SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS OF THE SCIENTIFIC AND RESEARCH ACTIVITIES

APPENDIX 2B

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1. PERSONAL DETAILS

1.1. Names and surname

Marcin Andrzej Kurek

1.2. Obtained diplomas (degrees)

2016 **Postgraduate course**, major: Information systems, applications and databases, Faculty of Information Management, Polish-Japanese Academy of Information Technology

2015 **Doctor of Philosophy**, discipline: food and nutrition technology, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences, thesis topic: "Effect of dietary fiber preparations' addition and micronisation level on selected quality characteristics formation of bakery products"; promoter: prof. dr hab. Agnieszka Wierzbicka, auxiliary promoter: Jarosław Wyrwisz Ph.D.; graduated with Honourable Mention

2014 **Bachelor**, major: managerial economics, Faculty of Economy and Management, Łazarski University, thesis topic: „Franchise as the enterprise's external source of financing"; promoter: dr Tadeusz Teofil Kaczmarek; graduated with Honourable Mention

2013 **Master of Science**, major: food technology and human nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences, thesis topic: "The application of liquid chromatography with tandem mass spectrometry (LC-MS-APCI-IT) in determining the vitamin E level changes in pork"; promoter: dr hab. Arkadiusz Szterk

2013 Annual program of the **Academy of Young Diplomats**, European Academy of Diplomacy

2012 **Bachelor of Science**, major: food technology and human nutrition, Faculty of Human Nutrition and Consumer Sciences,, Warsaw University of Life Sciences, thesis topic: "The analysis of meat color changes influenced by heat treatment"; promoter: dr inż. Magdalena Zalewska

1.3. Information on previous employment in scientific units

01.2017 – date	Warsaw University of Life Sciences, Faculty of Human Nutrition and Consumer Sciences, Department of Technique and Food Development, **head of project LIDER**: "Microencapsulation as the technique for increasing the application of in the food industry", no: LIDER/25/0022/L-7/15/NCBR/2016
11.2016 – date	Warsaw University of Life Sciences, Faculty of Human Nutrition and Consumer Sciences, Department of Technique and Food Development – **assistant professor**
09.2013 – 10.2016	Warsaw University of Life Sciences, Faculty of Human Nutrition and Consumer Sciences, Department of Technique and Food Development – **research assistant**, working in the Project "Bioproducts", innovative technologies of pro-health bakery products and pasta with reduced caloric value, no: UDA-POIG.01.03.01-14-041/12
06.2014 – 06.2015	Warsaw University of Life Sciences, Faculty of Human Nutrition and Consumer Sciences, Department of Technique and Food Development – **scientific worker** in the Project: "Optimization of beef production in Poland, in accordance with the strategy" from fork to farm ", no: POIG.01.03.01-00-204/09

2. SCIENTIFIC ACHIEVEMENT BEING THE BASIS OF THE HABILITATION PROCEDURE

2.1. Title of the scientific achievement

The scientific achievement, in accordance with Article 16, Paragraph 2 of the Act of 14 March 2003 concerning the scientific degrees and titles (Journal of Laws No. 65, item 595, as amended), is the series of five publications entitled:

“**Research on the use of dietary fiber in food production - a technological and nutritional approach.**”

2.2. The list of publications constituting the scientific achievement

H.1. **Kurek, M. A.,** Wyrwisz, J., Karp, S., & Wierzbicka, A. (2017). Particle size of dietary fiber preparation affects the bioaccessibility of selected vitamin B in fortified wheat bread. *Journal of Cereal Science*, *77*, 166-171 (IF: 2,302; MNiSW: 35)

My contribution to the creation of this work consisted in co-creating the concept of the article, reviewing the literature, making experiments and developing methodologies, preparing the manuscript and fulfilling the role of a correspondent author. My percentage is 70%.

