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Review Article

MODERN TECHNOLOGICAL SOLUTIONS USED IN THE PRODUCTION OF BAKERY PRODUCTS WITH HIGH BIOLOGICAL VALUE

Marta Brodowska[1], Dominika Guzek[1], Agnieszka Wierzbicka[1]

[1] Division of Engineering in Nutrition, Department of Functional Food and Commodities, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences (WULS-SGGW), 159C Nowoursynowska Str., 02-776 Warsaw, Poland, e-mail: marta_brodowska@sggw.pl; dominika_guzek@sggw.pl; agnieszka_wierzbicka@sggw.pl

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ABSTRACT
Biological value of the food products is a result of the presence of bioactive substances and the proportions of the components. Technological development allows to optimize and accelerate the processes of bread production and increase value of food. Bakery industry used whole grains and pseudocereals as additional source of active compounds, biotechnological techniques as using appropriate yeast strain and encapsulation, which provide protection of substance and their controlled release in production of functional bread. The adding to bread fruits, vegetables and condiments may increase content of vitamin, minerals, dietary fiber and other bioactive compounds.

Keywords: bread, bakery products, functional food products, bioactive compounds, antioxidants, microcapsulating.

INTRODUCTION

The increased biological value of food products is a result of the presence of one or more bioactive substances and the proportions of the components. Increased biological value food products may be traditional food products with a balanced nutritional value, as a consequence of natural bioactive ingredients or they may include modified food products e.g. enriched in certain biologically active substances [11, 35]. Biologically active substances are often non-nutrive components characterized by health-promoting properties, positive, documented impact on health. They can act as prophylactic or as an adjunctive factors in the therapy of diseases. Biologically bioactive substances include dietary fibers, oligosaccharides (prebiotics), proteins and peptides, polyunsaturated fatty acids (PUFA), minerals, vitamins, polyols, choline, lecithin, phytochemicals including antioxidative substances (such as polyphenols, anthocyanins), phytosterols and probiotics microorganisms [21].

Cereals including breads and other bakery products are frequently purchased and regularly consumed food products. As a consequence they may be a perfect carrier for bioactive substances which may provide systematic intake of specified doses [50]. In Europe, consumption of bread enriched with bioactive compounds is constantly increasing because consumers understand the role of health-promoting component of such products. Therefore, in the nearest future the bakery products may be increasingly used to deliver specific biologically active compounds to diet and to increase their intake [25], that is presented in Table 1. The other possibility is using bread with increase nutritional value, designed-to use in prevention of some diseases [15].

PSEUDOCERALAS AND WHOLE GRAINS AS ASOURCE OF BIOACTIVE COMPOUNDS

Pseudocereal grains such as buckwheat, amaranth or quinoa or other crops, such as oat and

Table 1. Maximum dose of bioactive components, which allows acceptable sensory attributes of bread

Level of supplementation in bread	Bioactive substances	Serving size	Amount per serving	References
51% of whole grain oat flour as substitution of wheat flour	*β*-glucan	approximately 30 g	0.78 g	Flander et al., 2007 [15]
30% of buckwheat flour as substitution of wheat flour	Total phenols	1g dry weight of baking bread	2.65 mg ±0.1	Chłopicka et al., 2012 [11]
30% of buckwheat flour as substitution of wheat flour	total flavonoids	1g dry weight of baking bread	32.9 µg ±4	Chłopicka et al., 2012 [11]
3% dry onion skin as substitution of wheat flour	quercetine (in buffer extraction)	100 g dry weight of baking bread	127 µg ±22.34	Gawlik-Dziki et al. 2013 [17]
4% turmeric powder as substitution of wheat flour	curcumin	50 g	4.6 mg	Lim et al., 2011 [35]
4% turmeric powder as substitution of wheat flour	total phenolic contents	50 g	40,12 mg, 2.5 x more compared with control	Lim et al., 2011[35]
Aproximately 0,5% of milk thistle fruit (1,4 g for every 250 g of dough) and probably may be higher	silymarin	–	Not indicated	Sadowska, 2006 [48]
3% powder ginger as substitution of wheat flour	total fenols content	–	2 x more compared with the control	Balestra et al., 2011 [2]
1g of grape seed extract / 500 g in bread before baking (0,2%)	catechins and proanthocyanidins	–	Approximately 6 x more compared with control (as antioxidant capacities)	Peng et al., 2010 [42]

