour extraction rate has a strong effect on the physical and chemical quality of flour. Antioxidant capacity of biscuits and total phenol content significantly increased when flour extraction rate was higher and was the highest in the samples produced of flour when extraction rate was up to 90%. The same biscuits had the highest rating for overall sensory impression [10].

A total phenol content and overall sensory evaluation of biscuits made of wheat flour and mixtures with other cereals is presented in **Figure 1**. Wheat flour with the extraction rate of up to 90% was blended with spelt, barley and buckwheat flour with similar extraction rate in different ratio: 25, 50, 75 and 100% of non-wheat flour in mixture [11].

Spelt (*Triticum spelta* L.), an ancient wheat species, was one of the major feed and food grains in ancient Europe [12]. This crop has very modest requirements in terms of environmental conditions and production technology. It is highly resistant to diseases and pests and it has very modest requirement in terms of fertiliser, which makes it very advantageous for organic production. Recent interest in use of spelt for ecologically grown foods has led to resurgence in its cultivation and research regarding the possibility of its utilisation [13–15].

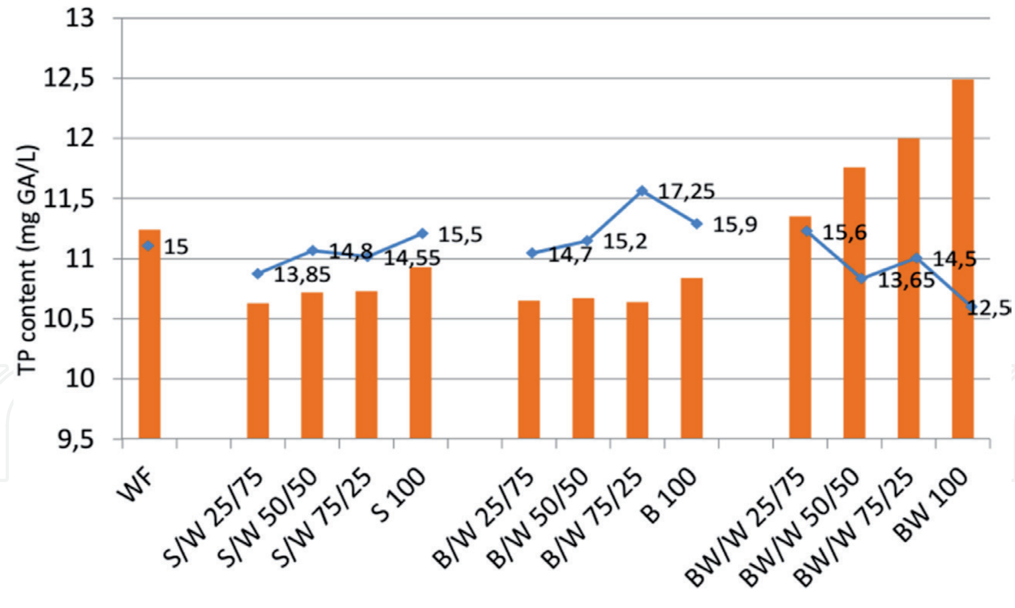

Figure 1.
Total phenolic (TP) content and overall sensory evaluation – Blue line (20 points maximum) of biscuits made of wheat flour (WF) and mixture of WF with non-wheat flour in different ratio (data from the author's private archive). WF – Wheat; S/W – Spelt/wheat; B/W – Barley/wheat; BW/W – Buckwheat/wheat flour; flour blends: WF with spelt, barley and buckwheat flour in 25, 50, 75 and 100% share.

Barley is gaining renewed interest as an ingredient for production of functional foods due to high concentration of bioactive compounds [16–19], especially because of high β-glucans content which ranges up to 9.0 (%, dry weight) [20] and is successfully used in flour-based confectionery such as biscuits and cakes. With its slightly nut-like aroma, it contributes to a unique flavour of these products and improves their nutritive values. Barley flour addition decreased spread ratio and increased antioxidant activity as the proportion of barley flour increased [21, 22].

The highest total phenolic content was recorded in samples made with buckwheat flour, and it was higher as share of buckwheat flour was increased (**Figure 1**). In addition, same samples were baked on two different temperatures (150 and 205 °C) to find out whether the baking temperature had any influence on the biscuit quality. Better physical properties were achieved when the baking temperature was 205 °C rather than 150 °C. Baking on 150 °C for prolonged time causes total phenol content reducing and makes some sensory properties worse. The best score for overall sensory evaluation had biscuit samples made of flour blend wheat/barley with high share of barley flour (75%). Nice and attractive nutty flavours were marked in these samples and they increased with the increase of the share of barley flour [11].

β-glucans content in same biscuits samples with barley flour was increased with the increase of the content of barley flour, and after 6 months of storage, the β-D-glucans content in all samples decreased slightly [23].

Over the last two decades, interest for buckwheat and related products has increased, especially in bakery products. Botanically, buckwheat does not belong in cereals but is studied together with them due to the same manner of utilisation [24]. Buckwheat flour has a huge potential in terms of improving the baking products in respect of considerable content of antioxidants, especially polyphenols and tocopherols. Its polyphenols are represented by phenolic acids and flavonoids, mainly rutin, a proven potent antioxidant. Due to a relatively high content of antioxidants in light and wholegrain buckwheat flours, they are used for substitution of wheat or other cereal flours in bakery, pasta and confectionery formulations in order to create either added value or gluten-free products [25].