H.2. **Kurek, M. A.,** Wyrwisz, J., Karp, S., & Wierzbicka, A. (2018). Effect of fiber sources on fatty acids profile, glycemic index, and phenolic compound content of in vitro digested fortified wheat bread. *Journal of Food Science and Technology*, *55(5):*1632-1640 (IF: 1,797; MNiSW: 35)

My contribution to the creation of this work consisted in creating the concept of the article, reviewing the literature, making experiments and developing methodologies, preparing the manuscript and fulfilling the role of a correspondent author. My percentage is 70%.

H.3. **Kurek, M. A.,** Karp, S., Wyrwisz, J., & Niu, Y. (2018). Physicochemical properties of dietary fibers extracted from gluten-free sources: Quinoa (*Chenopodium quinoa*), amaranth (*Amaranthus caudatus*) and millet (*Panicum miliaceum*). *Food Hydrocolloids*, *85,* 321-330 (IF: 5,089; MNiSW: 45)

My contribution to the creation of this work consisted in creating the concept of the article, reviewing the literature, making experiments, preparing the manuscript and fulfilling the role of a correspondent author. My percentage is 70%.

H.4. Kurek, M. A., Karp, S., Stelmasiak, A., Pieczykolan, E., Juszczyk, K., & Rieder, A. (2018). Effect of natural flocculants on purity and properties of β-glucan extracted from barley and oat. *Carbohydrate Polymers*, *188*, 60-67 (IF: 5,158; MNiSW: 40)

My contribution to the creation of this work consisted in creating the concept of the article, reviewing the literature, completing some of the experiments, preparing the manuscript and fulfilling the role of a correspondent author. My percentage is 55%.

H.5. Kurek, M.A., Moczkowska, M., Pieczykolan, E., Sobieralska, M. (2018). Barley β-D-glucan – modified starch complex as potential encapsulation agent for fish oil. *International Journal of Biological Macromolecules*, 120, 596-602 (IF: 3,909; MNiSW: 35)

My contribution to the creation of this work was to co-create the concept of the article, review the literature, make experiments and develop methodologies, prepare the manuscript, fulfill the role of correspondence author and statistical analysis. My percentage is 65%.

The total Impact Factor (IF) for five works is **18.255**. The sum of points according to the unified journal evaluation for the years 2013-2016 published on 26/01/2017 by the Ministry of Science and Higher Education is **190**. Copies of works included in the monothematic series of publications constituting a scientific achievement together with statements of co-authors determining their contribution to the creation of each publication are attached to Appendix 4.

2.3. Presentation of the scientific aim of studies and their results accompanied by the possibilities of application of results of achievement

2.3.1. Introduction

Dietary fiber - definition and classification

According to the definition proposed in 2001 by the American Association of Cereal Chemists International, dietary fibers are edible parts of plants or carbohydrate analogs that are resistant to digestion and absorption in the human small intestine and are also completely or partially fermented in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and related plant substances. Dietary fiber has a positive effect on human physiology, including laxative properties, lowering blood cholesterol levels and lowering blood glucose levels (DeVries et al., 2001).

The current recommendations of many scientific centers dealing with human nutrition recommend that the daily intake of dietary fiber should be about 25-30 grams per person per day. In the vast majority of the world, intake of dietary fiber is at a lower level than recommended. In well-developed countries the daily consumption is around 15-18 grams per person per day Thus, very intensive scientific, technological and industrial research is carried out to change this state of affairs.

Dietary fiber is a group of chemically heterogeneous compounds. All fiber fractions are combined by the fact that they are made of sugars, while their conformations, the capacity of bonds and length of polymer chains make dietary fiber a component of a diet with a very wide spectrum of activity on human physiology as well as technological properties. The most common division of dietary fiber is the division into soluble and insoluble fractions. The insoluble fraction includes among others cellulose, hemicelluloses extracted from acidic solutions, lignin. On the other hand, soluble fractions are among others pectin, neutral hemicelluloses, β-glucans, inulin, oligosaccharides, xanthans, alginates.

However, the latest research proves that this division is quite conventional, because the solubility of dietary fiber is dependent on its chemical form, which can be modified by means of various technological treatments (Burton-Freeman, Liyanage, Rahman, & Edirisinghe, 2017; Liu et al., 2016; Maicaurkaew, Jogloy, Hamaker, & Ningsanond, 2017). For this reason, the division into dietary fiber, which ferment or not in the large intestine, is more often found (Berer et al., 2018).