barley, are rich sources of bioactive compounds e.g. flavonoids, phenolic acids, unsaturated fatty acids, trace elements and vitamins characterized by well-known positive effect on human health [7, 17, 26, 45]. The increase of consumption of bread with addition of pseudocereals can significantly improve antioxidant potential of diet, because it is known that the pseudocereal whole grains are rich in various antioxidative compounds [30, 38]. Moreover, in bakery products with addition of pseudocereal whole grains also general nutritional value e.g. quality and quantity of protein, dietary fiber content, fatty acid profile may be enhanced [39]. Such products are also good to ensure diversity of diet, what is nowadays a serious problem in Poland, especially in case of individuals with diet-related diseases [58]. The pseudocereals are free of gluten so they can be useful in diet therapy of celiac disease [52]. The sensory value of bread is very important, because taste and flavour of influence consumer preferences of cereal and other groups of products. The research revealed that the additions of pseudocereal flours improves not only the nutritional value of bread, but also the bread making properties (chemical, rheological properties), extends the shelf life of the product, is associated with more delicate crumb and lower firmness.

Chłopicka et al. [9] analysed the effect of adding 15% and 30% of pseudocereal flours including buckwheat, amaranth and quinoa, on the antioxidant capacity and sensory value of breads. In spite of the facts, that the content of total flavonoids in flours was about 2–4 times higher than in final product. In the final product it was still significantly higher than in a wheat bread. Buckwheat flour was characterized by had the highest phenol content approximately 7.25 mg/g of dry weight. The 30% dose was more effective in enhancing antioxidant activity than the 15% dose. The addition of buckwheat was associated with antioxidant activity is 2 times higher (while measured as a Ferric Reducing Ability of Plasma – FRAP) and 3,64 times higher (while measured as diphenylpicrylhydrazyl – DPPH) in comparison no addition of pseudocereal flours. Simultaneously, the addition of amaranth and quinoa was associated with antioxidant activity 1.20–1.79 times higher, and 0.60–1.71 higher for FRAP and DPPH respectively. It was concluded, that the addition of buckwheat, amaranth, quinoa flours to wheat flour improved antioxidant status of bread, while buckwheat flour was more effective than other studied pseudocereals. Buckwheat bread had also a highest content of phenolic compounds. The analysis of sensory results suggested that the buckwheat bread was characterised by has more positive sensory than amaranth and quinoa bread, especially taste, aroma and colour. The results indicate that bread fortified with pseudocereal flours, particularly with buckwheat flour, but depending on the dose, may improve nutritional value of bread and this bread may be chosen by consumers as preferred.

Many studies indicate that regular intake of whole grains provide a wide range of nutrients, including phytochemicals, that results in serious health benefits. Whole grain products consumption is associated with reduced risk of diseases such as cancers [48, 45], cardiovascular diseases [24], hypertension [3, 13] and diabetes [31]. Therefore, consumption of grain products as the main part of the daily menu, higher than is currently observed in western population, is recommended by dieticians, nutritionists and doctors [41, 44]. Miller et. al [34] compared the antioxidant capacity of breakfast wholegrain cereals and some fruits and vegetables. Antioxidants content was expressed as Trolox equivalents/ 100 grams (TE). Whole grain breakfast cereals contained from 2200–3500 TE. Fruits generally ranged between 600–1700 TE, with a highest values of 3700 TE for berries. Vegetables ranged averaged 450 TE with a high of 1400 TE for red cabbage. The one serving (41 g) of ready to eat breakfast whole grains cereals provides 1120 TE, while one serving of vegetables and fruits (85 g) provides 380 TE and only 1020 TE respectively. It may be concluded, that whole grain breakfast cereals may be, except fruits and vegetables, the most important source of antioxidants in the diet.