However, a high content of buckwheat flour in biscuits deteriorates physical characteristic and sensory attributes (**Figure 1**). Total phenolic content in biscuit samples made with buckwheat flour was significantly higher than in samples made of wheat flour and other composite flours, but overall sensory score decreased with the increase of the content of buckwheat flour in the recipe and it ranged from 15.6 (good sensory quality) in samples with 25% buckwheat flour added to 12.5 (satisfied sensory quality) in biscuits made of buckwheat flour only [11].

In addition to high nutritive and non-nutritive potential of buckwheat, we cannot forget tartary buckwheat (*Fagopyrum tataricum* Moench), which contains up to 100 times the amount of rutin found in common buckwheat [26]. Tartary buckwheat showed about 9 times higher antioxidant activity in comparison to common buckwheat and about 20 times higher total phenol content [27]. The importance of tartary buckwheat is widely recognised, but some disadvantages of its usage in flour-based confectionery should also be taken into account, as particles size and share of bran in tartary buckwheat flour. Besides, in final products with tartary buckwheat the slightly bitter taste can appear [24].

Enrichment of biscuits can be achieved by partial replacement of wheat flour with chia seeds [28]; with defatted maize germ flour [29] and with flaxseed [30–32].

Sesame seeds, as the main ingredients, add a nutty taste and a delicate aroma to tahini halvah. Besides making halvah, sesame seeds are widely used for the preparation of rolls, crackers, biscuits and cakes [33].

Dietary fibres in the bran and germ of cereal grains have been added to biscuit formulations that originally contained almost no dietary fibres in original recipes. Purple rice is a good choice to replace wheat flour because it contains high fibre contents and a range of antioxidants; and has a considerable potential for use in biscuits and related products [34].

Substituting wheat flour with germinated brown rice flour for sugar-snap cookies resulted in increasing the residual moisture content and decreasing the hardness. Cookies with acceptable quality and improved nutrition can be prepared by partial or complete replacement of wheat flour with the heat-moisture treated germinated brown rice flour [35].

Fibres of different cereals (wheat, rice, oat, and barley) caused different changes in biscuit dough behaviour. For a bran level of addition from 10% to 40%, oat and rice bran increased water absorption less than barley and wheat bran. Also, dough development time was higher in the case of wheat and rice bran blends than for doughs with oat and barley brans. Dough stability, which indicates dough strength, decreased significantly in the case of oat and barley blends, whereas the extent of decrease was relatively marginal in the case of wheat and rice bran blends. Extensibility values were greatly reduced by the addition of bran from either of the sources. The sensory quality of biscuits was acceptable at 20% for wheat bran and barley bran and 30% for oat bran only [36].

Jerusalem artichoke powder and cocoa beans shell powder additions in biscuit formulation had considerable effects on the physical–chemical properties of biscuits. The nutritional value increased due to the content of dietary fibre increased [7].

Through the substitution of wheat flour with malted barley bran, it is possible to produce nutritious and consumer acceptable cookies especially at 5% substitution level [37]. One possibility to increase the content of fibres in the diet is to enrich products with pure isolated fibres. Fibre-rich preparations are produced primarily with the use of parts of cereals, fruit and vegetables which are by-products from milling and fruit and vegetable processing [38].

3.1.2 Milk and whey powder in flour-based confectionery improvement

Usually, milk is a popular liquid for use in cake batter. In addition to contributing water, milk adds flavour and nutrients especially protein and contains certain compounds that help produce a velvety texture, a creamy white crumb, and a browner crust. The lactose in the milk participates in the Maillard reaction resulting in a brown crust [4]. Adding of milk derivatives also were reported to help the product to brown during baking and add to its nutritive value.

Whey is an excellent source of proteins which are considered to be high quality proteins that contain all of the amino acids required by humans, as well. Whey proteins were found to contain relatively high amounts of lysine, a dietary essential amino acid, that in sometimes limiting in the diets for humans, particularly those high in cereals. Increasing the levels of supplementation with whey powder resulted in a significant increase in the score of aroma of biscuits. Biscuits made from wheat flour supplemented by 10% whey powder showed the best scores for overall acceptability [39].

The nutritional value of whey proteins depends on the favourable ratio of amino acids, especially essential amino acids. Cysteine, lysine, and tryptophan proteins of whey have a better biological value and the favourable ratio of cysteine/methionine has a better biological availability in the organism when compared to other meat-based or plant-based proteins [40]. Whey proteins, due to their nutritional value and functional properties, can be an acceptable alternative to carbohydrates and fats and they can be a highly valued protein component in gluten-free baked goods.

3.1.3 Fruit and related products in flour-based confectionery

The incorporation of fruit in different forms into recipes for production of flour-based confectionery is a good way to improve not only nutritive and non-nutritive value but also physical and sensory quality of final products.

A number of researches confirmed a possibility to develop different flour-based confectionery with improved functional characteristics using fruit and fruit products and by-products like pineapple powder [41]; banana flour and sesame seeds - cookies made with formulation 20% banana flour and sesame 8% had high antioxidant capacity with good stability in storage time [42]; raspberry pomace [38]; mango kernel and seed to improve protein content [43]; citrus dietary fibre as a potentially functional ingredient in biscuits and other sweet bakery products [44]; white grape pomace for the novel formulation of biscuits as an alternative source of dietary fibres and phenols [2] and blackcurrants and jostaberry powder as good sources of antioxidants and fibres [45].

By-products from fruit processing are pomace, spent fruit or fruit stones. These contain considerable amounts of bioactive components including dietary fibres which are highly desirable for dietary purposes. Using by-product raw materials such as raspberry and blackcurrant seeds in the form of food additives is one of the ways to increase health properties of food and prolong their shelf life [38].