During my scientific work, I observed that there are dietary fiber fractions that are soluble in water but depending on the molecular weight, they are or not soluble in ethanol when its content in the solution is over 50% (**H.3; H.4**.). This is justified by what other researchers have found that the molecular weight of the dietary fiber is very important for the solubility of dietary fiber. For this reason, a new division was carried out: high fiber weight dietary fiber (HMWDF) dietary fiber is observed more often - hemicellulose, pectin, β-glucan, gum and mucilage, cellulose, lignin; low molecular weight dietary fiber (LMWDF) - fructans and galactooligosaccharides; synthetic fibers - polydextrose, various derivatives of dextrins; resistant starch - various types of resistant starch from RS1 to RS5.

The role of dietary fiber in human nutrition

Even though dietary fiber is not digested in the human digestive tract, it nevertheless fulfills essential functions in the human body. Dietary fiber is a very important nutrient ensuring the proper functioning of the human body, as well as prevention against a range of diet-related diseases. According to consumers, intake of dietary fiber is most often associated with a reduction in the risk of cardiovascular disease, diabetes and cancer, in particular those that occur in the digestive system, e.g. the large intestine and improve the peristalsis of the digestive system (Huang, Xu, Lee, Cho, & Qi, 2015). From the point of view of a systematic approach to the role of dietary fiber in the human body, some of the following functions should be specified.

- **Increased fecal mass.** A high-fiber diet affects the formation of a larger mass with increased softness in the large intestine, which causes its increased peristalsis by shifting the excretion content. The role of insoluble dietary fiber fraction in increasing fecal mass and shortening intestinal transit time is known and well-described in literature for many years (Dahl, Lockert, Cammer, & Whiting, 2005).
- **Reducing blood cholesterol.** The reduction in blood cholesterol is also a well-described mechanism in the literature. The effect on blood cholesterol lowering is closely related to soluble fiber fractions because it forms a viscous layer in the small intestine, which increases the viscosity of the entire content in the intestine. This results in the reduction of reabsorption of bile acids, which in turn, leads to their increased synthesis from cholesterol, which reduces its level in the blood (Othman, Moghadasian, & Jones, 2011).
- **Reduction in postprandial glucose.** A similar mechanism is responsible for lowering postprandial glucose. Fractions of dietary fiber in combination with digestive juices become sticky (eg β-glucan, pectin, gums) and become thicker. This results in longer emptying of stomach contents, increased intestinal transit time, as well as a reduction in starch digestion, which is put to a lower content of glucose that can be absorbed (Garcia et al., 2007; **H.2.**).
- **Prebiotic influence.** Dietary fiber is prebiotic because it has a positive effect on increasing the number of bacteria in the human gastrointestinal tract, in particular, bifidobacteria and lactobacilli, which produce short-chain fatty acids with a positive effect on the host organism. In addition, bifidobacteria compete against pathogenic bacteria; as well as stimulate the immune system and synthesise some B vitamins in the human gastrointestinal tract (Niness, 1999).
- **Impact on the regulation of body weight.** It was found that increased viscosity of β-glucan (soluble fraction of dietary fiber) positively influences the prolongation of elevated cholecystokinin, which results in a prolonged feeling of satiety (Pentikäinen et al., 2014).
- **Other mechanisms.** There are several other, not less important, pro-health mechanisms that are specific to individual substances classified as dietary fiber. These include: a positive effect on mineral absorption; protective effect on the mucous membrane of the small intestine; antioxidant capacity; reducing the risk of cancer (Greenwood, Cade, White, Burley, & Schorah, 2004; Sánchez-Zapata, Viuda-Martos, Fernández-López, & Pérez-Alvarez, 2015; Willats, Knox, & Mikkelsen, 2006).