Taking into account, the typical western diet and general lifestyle, dietary fiber is a deficit nutrient, so new ways to deliver it may be of a great value. There is a trend to seek for new sources of dietary fibre as components for the food industry [8]. Whole oat grain contains significant amounts of dietary fiber, especially water-soluble (1→3), (1→4)-*β*-D-glucan. The *β*-glucan content in oat varies from 2.3 to 8.5/100 g [54]. The main problem that appears during using oat as a component of bakery products, is deterioration of baking quality, because oat proteins, which do not possess the visco-elastic properties, as wheat gluten possesses, are usually denaturated by a heat treatment [18]. Exceeding 20 g of oat/100 g of products could leads to obtaining moist, gummy bread. Baking technology for bread characterised by high oat whole grain content, acceptable texture and sensory characteristics was developed by Flander et al. [12]. The elaborated baking technology requires using oat whole grain (51 g/100 g of flour) and white wheat (49 g/100 g of flour). The processing conditions, as baking temperature, time and temperature of proofing had the most essential influence on bread quality. Maximum volume, minimum hardness were achieved by adding 15.2 g of gluten/100 g of flour and 91.5 g of water/100 g flour to the dough, after proofing the bread at 40 °C for 75 min and baking it at 210 °C for 4 minutes. The optimum thickness and crispness of the crust as well as optimum flavour, were obtained in the same conditions as the maximum volume and minimum hardness of oat bread. The amount of *β*-glucan in oat bread was 2.4 g/100 g of bread compared with the amount of *β*-glucan in the wheat bread (1.3 g/100 g of bread). Therefore, a portion (approximately 30 g) of the bread contains 0.78 g of *β*-glucan. In the mentioned study decrease in molecular weight of *β*-glucan was also noticed. It may be a result of the *β*-glucan hydrolysis caused by endogenous enzymes present in wheat flour. To sum up, it is possible to obtain the bread characterised by high content of bioactive *β*-glucan and typical structure, as well as being perceived by consumers as tasty, by optimizing recipe and parameters of processing.

USING OF BIOTECHNOLOGICAL TECHNIQUES TO INCREASE HEALTH-PROMOTING PROPERTIES OF BREAD

Except *β*-glucan, also other ingredients, characterised by health-promoting properties may be added to bread and bakery products. Such ingredients are either substances, that are not observed in conventional products, or such substances, which exist, but in a small amount – often too small to exert an influence on human health and well-being. In such case, adding additional quantity of substances, may be of great value. The obvious additives, such as B vitamins, are ingredients, that are naturally observed in the grain and are removed during grinding.

Attractive for consumer idea, being used to increase folate intake is biotechnological technique using the yeast to enhance the concentration of folates naturally occurring in fermented food products. Folate content in yeast fermented food products may be significantly increased by using a selected yeast strain and proper cultivation procedure dedicated for the selected strain. Hjortmo et al. [22] conducted such an analysis using *Saccharomyces cerevisiae* CBS7764 strain and commercial baker's yeast as a reference strain. *Saccharomyces cerevisiae* CBS7764 strain was cultured in defined medium and harvested in the fermentative phase of growth (respiro). Commercial compressed baker's yeast were bought in local store and was stored in refrigerator until baking. Folate content was 3–5 times higher in the wheat bread with a *Saccharomyces cerevisiae* CBS7764 strain than in conventional bread. The obtained dough contained 135–139 μg of folate/100 g of dry matter, compared to wheat bread with commercial baker›s yeast, containing 27–43 μg of folate/100 g of bread. The practical possibility of application this strategy indicates that using appropriate yeast strain to production of bread is an attractive alternative in comparison with bread fortification of with synthetic folic acid.