Berries have a good nutritional profile and attractive sour–sweet taste and colour, mainly blue, red or purple. They are typically high in fibre, vitamin C, antioxidant and polyphenols and present a good choice for flour-based confectionery improvement.

Blueberries can contribute both flavour and nutritional value to cereal-based foods, adding fibres, vitamins and minerals, and only low levels of sugar and fats. Most importantly, blueberries are rich in plant polyphenols that can complement cereals, which are rich in fibre but low in total phenolic [46].

Fruits of the forest plant species can be used as basic or complementary raw material for production of a series of very nutritious food products (jam, marmalade, juices, carbonated soft drinks, distillates) or as ingredients to confectionery and bakery products. Great importance is ascribed to the group of herbaceous and woody plants, among which the most important are: Cornelian cherry (*Cornus mas L.),* woodland strawberry (*Fragaria vesca*) and bilberry (*Vaccinium myrtillus L.*) as excellent sources of phenolic compounds, anthocyanin contents and other bioactive components. These species are very rarely attacked by plant diseases and pests. Apart from features of genetic durability and resistance, fruits have medicinal properties deriving from an abundance of very valuable components. All this resulted in a greater demand for organically grown food, rich with biologically valuable components, and products based on these varieties can certainly meet this demand [47].

Numerous studies have dealt with apple powder or pomace addition in cookie formulation and the influence on final product quality: effect of the addition of commercial apple fibre powder on dough characteristics and the physical and sensory properties of cookies [48]; the nutritional value, sensory evaluation and the hypolipidemic effect of biscuits fortified with apple fruits powder [49]; influence of pineapple, apple and melon by-products on physicochemical and sensory quality [50] and nutrition, rheology of dough and quality of cookies with apple pomace powder [51]. Replacing wheat flour with 15% or 30% of apple pomace resulted in 3–6% of fibres in the finished product [52].

In terms of apple processing autochthonous cultivars are becoming more and more interesting as they are more tolerant to diseases and highly rich in nutritive and non-nutritive compounds such as polyphenols and can improve final products [53].

A potential raw material which can be used for production of food with added nutritional value is tomato pomace, a by-product from tomato processing: a tomato pomace powder [54] and insoluble tomato fibre as alternative source of bioactive components in cookies [55].

3.1.4 Honey and bee products in flour-based confectionery

Honey and other bee products (pollen and propolis) are considered as valuable components for food improvement, widely respected for their high nutritive value and protective characteristics. Besides acting as a sweetener, honey contributes to more intensive aroma, thanks to its unique flavour, and in same time balances and enhances the flavour profiles of other ingredients. Honey also extends the shelf life of bakery foods naturally, and products that contain honey dry out more slowly and have a lesser tendency to crack. It caramelises quicker than sucrose and gives a darker appearance to final products [9].

The honey biscuits made from buckwheat, rye, spelt and wheat flour are products with good quality and long-term shelf-life and meet the parameters of a dietetic food because of low percentage of fat [56].

The applications of bee pollen as a dietary supplement and finding an optimal recipe for biscuits have been studied and according to obtained results, the addition of bee pollen did not affect the fat content in biscuits; it had a statistically significant effect on sugar, protein, ash, fibres, as well as the content of polyphenols and antioxidant potential. Biscuits that had been improved with bee pollen were characterised by higher penetration work and a darker surface when compared to the control ones [57].

3.1.5 Some examples of cakes improvement

It is already known that the particle size of wheat flour can influence the quality of flour-based confectionery. This is particularly important when we talk about cakes. Those products usually include eggs in their formula and are softer than biscuits.

Eggs affect the texture of cakes in several ways. They perform emulsifying, leavening, tenderising and binding functions. They also contribute colour, nutritional value and desirable flavour and they are essential for obtaining the characteristic quality of most cakes. The cakes are relatively high in sugar and shortening. A typical cake formula contains quite a lot of water and depends on air incorporated during mixing for much of its leavening. Due to eggs and the intensive mixing process, the dough/batter for cakes is tenderer and has a higher specific volume than the dough for bread and biscuits.

The differences between dough and batter are reflected in texture: dough consists essentially of flour and liquid as milk or water and is stiff enough to knead or roll, while batter is made of flour, eggs and milk or water and is thin enough to pour or drop from a spoon.

Batter for cake making or sponge foam is a colloidal system composed of liquid and gaseous phases where the air presents the dispersed phase. The air is distributed in the form of very fine bubbles more than 60% in the mixture. That is why the specific weight of the batter ranges from 0.3 to 0.5 g/mL [5].

Due to such fine and foamy structure of the cake batter, the particle sizes of the flour should be very fine and uniform.

White wheat flour is suitable for cake production, while flour with high milling extraction rate does not have an adequate quality for cake making, because of the high presence of bran.

Possible increase in the fibre content of industrial cakes can be achieved by adding fine milling wheat bran of small particle sizes (32–100 μ - 55% and 15–45% below 32 μ). Wheat fibre were added (1, 2, 3, 4 and 5%) in three types of flour (T-400, T-500 and T-850). The type of flour is determined on the basis of the ash content (%) in the flour and is closely related to the milling extraction rate. Wheat flours T-400 (ash content up to 0.45%) and T-500 (ash content 0.46–0.55%) belong to white flours. T-850 flour contains ash in the amount of 0.8 to 0.9% and belongs to semi-white wheat flours.