There are also studies that show that dietary fiber may adversely affect the bioavailability of certain nutrients, such as micronutrients or vitamins or other nutrients. It has been proven that dietary fiber may reduce the bioavailability and absorbability of antioxidants (eg from the group of polyphenols) or water-soluble vitamins (**H.1.**; Palafox-Carlos, Ayala-Zavala, & González-Aguilar, 2011; Pérez-Jiménez et al., 2009).

Technological properties of dietary fiber

Dietary fiber has several technological properties that make it an interesting food ingredient from the perspective of food producers. Most insoluble fibers can absorb water in their structure, which is called water absorption. It is a very important functional property of dietary fiber, because it allows you to reduce the caloric density of food, and at the same time, enrich it with dietary fiber (Kurek, Piwińska, Wyrwisz, & Wierzbicka, 2015).

The water absorption of fiber is a particularly beneficial feature wherever you need to avoid syneresis or modify the viscosity or texture of finished products. Dietary fiber not only absorbs water but also oil, which means the dietary fiber can be used successfully in foods with high fat or emulsion content while reducing their calorie content. The chemical structure of dietary fiber affects both water and oil absorption and depends on process conditions, eg temperature.

An additional feature of dietary fiber - mainly observed in the case of soluble fibers - is viscosity. The improved structure and texture are maintained due to the increase in product viscosity (**H.3.**). Due to the increasing viscosity of the dietary fiber, it can be used as a thickener or a structuring component. A very important advantage that is just beginning to be used on an industrial scale is that dietary fiber has anti-dandruff properties. For this reason, dietary fibers can be used as coating materials in the technology of microencapsulation of substances with a high propensity for oxidation (eg fat) (Elleuch et al., 2011; **H.5.**).

Possibilities of obtaining dietary fiber

Dietary fiber is often already in the finished product since it is contained in the raw material used in production. However, technologies of product fortification for dietary fiber are increasingly being used, so it is necessary to obtain it, most often through extraction. Currently, there are several main methods of extracting dietary fiber, such as chemical methods, enzymatic, enzymatic and chemical methods or enzymes supported by ultrasounds or microwaves.

Each of these methods affects the technological properties and physiological properties of dietary fiber. Chemical methods are methods that use the basic environment or the acidic environment to release the plant cell structures to obtain dietary fiber. However, studies show that they are not effective methods of obtaining soluble dietary fibers because the conditions of chemical extraction are not very specific and lead to poor performance (Ahmad, Anjum, Zahoor, Nawaz, & Ahmed, 2010). In addition, in the production on an industrial scale, the problem of large amounts of solutions harmful to the environment remains unresolved.

A slightly more effective and universal method of extracting dietary fiber, which allows keeping not only insoluble but also soluble fraction is the enzymatic method, which consists in multi-stage subjecting the material to digestion by various enzymes (most often alpha-amylase, protease, and lipase). Dietary fiber is not digested by these enzymes, so it remains in solution until the end of the incubation. The enzymatic method allows the best preservation of soluble fiber properties (Daou & Zhang, 2014; **H.3.**). Enzymatic-chemical methods are a compromise between higher yield and maintaining the technological properties of dietary fiber. However, changes in other nutrients, such as proteins, after contact with strong bases or acids, work against the recovery of fiber with the desired parameters (Ma & Mu, 2016).

The enzymatic extraction can be supported by ultrasound because they cause changes in the plant raw material, which intensifies physical processes or based on mass exchange. Thanks to the use of ultrasounds, it is possible to quickly compress and expand the material due to the passing acoustic wave and induce cavitation, which causes a local increase in temperature and pressure. Ultrasound can be both an individual method of obtaining dietary fiber as well as an assisting process (**H.3.**).

During enzymatic extraction, macronutrients such as starch or proteins are degraded. The extraction processes are alternating with the centrifugation or reaction of solutions from solid particles. It has been proven that the properties of dietary fiber affect its electric charge, which is dependent on the presence of micronutrients in the solution (or suspension) in which the dietary fiber is found. For this reason, during the habilitation, the innovative method of assisting the extraction of dietary fiber (β-glucan) by means of flocculation was developed, which enables purification of dietary fiber due to the binding of micronutrients to large aggregates and their centrifugation (**H.4.**).