Wholegrain bread is generally regarded as characterised by better nutritional value than white bread, because of higher content of dietary fibre, vitamins, especially B vitamins as well as micro- and macronutrients. However, wholegrain bread is also characterised by high level of phytate (myo-inositolhexakisphosphate, InsP-6), which may chelate and bind minerals, resulting in insoluble complexes generation, that may lead to mineral absorption and bioavailability decrease. As a result, it may reduce the nutritional value of wholegrain product [27, 5]. Leenhardt et al. [28] analysed changes in phytate hydrolysis caused by sourdough fermentation or exogenous organic acid *in vitro* addition. This was indicated that lowering pH of the dough to approximately 5.5, caused by adding sourdough or lactic acid, in both cases, was associated with a significant reduction of phytate content (approximately 35% of reduction). Other authors confirm, that both mentioned fermentation methods are useful techniques allowing to decrease the amount of phytate in wholegrain cereals and as a consequence to maintain potential high nutritional value of the product [32, 43].

ADDING INGREADIENTS SUCH AS FRUITS, VEGETABLES AND CONDIMENTS, RICH IN BIOACTIVE SUBSTANCES TO BREAD

Fruits and vegetables intake is associated with reduced risk of some cancers and cardiovascular diseases. While these protective effects have been *inter alia* attributed to the content of beta-carotene, ascorbic acid and phenolic compounds. The majority of the beneficial health effects of flavonoids are attributed to their antioxidant and chelating properties. Polyphenols and dietary fibre from fruits demonstrate health-promoting properties and may play a key role in health improvement and disease prevention in some population groups [37]. This is the reason why using fruits, vegetables or their products in bread production, as an additional source of biologically active compounds that may simultaneously improve sensory properties of bakery products, could be very promising.

Gawlik-Dziki et al. [14] studied the effect of adding ground onion peel on the antioxidative and sensory properties of bread. To determine the *in vitro* bioaccessibility and bioavailability the human gastrointestinal tract model was used. Onion peel contains 4.6 mg mastication-extractable quercetin/g of onion. Quercetin was highly bioaccessible during *in vitro* experimental conditions, but only about 4% of quercetin was extracted during simulated digestion. The antioxidative potential of bread with onion peel addition was significantly higher than the antioxidative potential in case of the control group. Onion peel as a compound of bread also demonstrated the potential against lipid oxidation and chelating abilities. The addition of 2–3% of onion peel was the optimum dose that caused significant improvement of antioxidative properties, while higher supplementation level did not cause any increase of the antioxidative potential of bread. Sensory evaluation revealed that the replacement of wheat flour in bread with no more than 3% of onion peel powder was associated with satisfactory consumer results and may comprise a valuable additive enabling development of functional properties of bread.

The example of indirect using the fruits in the baking process may be the addition of grape seed extract (GSE). The extract is a good source of catechins and proanthocyanidins, both being powerful antioxidants. The bread was supplemented in an amount of 300 mg, 600 mg and 1 g/500 g of bread. The results of research indicated that the bread with the addition of GSE had stronger antioxidative activity than control. However, thermal processing caused 30–40% decrease of antioxidative activity of extract. Authors also studied the effect of GSE on the formation of detrimental N-(carboxymethyl)lysine (CML), being advanced glycation end-product present in bread. CML in food is considered as a toxic substance, associated with oxidative stress, increased risk of diabetes and atherosclerosis. The results indicate that the GSE could reduce CML formation in bread and the mentioned action is dose-dependent. Moreover, except for an acceptable colour change, adding the GSE to bread did not have essential effect on the quality attributes of the bread. The results indicate that grape seed extract added to bread as an enriching compound may be promising additive to create functional food products with reduced CML level, that may be associated with reduced health risks, and high antioxidative activity [36].

Dietary fiber, according as its water solubility is categorized as water-soluble dietary fiber (SDF) and water-insoluble dietary fiber (IDF). SDF such as β-glucan and arabinoxylan can create viscous solutions leading to increased viscosity in the intestine and slowed intestinal transmission, delayed gastric emptying, as well as binding glucose and delaying sterols absorption in the intestine [57]. Consequently, viscous soluble fiber can be useful in lowering serum cholesterol, postprandial blood glucose, and insulin levels. IDF such as lignin, celluloses and hemicelluloses are characterised by higher water-holding capacity then SDF. IDF causes increasing of the fecal bulk. Lignin is also a lipophilic phenolic polymer absorbing bile acids [57, 40].