According to the obtained results excellent sensory properties (shape, structure, chewing, smell and taste) showed samples made of flour T-400 with fine wheat fibre added up to 5% and samples made of flour T-500 up to 4% of wheat fibre [58]. These samples can be treated as *Source of fibre* according to EC Regulation on nutrition and health claims made on food [59].

Cake samples made with just T-850 flour and 1–5% fine wheat fibre added elicited inferior results with significantly smaller diameter and height and greater weight which is not in accordance with the parameters determined by the manufacturer's specification. Acceptable values determined by the manufacturer for this product are: diameter 52–55 mm, height 7–10 mm and weight 4.7–5.0 g [58].

An excellent way to improve nutritional value of cakes is using omega-eggs in formula instead of common eggs which can reduce omega-6 and omega-3 fatty acid ratio in cakes.

Several sources of information suggest that human beings evolved on a diet with a ratio of omega-6 to omega-3 essential fatty acids of approximately 1, whereas in Western diets the ratio is 15/1–16.7/1. Western diets are deficient in omega-3 fatty acids, and have excessive amounts of omega-6 fatty acids compared to the diet on which human beings evolved and on which their genetic patterns were established. Excessive amounts of omega-6 polyunsaturated fatty acids and a very high omega-6/omega-3 ratio, as is found in today's Western diets, promote the pathogenesis of many diseases, including cardiovascular diseases, cancer and inflammatory and autoimmune diseases, whereas increased levels of omega-3 (a low omega-6/omega-3 ratio) exert suppressive effects [60].

Cake samples made with omega-eggs (obtained by enriching the chicken feed with fishmeal or flax) contain 5 times more omega-3 fatty acid approximately 10 times more EPA - C 20:5 (n = 3) and 2.8 times more DHA - C 22:6 (n = 3) than standard samples. Moreover, omega-6/omega-3 fatty acid ratio in samples made with standard eggs was 14.94 and 2.84 in samples made with omega-eggs. Using omega-eggs instead of standard eggs does not affect the specific weight and viscosity of the batter. Differences in basic chemical composition of cake samples produced with standard and omega-eggs are negligible and do not influence the general cakes quality [61].

3.1.6 Gluten-free flour-based confectionery

Gluten proteins are storage proteins in wheat, situated in kernel endosperm. Gluten is responsible for dough development and for forming the viscoelastic properties. In addition, the gluten directly influences the dough's ability to retain gas. The role of gluten in bakery products making is crucial. However, recently we are aware of an increased interest in gluten-free diet because of the increased incidence of celiac disease, gluten intolerance and allergies. However, gluten-free diet for people who have never been diagnosed with celiac disease or gluten intolerance can lead to unbalanced nutritional diet caused by low dietary fibre intake.

The European Union (EU) adopts common rules concerning the composition and labelling of foodstuffs intended for people suffering from intolerance to gluten (coeliac disease). Food labelled *gluten-free* must contain less than 20 mg/kg of gluten in the finished product, and *very low gluten* must contain less than 100 mg/kg of gluten in the finished product [62].

Celiac disease is widespread and is often underdiagnosed. It can affect a variety of genetically susceptible people from the young to the old. Presently, the only treatment for celiac patients is lifelong gluten-free diet. Scientists and technologists continue in their quest to improve the quality of gluten-free products and their main goal is to create a product of a similar standard to the gluten-containing products. Studies are focused on ingredients and processing methods which have been documented to develop or improve the processing characteristics and nutritional properties of gluten-free products [63].

Many studies have investigated the properties of gluten-free biscuits using different types of cereal which do not contain gluten (maize, rice and rice starches); sorghum and pearl millet flours; and pseudo-cereal flours.

Some formulations of gluten-free baked goods include additional starch to increase viscosity and create an appropriate texture of the gluten-free dough or batter and of the finished product. Potato, corn, rice, and tapioca starches are common ingredients in gluten-free baked goods [64]. Pseudo-cereals such as amaranth, buckwheat and quinoa are valuable nutritious ingredients in gluten-free formulations thanks to their high protein quality and abundant quantities of fibre and minerals such as calcium and iron. Buckwheat is especially a good choice for production of these products when it comes to its proteins and high content of valuable bio-components.

The use of buckwheat flour generally has positive results in the finished product, particularly when a hydrocolloid is also present in the formulation [64]. There are several flour blends with buckwheat convenient for preparation of gluten-free biscuits: dark rise flour (50%), corn starch (30%), buckwheat flour (10%) and millet flakes (10%); buckwheat flour 25–75% and bean flour 25–75%; buckwheat flour (130 g), corn starch (60 g) and corn flour (60 g) [25]. Addition of buckwheat flour into the rice flour cookie formulation did not lead to a negative impact on the sensory quality of the evaluated samples. The addition of 20% buckwheat flour into the cookie formulation achieved the lowest differences in instrumental properties compared to the control sample, and good sensory properties [65]. In products such as crackers, cookies, and biscuits where less of a gluten-like structure is needed to achieve a desirable texture and dough workability, buckwheat alone, with no supplement, may be appropriate [66]. Potato, cassava flour, rice flour, soybean, extruded soy protein, pumpkin powder, taro, sweet potato and potato have been successfully used to produce gluten-free biscuits [67, 68]. In addition, other valuable ingredients can be used for these products: xanthan gum which had significant effects on chemical, physical, textural and sensorial characteristics of gluten-free cookies [69]; rice and coconut flour mixture [70] and maize starch and pea protein added in rice flour as tools to modify the characteristics of gluten-free cookies [71].

According to a number of studies in general, more desirable quality and sensory properties are expressed when the formulation includes a mixture of gluten-free flours and starches rather than a homogeneous formulation [64].