The scientific collection of publications entitled: "Research on the use of dietary fiber in food production - technological and nutritional approach" presents new cognitive elements both in the field of new information regarding the bioaccessibility of vitamins present in the model food matrix and the impact of dietary fiber from various sources on the bioavailability of fatty acids, phenolic compounds and digestion of starch. In addition, the paper describes the technological properties of dietary fibers derived from quinoa, amaranth and common millet obtained using three different methods, as well as the method of β-glucan extraction using flocculants. Antioxidant properties were described using the soluble fiber fraction, which is β-glucan, for microencapsulation of fish oil.

2.3.2. Scientific goal

The main scientific goal of achievement, being the basis for applying for the academic post-doctoral degree (habilitation) in accordance with the requirements of the Act of 14 March

2003 on academic degrees and academic title and on degrees and title in the field of art (Journal of Laws from 2003, No. 65, item 595, as amended), and in accordance with the requirements of the Act of 27 July 2005 Law on Higher Education (OJ 2005 No. 164 item 1365, as amended) and in accordance with the Regulation of the Minister of Science and Higher Education of September 26, 2016 on detailed procedure and conditions for conducting activities in the doctor's thesis, in the habilitation procedure and in proceedings for granting the title of professor (Journal of Laws of 2016, item 1586).is the analysis of the possibility of using dietary fiber in food production, considering its impact on nutritional value and technological properties.

Detailed goals are:

- to study the impact of the use of dietary fiber of various origins in the model food matrix (wheat bread) on the nutritional value and bioavailability of nutrients (**H.1.; H.2.**);
- analysis of the impact of methods of extracting dietary fiber on technological properties (**H.3; H.4.**);
- verification of the possibility of using dietary fiber as a coating material in microencapsulation technology (**H.5.**).

The following research hypotheses were constructed:

- the particle size of dietary fiber affects the bioaccessibility of selected B vitamins contained in the food matrix
- the use of dietary fibers of various origins affects the nutritional properties and bioavailability of nutrients contained in the food matrix
- there is a possibility of high efficiency of dietary fiber extraction with favorable physicochemical properties from gluten-free sources
- the use of flocculants supports β-glucan extraction
- β-glucan may be a component of the coating material used in microencapsulation of fish oil.

2.3.3. Research results and discussion

2.3.3.1. The effect of dietary fiber on the bioavailability of nutrients in the model food matrix

Bread is one of the main products in which dietary fiber exists because it is in flour, which is a product of grain milling. In a typical wheat bread, there is 2 to 4 g of fiber per 100g of product; and in the case of wholemeal bread, this amount can reach up to 8g per 100g of product. Bread is one of the most widespread products in the world, hence it can act as a model food matrix to determine the effect of various additives, supplementary substances, and bioavailability of ingredients. The part of a given compound that is released from the matrix in the gastrointestinal tract and thus becomes available for absorption through the intestine is considered to be bioavailable (Benito & Miller, 1998).

Enrichment of bread with dietary fiber has already existed in food technology for many years. One of the reasons why bread is enriched with fiber is that more and more research points to the fact of residual agricultural pollution (like pesticide residues or heavy metals), as well as mycotoxins in products derived from full milling (Cheli et al., 2010). In addition, wheat bread is a product with a high glycemic index due to being in the composition of rapidly digestible starch (Sui, Zhang, & Zhou, 2016).

While in the literature there are known studies on the impact of grinding on the content of vitamins in bread or the impact of different production methods on their bioaccessibility. This study determines the bioaccessibility of selected B vitamins from bread in the model digestive system *in vitro* depending on the size of the particle used in the production of fiber bread is a distinctive contribution to the field of human nutrition science (**H.1.**). Another area that I have described is the effect of different types of fiber on the profile of fatty acids, the glycemic index and the content of phenolic compounds in the bread also subjected to *in vitro* digestion. (**H.2.**).