To increase the level of dietary fiber in diet, it could be added, as an enrichment of various bakery products (not only bread), the preparations obtained from by-products of the fruit, vegetable or cereal industry. The cookies with the addition of raspberry pomace and buckwheat hulls are characterised by higher total dietary fiber content in comparison with the control cookies without such addition (6.65–16.45 g of dietary fiber/ 100 g vs. 2.90 g of dietary fiber/100 g) and were characterised by varied composition of the fractions (both SDF and IDF fractions). Sensory analysis revealed that the best sensory profiles were observed in case of cookies in which used 10% and 20% dose of raspberry pomace. Cookies with buckwheat hulls addition were also characterised by higher dietary fiber content in comparison with control, but worse sensory properties [19].

The addition of herbs and condiments to bread improves its flavor, aroma and increases the nutritional value. It also allows to reduce of amount of salt [20]. Herbs in the bakery industry, depending on technological requirements, may be used in a dried form, milled form (0.5–1%), or as the extracts (0.001–0.01%) [5].

Curcumin (being a catechin) is the main bioactive compound occurred in the turmeric rhizome (*Curcuma longa L.*). Curcumin and its derivatives have strong antioxidative, anti-inflammatory, anti-cancer and anti-depressive properties, as well as they regulate the immunological system. Dried turmeric rhizomes are yellow and are used as a condiment [53]. Turmeric powder also may be used as bioactive component added to the functional bread. Lim et al. [29] analysed also possibilities of using the turmeric powder as a flour substitute. Wheat bread with addition turmeric powder was developed and analysed to assess the physical characteristics, content of bioactive components and their properties, as affected by various substitution levels. The results indicated, that values of a* and b* components of colour, crumb hardness, curcumin and total phenolic contents in bread significantly increased with the addition of turmeric powder. On the other hand, water activity, specific volume of bread and crumb L* component of colour (brightness) simultaneously decreased with the addition of turmeric powder. Bread prepared with 8% of turmeric powder contained almost 5 times more total phenols (150.5 mg/100 g of bread), in comparison with conventional wheat bread (30.9 mg/100 g). Addition of no more than 4% of turmeric powder was associated with acceptable sensory properties which were comparable to those observed for control wheat bread. Everyday consumption of 50 g (two slices) of bread with the addition of 4% of turmeric powder provides about 4,6 mg of curcumin and 40.12 mg of total phenolic compounds. Probably, as a result of increased antioxidant activity and lower content of fat, bread with the addition of turmeric powder may be also characterised by an extended storage time. During the storage, the mould appeared after 3 weeks, while in case of the conventional wheat bread, the mould appeared after 1 week. It may be concluded, that using turmeric powder allows to create functional bread with satisfactory sensory properties and improved functional properties.

An interesting and innovative addition to the bread, may be a little-known for its properties, milk thistle fruit, that was examined by Sadowska [42]. The study analysed the impact of biologically active compounds – flavonolignans complex also called the silymarin (containing flavonolignan, mainly silybin) on the quality of bread. Silymarin is one of the basic substances used as an element of the adjunctive therapy in the treatment of liver diseases. The levels of silymarin added were selected to be not higher than 10% of medicinal dose. The milk thistle fruit was applied in the doses of 0.16 g, 0.336 g and 0.56 g/100 g. The addition of mentioned doses of milk thistle fruit did not influence sensory and physical properties of wheat dough. Consequently, it may be used to create breads rich in silymarin. The results of the study were the object of the patent-pending and bread with milk thistle fruit is to be called the “bread of the liver”.