Gluten-free biscuits made of Jerusalem artichoke and corn composite flour showed an increase in protein, fibre, ash and minerals especially Fe, Ca and Mg with the increase in the Jerusalem artichoke concentration [72]. Some similar gluten-free products that included linseed meal, amaranth and buckwheat in their formulation had increased protein, fibre and alpha-Linoleic acid in the composition of the linseed meal [73]. Lupin flour and buckwheat flour could successfully use in gluten free cakes and each of them individually showed a positive effect on quality of products. Samples with buckwheat flour added in amount of 5% showed improved volume index and softness, such as samples with 20% of lupin flour added. In addition, cake samples with lupin had higher content of protein, fat, Ca, Fe, Mn, P and Zn. Buckwheat flour particularly influenced on content increase of K and Mg in cakes. However, high levels of lupin (30–40%) and buckwheat (15–20%) had negative effects on cakes quality [74].

Rice, maize, sorghum and pearl millet had also a good potential for production of gluten-free cookies [75].

According to analysis of gluten-free cookies based on coconut powder as main ingredient it was found that samples were acceptable in relation to sensory evaluation and general quality and concluded that coconut could be used as main bakery ingredient and a successfully alternative to wheat flour [76].

In general, production of gluten-free food means the exclusion of all possible gluten-containing raw materials, selection of an alternate flour source, acceptable sensory characteristic, enhancement of the nutritional quality, product safety and labelling [77].

3.2 Reducing of caloric value in flour-based confectionery

Many calorie-rich dietary components contribute to obesity. However, the contribution of confectionery to obesity in children and adolescents has not been well determined and there is no evidence of positive associations between confectionery consumption and overweight, obesity or other obesity-related outcomes in children and adolescents has been found. The study suggests that, whatever its adverse contribution to other aspects of human health might be, confectionery is not a major driver of obesity [78].

Nevertheless, confectionary has focused for the last couple of decades on the production of low-calorie, high-fibre foods in response to public interest for low-calorie and functional products.

3.2.1 Reducing of sugar in flour-based confectionery

Sugar provides energy for the body (1 gram of sugar provides 4 kcal or 17 kJ). In the form of glucose, sugar serves as an immediate energy source for the brain. Taking too much sugar (including free sugars) may lead to excessive energy intake and increase the risk of getting overweight and obesity and also increase the risk of dental caries.

Sucrose is the main sugar used in flour-based confectionery contributing up to 30–40% of all recipes and it plays an important role in the manufacturing as well as in the final product quality. However, for health reasons, high levels of sucrose are undesirable, making sucrose replacement an important issue today.

The question of how to replace sugar in bakery products by using healthy sugar alternatives has been challenging scientists for a long time. The main problem with reducing the amount of sugar is ensuring the product quality in terms of appearance, sweetness, texture, volume and microbial shelf life. Sugar contributes to browning, crystallisation, control of starch and protein thermal settings, structure, bulk, bodying and viscosity, fermentation, hygroscopicity, humectancy and moisture migration control, as well as to freezing point depression and osmotic pressure control [79].

Sugar replacement strategies should especially focus on mimicking the sucrose functionality concerning morphology, i.e. spread and volume, and texture. Sugar replacements can be classified into two groups: extensive and intensive sweeteners [80].

Extensive sweeteners are bulking ingredients such as polyols, oligosaccharides, dextrins which are often used in a one-to-one replacement of sugar. In terms of their functionality, the extensive sweeteners mainly act as plasticizers/co-solvents, although some such as polyols also have some sweetening function.

On the contrary, intensive sweeteners are mainly used for their sweetening and consequently added in small amounts. For these reasons, it can be safely assumed that they do not contribute to the structure, texture, and morphology of biscuits [80].

Nevertheless, we have to keep in mind that the reduction of calories in flour-based confectionery is particularly difficult if only sugar is replaced. According to Regulation EC [59] different claims can be used based on sugar concentrations: Low sugars; Sugar-free and No added sugars. If sugars are naturally present in the food, the following indication should also appear on the label: 'CONTAINS NATURALLY OCCURRING SUGARS'.

Some polyols can be used to substitute sucrose in cakes and biscuits, especially erythritol and maltitol. They have lower energy value than carbohydrates, namely 2.4 kcal/g, except for erythritol that has no energy value [81].

Mannitol, sorbitol, maltitol, erythritol, isomalt, xylitol and lactitol are considered as food additives and listed as an" E" number in the list of ingredients [82]. In general, the features of polyols are as follows: they are stable during storage at high temperatures; they do not react with other food constituents; they do not participate in Maillard reactions, caramelisation and inversion; they have a lower energy value then sucrose and other natural sugars; they do not raise the level of toxic substances in blood (cholesterol, triglycerides and lipoproteins); they are not toxic and they do not cause tooth decay.

A limiting factor when using polyols in confectionary in general is their relatively low sweetness compared to sucrose, except for xylitol which is of equal sweetness as sucrose. Given that they have a negative heat of solution, some of them cause a cooling effect in the mouth, especially xylitol and erythritol, which can be also considered as a limiting factor when they are used in some confectionery products.

In addition, it is important to note another negative effect of polyols. As they cannot be fermented and are very slowly absorbed, osmotic diarrhoea may occur when consumed in high amounts. The extent of laxative effect depends primarily on the type of polyol. Compared to other polyols, the absorption of erythritol is more efficient and its intake causes very small or no laxative effect [83]. Foods containing more than 10% added polyols have to be labelled with a claim "excessive consumption may produce laxative effects" [82].