The material for testing the bioaccessibility of selected B vitamins (thiamine, riboflavin, niacin, and pyridoxine) was wheat bread with the addition of dietary fiber with a fiber content of 44g per 100g of product (**H.1.**). I have constructed the experiment in such a way that the preparation of bread was used in the form of dietary fibers in such a quantity that the total fiber content in bread was 2,1; 7.2 and 12.3% and in each of these groups different particle sizes of dietary fiber were used - 280, 190 and 100 μm.

After baking, the bread was digested according to the protocol proposed in the international consensus on a standardized in vitro digestion model with minor modifications (Minekus et al., 2014; Oomen et al., 2003).

The same model of digestion was used in the study on the effect of fiber of different origin on the content of fatty acids, the bioavailability of starch and phenolic compounds with a change in the content of enzymes in Zhang, Huang, & Ou (2011) (**H.2.**). The material for testing was wheat bread, in which wheat flour was replaced in such a way that the total fiber content was 6g per 100g of product. Dietary fiber came from three different sources - oats (a characteristic high content of β-glucan); flax (characteristic high content of mucilage) and apples (characteristic high pectin content).

In the case of studies on the bioaccessibility of B vitamins, the method of determining vitamins using high-performance liquid chromatography according to the method was used by Ekinci & Kadakal (2005). In the fatty acid profile studies, the method of testing the fatty acid methyl esters content after previous fat extraction with petroleum ether and acetone was used. The glycemic index was determined in vitro using the degree of hydrolysis of starch according to the method developed by Goñi, Garcia-Alonso, & Saura-Calixto (1997). The content of phenolic compounds was measured using the Folin-Ciocalteu method.

In work **H.1.** as a statistical method, the response surface methodology was used, the aim of which was to find the optimal replacement of wheat flour with dietary fiber of optimum particle size at the maximum bioaccessibility level of selected B vitamins.

Before undertaking bioaccessibility studies in H.1., the content of B vitamins in the bread was examined before it was digested. The highest thiamine content was present in the trials, where the fiber particle size was 190μm, and the fiber content was 12.3% (0,510 mg/100g). Thiamine content in bread, however, is quite hard compared to other research, because it strongly depends on the flour used. Thiamine is used for fortifying wheat flour in many countries (Tiong, Chandra-Hioe, & Arcot, 2015).

In the case of riboflavin and pyridoxine, the highest value was achieved in the case of a bread test with a fiber content of 2.1% at 190 μm of the fiber particle size. In other studies, such as Nurit, Lyan, Pujos-Guillot, Branlard, & Piquet (2016) it was observed that the higher content of B vitamins was determined in bread, to the fortification of which wheat bran with larger particle size was used.

In my research, the trend was similar, and the possible differences can be explained by the fact that the fiber added was oat fiber, which is characterized by a different level of B vitamins than wheat bran. Between the research groups, which differed in the content of dietary fiber and the size of its particle, changes in vitamin content were also observed, which can be explained by the different thermodynamics of reactions taking place during baking. These other thermodynamics is caused by a different water content in the individual samples because the higher content of dietary fiber brings with it the need to increase the water content to maintain the same rheological properties of the dough.

Biological availability is shown in Fig. 1, as a percentage of vitamins that could not be recovered, after digestion. The A axis represents, the content of dietary fiber in the sample. The B axis is the particle size of dietary fiber. The bioaccessibility of thiamine has been previously evaluated in aleurone fractions from durum wheat (Zaupa i wsp., 2014) or corn bran (Yu i Kies, 1993) and ranges from 75% to 95%. The particle size also influenced the bioaccessibility of riboflavin in a linear and quadratic approach in my study, and the effect of dietary fiber content was less significant ($p \leq 0.05$). A more adapted model was obtained for the bioaccessibility of niacin and pyridoxine (lack of fit, respectively - 0,925 i 0,982).

The bioaccessibility of niacin was significantly dependent on the content of dietary fiber ($p \leq 0.01$) and particle size ($p \leq 0.05$). The interaction between the content of dietary fiber and particle size significantly influenced the bioaccessibility of niacin and pyridoxine. My research concerned an *in vitro* environment, so the results may be slightly different from the results obtained from other scientists who measure bioaccessibility, which is a more complex parameter (Carbonell-Capella, Buniowska, Barba, Esteve, & Frígola, 2014).