The ginger powder addition was also examined due to its antioxidative properties. The rheological properties of dough were analysed using dynamic rheological measurements. The highest total phenolic content – 0.48 and 0.71 mg of GAE (gallic acid equivalent) per g of dry weight of crumb and crust respectively, and the highest radical scavenging activity – 0.15 and 0,24 μM of DPPH (2,2-diphenyl-1-picrylhydrazyl) per mg of dry weight of crumb and crust respectively were achieved in case of bread with the highest content of ginger powder (6%). Simultaneously, the above-mentioned sample was characterised by worst rheological properties associated with tough structure of the dough and texture of the bread. Furthermore, sensory evaluation revealed, that this ginger bread sample was not acceptable for consumers. Bread with the 3% addition of ginger powder was characterised by better rheological characteristics and higher sensory acceptance, while antioxidant capacity was 2 times higher compared with the control bread. It may be concluded, that the 3% addition is the maximum dose, which allows to obtain satisfying attributes of bread with ginger powder [1].

CHOLESTEROL-LOWERING BREAD

Phytosterols (plant sterols) are one of the compounds building the plant cell membranes. Their chemical structure resembles the structure of cholesterol, so that they can be treated by human body as the cholesterol and, as a consequence, their consumption may cause a decrease of blood cholesterol level. In the intestine, phytosterols are combined with the same receptors of intestinal cells as the cholesterol is, so the absorption of the cholesterol is blocked and its excretion is increased. Except for a decrease of total cholesterol levels, phytosterols may also influence the lipid profile, lowering the level of LDL-cholesterol (low density lipoprotein-cholesterol), which is called “bad cholesterol’. The therapeutic dose of phytosterols, that lowers LDL-cholesterol is 2 g per day. However, the delivering such quantities in a typical diet is not possible, so to obtain beneficial result, it is necessary to incorporate phytosterols into functional products. Developing functional products with phytosterols added, it is necessary to take into account the average amount of enriched product consumed in the diet and added amount should provide a 2 g dose of phytosterols in an average daily serving. The most common food product enriched in phytosterols are margarines, but also cheeses, juices, breads, confectionaries and enriched cereals [55]. Clifton et al [10] compared the effectiveness of the same dose of phytosterols (1.6 g) depending on the product to which it was added. In case of bread, LDL-cholesterol level was 6.5% reduced, that was lower reduction in comparison to milk (15.9%) and butter (8.6%), but higher than in case of cereals (5.4%). Moreover, only in case of bread, added phytosterols had also influence on increasing HDL-cholesterol (high density lipoprotein-cholesterol), which may reduce risk of cardiovascular diseases. Other studies also indicate the effectiveness of rye bread with high content of fiber and enriched with phytosterols in lowering blood cholesterol levels. Consuming daily two servings of bread enriched with phytosterols, instead of one, had more positive effect (LDL-cholesterol was 10.4% reduced, instead of 8.1%) [49]. The Scientific Committee on Food (SCF) in its opinion “General view on the long-term effects of the intake of elevated levels of phytosterols from multiple dietary sources (...)” indicated that there was no evidence of additional benefits at intakes higher than 3 g/ day and that high intakes might induce undesirable effects and that it was therefore prudent to avoid plant sterol intakes exceeding 3 g/day. Simultaneously, bakery products shall be presented in such a manner that they can be easily divided into portions that contain either maximum 3 g (in case of one portion per day) or maximum 1 g (in case of three portions per day) of added phytosterols [55].

ENCAPSULATION AS EFFICIENT METHOD OF ENRICHING FOOD PRODUCTS IN BIOACTIVE COMPOUNDS

Encapsulation of active food ingredients is useful in developing functional food products, because it is an easy and effective way to deliver and protect bioactive compounds, such as vitamins, other antioxidants or fatty acids [2]. Encapsulation assures enhanced food product functionality and stability of substances including slow or controlled release during storage [33]. Encapsulation is a modern technology of packaging solids, liquids or gaseous materials in minuscule, sealed capsules that enables releasing their content under specific conditions. As a consequence, encapsulation protects the core from unfavourable environmental conditions and extends shelf life of a product [46].