Erythritol can be applied successfully in cookies, biscuits and cakes, where it improves stability and shelf-life if about 7% of it is added [84]. Maltitol offers the closest approximation to the properties of sugar. It can substitute sucrose in the quantitative and qualitative sense without damaging the final product texture and exhibiting aftertaste and compared to the other polyols, it has been evaluated as the most suitable sucrose substitute in biscuits and cookies and showed the highest sensory acceptance [81, 85–88].

More recently, there have been many researches dealing with the replacement of sucrose with different polyols such as using maltitol and fructo-oligosaccharides-sucralose as sweeteners and polydextrose as a fat replacer to produce highly acceptable reduced-calorie biscuits by using dairy–multigrain composite flour [89]; sucrose reduction and its replacement by erythritol and maltitol in short dough biscuits where sugar-free and erythritol-containing biscuits were compact, elastic, and resistant to the breaking force compared to the control biscuits and the maltitol-containing biscuits [90]. The use of sorbitol, maltitol, isomalt and erythritol as total sucrose replacers in muffins resulted in muffins with polyols that had lower height than samples with sucrose and this shows that this type of polyols also influenced the texture. At the same time, no differences were found in the sensory acceptance of sucrose, sorbitol and maltitol muffins [91].

A combination of polysaccharides, such as polydextrose, oligofructose or maltodextrin and high-intensive sweeteners, in order to ensure the techno-functional properties of sugar-reduced flour-based confectionery represents relevant perspective in sugar reduction and caloric value decreasing, as well [83].

It is important to recognise that in addition to being important bulking agents such as gluco-polysaccharides (polydextrose, resistant starches and maltodextrins) and fructo-oligosaccharides supporting high-intensity sweeteners, polyols or sugar in formulations, these particular polymeric materials have noticeable physiological benefits that are related to their soluble dietary fibre and potential prebiotic properties [92].

In recent times, stevia and its extracts have become increasingly popular high-intensive sweeteners and their use in confectionery is becoming widespread.

Natural high-intensive sweeteners are steviol glycosides, stevioside and rebaudioside A (Reb-A) found mainly in the leaves of stevia. *Stevia rebaudiana* Bertoni is a plant with great potential as an agricultural crop for the production of a high-potency natural sweetener. Owing to its proximate composition and its content of health-promoting phytochemical constituents, it is also a suitable raw material for the extraction and production of functional food ingredients. *Stevia* is a low-calorie sweetener 300 times sweeter than saccharose. The sweetening compounds, found mainly in the leaves of the plant, are steviol glycosides, with stevioside being the most abundant, followed by rebaudioside A [93].

Nevertheless, if only intensive sweetener is used in cakes or biscuit making instead sucrose or the other natural sugar, side effects on the texture and sensory characteristics of the product may occur. Intensive sweeteners do not have the same bulking ability as sugar, and texture may be altered in some baked products, especially biscuits. Also, the taste may be slightly altered due to the aftertaste of some sweeteners.

Biscuits made of Reb A as sweetener were less acceptable than biscuit made of sucrose or fructose (**Figure 2**). They were lighter in colour than samples made of natural sugars which have a caramelising/browning effect [11].

Reb A biscuits, without natural sugars added, had less caloric value than biscuits made of sucrose or fructose. However, the caloric reduction did not reach 30%, so these products could not be classified as "energy reduced" products [11].

The effect of stevia and steviol glycosides on the flour-based confectionery physical and chemical quality and dough rheology has been widely investigated, and very often in combination with some polyols or bulking agents to mimic the characteristics of sugar and to provide adequate moisture and texture.

The aqueous extract of stevia can be a potential bioactive ingredient in developing functional cookies produced of oatmeal flour [94]; and potential to regulate glycaemic response of muffins by incorporation of 50% stevianna or 50% inulin with no effects on the final product texture [95]. Erythritol and stevia as sugar substitutes influence various rheological characteristics of wheat dough depending on their level and type. The addition of stevia and erythritol, reduces the consistency of the dough and the water absorption [95, 96].

The sucrose replacement by different concentrations, as well as a combination of isomalt, maltodextrin and stevia, was approached to produce sugar-free biscuits and it was found that neither isomalt, maltodextrin nor stevia individually has the potential of producing sugar-free biscuits. The addition of appropriate amounts of isomalt, maltodextrin and stevia (6; 2.5 and 0.06%, respectively) to correct the appearance, texture, and sweetness of sugar-free biscuits can replace sucrose and give products with acceptable properties. Despite the fact that used sugars-replacements do not participate in Maillard reactions, biscuits had an even better golden-brown colour than those manufactured with sucrose [97]. The colour of biscuits made of stevia and maltitol as sweeteners can be improved with the addition of coffee silverskin as a natural colouring and a source of dietary fibre, as well [98].

The market aims at removing the unhealthy ingredients in formulations, particularly sugars, but pays attention to customer satisfaction. Baked goods manufacturers are currently utilising intense as well as high-volume artificial sweeteners as conventional sugar replacements [99].

3.2.2 Reduction of fats in flour-based confectionary

Fats have the highest calorific value of any other ingredients used in flour-based confectionery - 9 Kcal/g or 37 KJ/g, which is more than twice than that of carbohydrates and proteins. This is why the consumers are highly concerned about the fat content in biscuits.