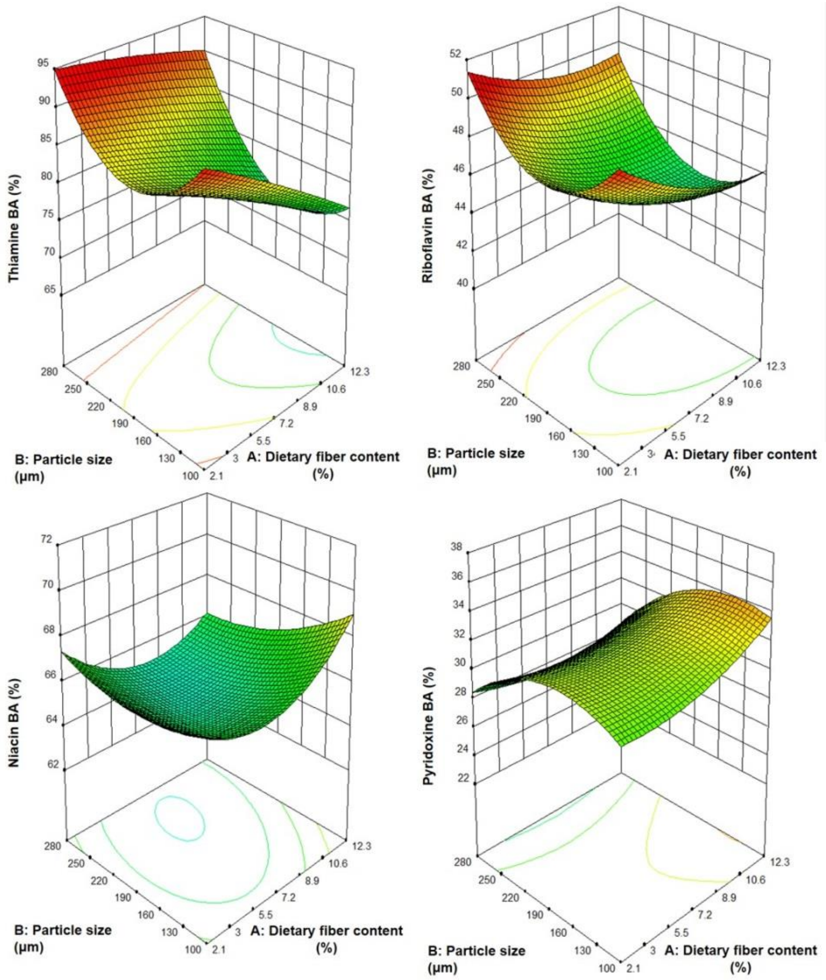
In vitro digestion is treated as a model of the description of processes occurring in the human digestive tract. The method used in the study could describe the behavior of vitamins in the human body during digestion because a continuous system was used, which means that digestive juices are successively added (Cardoso, Afonso, Lourenço, Costa, & Nunes, 2015).

Numerical optimization of variable processing, particle size, and fiber content was carried out to achieve maximum possible bioaccessibility values for selected vitamins in this study. Optimal values were obtained after assigning the models to independent variables, with the proviso that the dietary fiber content should be more than 6 g / 100 g products to obtain a product that provides a high fiber dietary declaration with a particle size in the 100-280 μm range. The optimal values were scored as 6.17% for dietary fiber content and 124.1 μm for particle size.

In the work **H.2.** the content of fatty acids present in the bread before digestion and after digestion was evaluated for both individual fatty acids, saturated (SFA), unsaturated (MUFA) and saturated (PUFA) groups. Obtained results are quite hard compared to world standards because, in many countries, butter is used to produce bread or oil or olive oil as an ingredient or as a material for spreading baking forms, hence the possibility of obtaining different results in each test. It was observed that SFA was the highest in percentage in the control sample (44.2%), while the lowest percentage was observed in the apple fiber sample (31.2%), where the PUFA content was the highest (40.8%).