Long-chain polyunsaturated omega-3 fatty acids, contained in flax seed oil and fish oil, are not resistant to oxidation during processing and storage. The oxidation of lipids is may be associated with lower nutritional value and sensory quality of products. Encapsulation can be a good way to protect lipids from oxidation. Borneo et al. [4] indicated that it is possible to obtain shelf-stable fortified food products characterised by high level of long-chain omega-3 fatty acids and acceptable sensory properties. They formulated a cream-filling to sandwich cookies containing 400 mg of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), being fish-derived n-3 fatty acids. EPA i DHA were encapsulated in a matrix of starch and gelatin. After 28 days of storage under 2 various temperature conditions (18°C and 35°C) and 2 various packaging conditions (modified atmosphere packaging and vacuum packaging), the maximum observed loss was 5%.

Gokmen et al. [16] developed functional bread enriched with omega-3 fatty acids. Corn starch characterised by a high amylase content was used to prepare nanosized complexes with flax seed oil. Then the complex was converted to powder by spray drying. The reaction of products of lipid oxidation with amino acids is contributing to the formation of potentially harmful products of Maillard reaction, such as acrylamide and hydroxymethyl furfural (HMF), so authors evaluated also encapsulation effect on formation of the above-mentioned products. The study revealed that encapsulation significantly decreased lipid oxidation and formation of acrylamide and HMF, in breads during baking. Scanning electron microscopic analysis of functional bread demonstrated that microcapsules added to dough stayed intact in the crumb, but in the crust were partially destroyed. The quality of bread with addition of nanoencapsulated flax seed oil, compared with bread containing free form of flax seed oil, was higher. The bread containing encapsulated substances was characterised by lower level of fatty acids thermoxidation and of harmful compounds formation during baking. Moreover, the use of encapsulation allows to reduce off flavor and to improve sensory attributes.

In the United States, Canada and some other countries, to reduce the risk of the neural tube defects, mandatory fortification of grain products, including flours, with folic acid was introduced. The folic acid is a one of B vitamins, which in a typical Polish diet, is a deficit nutrient. The folic acid is *inter alia* involved in the metabolism of homocysteine, by regulation of its concentration in blood. Homocysteine is a homologue of the cysteine amino acid that may cause damage of the blood vessels and is associated with atherosclerotic and advanced thrombosis. Folic acid, which is used in diet supplements and added to food products, is a synthetic and oxidised form of folate because of its higher stability and bioavailability. However, too high levels of synthetic folic acid should not be used, because too high levels of folic acid in blood can mask the hematological symptoms of cobalamin deficiency. It may also foster carcinogenesis, contribute to the development of anemia and cognitive impairment, as well as to decreased immune function [48]. A reduced form of folic acid, L-5-methyltetrahydrofolic acid (L-5-MTHF), is characterised by similar bioavailability as synthetic folic acid, but simultaneously do not mask vitamin B12 deficiency and could be potentially safer while used to fortification compared with not reduced form [23, 58]. Tomiuk et. al [51] analysed the L-5-MTHF from during baking and storage of a fortified white bread. They used microencapsulation of L-5-MTHF, with or without addition of sodium ascorbate (ASC), using skimmed milk powder (SMP) as coat. This study proved that skimmed milk powder is an effective microencapsulating agent. Moreover, the presence of ASC improved stabilising L-5-MTHF in baked white bread. In addition, skim milk powder, which is also used as an enriching wheat bread, acted as a bulking agent in baked products and agent improving uniformity of dispersion of L- 5-MTHF.

Yan [59] patented method of a multi-core encapsulation. The main novelty in this method, is encapsulating bioactive compound and then applying a second layer over the previously encapsulated core. This provides multi-layers of protection of bioactive substance. And currently, Ocean Nutrition Canada uses this technology to produce stable omega-3 encapsulated powders. This encapsulated power may be used to enhance bakery products with a higher amount of unsaturated fatty acids.

CONCLUSION

Similarly, as in other food-related sectors, the bakery industry is undergoing major transformations, being *inter alia* driven by changes in consumer demands. Increasing the nutritional and health-promoting value is becoming a trend, which shapes consumers' interest in bakery products. On the other hand, technological development allows to optimize and accelerate the processes of bread production. Using fruits, vegetables or their products as a source of biologically active compounds, exploitation of encapsulation and the use of biotechnological methods are new opportunities to produce functional bakery products with increased nutritional value. It could indirectly influence consumers' health and well-being.

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