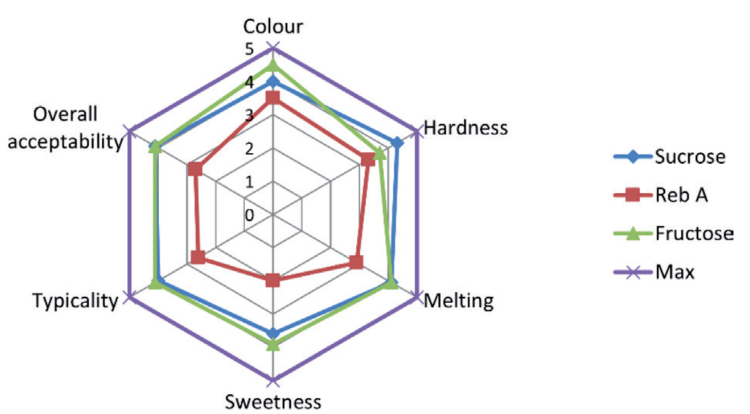

Figure 2.
Sensory evaluation of biscuits made of sucrose, fructose and Reb a (data from the author's private archive).

However, the simple reduction of fat in a biscuit recipe and recipes for other similar products usually results in quality deterioration such as excessive hardness, non-porous and unsatisfactory structure, and poorly expressed taste and aroma. In addition, low fat doughs are tougher, harder and stickier than normal doughs and a number of difficulties appear during manufacturing. In general, the important roles of the amount and type of fat in flour-based confectionery are reflected in an even distribution and possibility of dough aeration, final dough hardness, spread in the oven, texture of the final products, sensory quality like mouthfeel and aroma and shelf life. Odour and aroma are more expressed in samples with higher fat content, as a consequence of liposoluble character of the most aroma components.

According to sensory evaluation of semi-hard industrial biscuits with different commercial vanilla aroma forms added it was found that biscuit samples with 12% fat showed better sensory characteristics for all vanilla aroma forms than samples with 10% fat in a recipe [11].

From a sensory point of view, it is more acceptable to reduce the fat than the sugar content in biscuits manufactured in industrial conditions, at least when products are not perceived as less sweet [100].

Using fats with lower levels of saturates is a good way to increase nutritive value of flour-based confectionery. A general principle in the reduction of saturate levels in fat is seen through an increase in the level of liquid oil in the product, as these liquid oils, such as rapeseed oil or sunflower oil, have the lowest levels of saturated fats. However, an increased risk of oxidation of the fats and the development of rancidity in the biscuit during storage can influence shelf-life of the products [101]. Those products have a relatively higher spread value than the others and had a relatively harder texture. Studies also showed that the cookies containing the oil started to spread earlier and continued to spread for a longer time. However, the quality of these cookies could improve by including 0.5% sodium steroyl lactylate in the formulation [102].

Fats in flour-based confectionery mainly containing a high level of saturates may represent up to 20% or 35% of the product. Trans fats are also usually added to bakery products and are related to the risk of heart diseases, since they increase low-density lipoprotein (LDL) cholesterol levels and reduce those of high-density lipoprotein (HDL) [99]. Reduction of saturated fat, in recipes is perhaps the simplest and preferred way in manufacturing, as it allows decrease in calories using standard ingredients with modifications to an existing, established recipe. It also offers potential for cost savings, as fat can often be one of the most expensive ingredients in a biscuit recipe. Apart from the general quality issues arising from a reduction in overall fat content in biscuit doughs, there is also an impact on the biscuit dough consistency and processing properties [101].

Due to these reasons, a number of different fat substitutes have been investigated to meet the demand for a reduced-fat biscuits and similar products. These fat substitutes can be categorised as protein-based, carbohydrate-based, or fat-based substitutes [103].

Some of carbonate-based fat substituents, alone or in combinations, have been widely used include polydextrose, maltodextrins, tapioca dextrins, potato starch, microcrystalline cellulose and gums such as alginates, xanthan gum, carrageenan, and locust bean gum. Combination of maltodextrin and guar gum resulted of 62.5% the fat reduction in low-fat soft dough biscuits [104].

A good approach to improve cakes is combination of inulin and oligofructose as fat and sugar replacers respectively. Regarding the sensory analysis, a replacement up to 50% of fat and 30% of sugar separately and simultaneously did not significantly change the overall acceptability of the cakes [105].

The consumer study revealed that fat replacement up to 15 g/100 g with inulin or hydroxypropyl methylcellulose (HPMC) provided acceptable biscuits, but higher replacement decreased the overall acceptability [106].

Biscuits prepared with either olive oil or sunflower oil and xanthan gum as fat replacer differed the most from the biscuits made with shortenings. The biscuits formulated with either olive oil or sunflower oil and HPMC as fat replacer had the closest sensory properties to the shortening biscuits while the sunflower oil/HPMC systems seemed to be the most suitable system for obtaining biscuits with a healthier fatty acid profile [107].

A mixture of tapioca dextrin and tapioca starch was used as a shortening replacement in short-dough biscuits. The trained panel results showed that the fat replacer increased the hardness and crumbliness, and that these effects were balanced out by the addition of resistant starch [108].

In general, those substitutions affect the textural properties of the baked products, making them harder, and thus they have lower acceptance levels than control products. Chia seeds (*Salvia hispanica* L.) contain a high content of oil (30%–40%) with a significant amount of omega-3 fatty acids (linolenic acid, 54%–67%), protein (15%–25%) and fibre (18%–30%) which makes them an excellent choice for improving the nutritional profile of bakery products. Many authors have used Chia seed in different forms to reduce fat content and also to improve general nutritive value of flour-based confectionery [99].

The most satisfactory technique used to reduce fat levels in biscuits is to improve the fat functionality by using surface active agents, emulsifiers. Emulsifiers contribute to reduced-fat biscuit recipes in improving texture, volume and dough consistency but the basic function of the emulsifiers is to provide the distribution of fat in the dough. Emulsifiers, principally diacetyl tartaric acid esters of mono- and diglycerides (DATEM) show a fat-sparing effect and its use is not limited to their pure action as emulsifiers. They also influence the properties of baked goods during manufacturing and storage. The fat-sparing effect of DATEM-ester is most effective if the emulsifier is added with the fat [101, 109].

The "ideal" fat substitute does not exist. However, a good solution presents a combination of different ingredients that may or may not belong to any of the classes of fat replacers. This approach may include emulsifiers, fat substitutes or mimetics, fibres, water control ingredients, and/or flavour and bulking agents [103].

3.3 Microencapsulation in flour-based confectionery

In food products, fats and oils, aroma compounds and oleoresins, vitamins, minerals, colourants, and enzymes have been encapsulated and show a promising approach to develop functionally active food products. The advantages of microencapsulation are reflected in its easy application, stabilised active component, enhanced acceptability, protection, controlled release and creating new functional food [110].

Bioactive compounds have been incorporated in microcapsules to stabilise them, to convert them into powders, to alleviate unpleasant tastes or flavours, as well as to improve the bioavailability. This technology enables the covering and protection of bioactive components by completely enveloping them with a physical barrier. This is a way of packaging solids, liquids, or gaseous materials in small capsules that release their contents at controlled rates over prolonged periods and under specific conditions.

As the biscuits or cookies are widely consumed snacks, they are therefore an ideal food for fortification [111]. The incorporation of microencapsulated vitamins into a food matrix contributes to the improvement of the food nutritional value, reduction of off-flavours, it permits the time-release of nutrients, enhances the stability to high temperature and moisture and reduces each nutrient interaction with other ingredients [112]. Microencapsulation presents a successful tool to raise lycopene stability. Besides, microcapsules of spray-dried lycopene were able to release pigment and colour into cakes samples in a homogenous manner [113].

Studies of improving biscuits with microencapsulated highly susceptible micronutrients including 5-methyltetrahydrofolic acid, which is regarded as one of the most bioactive forms of folate [111] and cookies with β-carotene [114] have shown encouraging results, as well.

Encapsulation is also a favourable method that allows extending the shelf life of specific confectionery products such as cakes.

Some high added value components such as essential oils have significant properties from nutritive and medicinal aspects. Antimicrobial activity is particularly important to use in functional foods making and enable prolonging the shelf life of the final product. Furthermore, their strong and atypical tastes and smells could be successfully camouflaged by encapsulation [115].

An illustrative example of this is the study of using encapsulated thyme (*Thymus vulgaris*) oil as a natural food preservative that can be applied to cakes to promote their shelf lives and avoid synthetic preservative [116].

Due to the numerous possibilities of application and various methods that allow for the most suitable solutions for the incorporation of certain functional ingredients into food matrix, microencapsulation will certainly find its place in the commercial production of flour-based confectionery products [110].

4. Conclusion

Improving the general quality of flour-based confectionery products is a common topic of many recent researches conducted in different fields. Based on the consumers' demand, food scientists and producers are now focusing on developing functional foods.

Given that the production of flour-based confectionery products is one of the most innovative branches of the food industry, as well as the fact that these products are most represented in the diet compared to other confectionery products, the trend of creating food that affects physiological functions and can reduce the risk of various diseases is particularly pronounced.

These products are extremely suitable for improvements and for creating new functional products. Numerous researches show that the addition of dietary fibres from cereals and fruits, as well as by-products produced during fruit processing can improve functional properties while retaining sensory characteristics. Furthermore, enriching these products with raw materials rich in bio-components such as berries and various seeds contributes to an increase in antioxidant activity, while improving sensory properties. Also interesting are researches related to the creation of flour-based confectionery products with probiotic properties.

Particularly important researches are being conducted regarding the substitution of ingredients in biscuits and similar products primarily when it comes to fats and sugars. When talking about the replacement of individual ingredients, it is necessary to take into account complex processes of interaction of water and other components such as fats, starch, proteins and sugar. Fat replacers play a key role in creating products with reduced fat content, i.e. reduced caloric value, and it is important to consider their rheological and physical properties, as well as to adjust process parameters. In the process of creating new flour-based confectionery products, numerous studies include examining the consistency of the dough, adjusting process regimes, as well as evaluating the appearance and texture of these products.

It is necessary to point out the advantages of microencapsulation in the production of functional flour-based confectionery products as a relatively new technique used to enrich various food products. It allows the incorporation of bio-components that are not naturally found in these products or that can be lost during baking. The microencapsulation allows the retention of thermolabile valuable compounds in the product and their gradual release. In addition, this technique allows the incorporation of some substances that extend the self-life of the product, such as cakes, and at the same time camouflage possible uncharacteristic taste and aroma of added components, which can jeopardise the overall sensory impression of the product if added directly during mixing. It is to be expected that this method, due to its numerous benefits, will be increasingly adopted in the production of flour-based confectionery products. However, its application in practice is still limited due to the possibility of raising product prices, which is an additional challenge for manufacturers.

Some different directions in producing functional flour-based confectionery products are sometimes difficult to implement in practice due to strict consumer demands to select and buy high value nutritive food with desirable sensory properties. However, producers mostly take into account the consumers' awareness of the importance of functional food and their willingness to buy such products. Anyway, continuous education of consumers to select high value nutritive food and estimate food quality is needed, especially regarding confectionery products.

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