The PUFA content of the obtained bread can be considered satisfactory, even if it was easily oxidized during the baking process. Observed results are consistent with the results obtained in other works, where the content of fatty acids in products with the addition of dietary fibers from oats or flax was tested (Aro et al., 2013; Menteş, Bakkalbaşşi, & Ercan, 2008; Simbalista, Frota, Soares, & Arêas, 2012).

Figure 1. Bioaccessibility of selected B vitamins with variable content of dietary fiber and its particle size (**H.1.**)



The digested portion of the bread was analyzed for fatty acids in the same way as bread samples. A sample of control bread was characterized by the highest value of palmitic acid and oleic acid, whereas oat dietary fiber had a higher content of oleic acid (36.63% of the total lipid content). The flax fiber sample was characterized by a high content of γ-linolenic acid, which is the same as the results obtained by Ribeiro, Peralta-Zamora, Maia, Ramos, & Pereira-Netto (2013).

The results obtained from the nominal bioavailability of fatty acids are even more important. This value was calculated to indicate the extent to which dietary fiber can permanently bind fat and what its fractions are bound to the greatest extent by using oil absorption. It was observed that the bioavailability of fatty acids in the control sample was quite high compared to other tests. However, PUFAs are the least bioavailable of all fatty acid groups in the range (72% in the oat fiber test up to 87% in the fiber test).

The results led to the conclusion that the addition of dietary fiber to bread not only changes the profile of fatty acids in the bread itself but also the ability to absorb oil affects its bioavailability. Some fatty acids were combined into insoluble dietary fiber fractions and were centrifuged as a human bolus simulation. W zakresie hydrolizy skrobi użyto poniższego wzoru w celu określenia powierzchni pod wykresem trawienia skrobi:

$$AC = C_{\infty}\left(t_f - t_0\right) - \left(\frac{C_{\infty}}{k}\right)\left(1 - e^{-k\left(t_f - t_0\right)}\right) \quad \text{(Equation 1)}$$

C_{∞} corresponds to the concentration in equilibrium (t_{180}), t_f this is the time of the end of digestion (180 min), t_0 this is the time of the beginning of digestion (0 min) and k it is a kinetic constant. As a control sample, wheat bread was used, so AC from bread with fiber samples and divided by AC from bread and was considered calcHI.

The glycemic index is a factor that is mainly affected by hydrolysis of starch during digestion. The value (C) is a parameter that shows the initial value of the digestion in the first minutes. The control sample had the highest value (80.5) and was significantly higher than the values for bread with oat, flax and apple fiber. Similar results, taking into account the effect of flax on the glycemic index, were observed in vitro tests carried out by Dahl et al. (2005). The value of k is a component of the equation that gives information about the slope and rate of hydrolysis of starch. The component was the highest in the control sample.

The area under the line in the graph was calculated as calcHI, and the lowest values were observed in the fiber test and the highest in the control sample. The general observation is that the control sample had the highest glycemic index and the lowest level sample with flax. However, all bread with dietary fiber in the study were considered as products with a low glycemic index.

I observed that indeed the highest total value of phenolic compounds had a sample with apple fiber, while the lowest sample with flax (Table 1). The results may seem surprising, but it should be considered that the test used a dietary fiber preparation, not pure fiber, hence differences in polyphenol values. Although these values were the lowest, in this sample they were characterized by the highest bioavailability. This can be explained by the fact that phenols are not a homogeneous group, and this compound, which was responsible for creating the highest quantifiable amount in the apple fiber sample, was the most easily degradable.

In the summary of the first two publications **H.1**. and **H.2**. being a scientific achievement, it can be concluded that enriching bread with dietary fiber can be a satisfactory method of enriching nutrients. The destructive effect of introducing dietary fiber into the bread structure can be prevented by using different particle sizes of dietary fiber. However, there are more hydroxyl groups that are susceptible to binding water and substances that are soluble in it when the particle size is smaller.

Table 1. Total phenol content in bread and bioavailable phenols and indicators obtained from the equation describing starch digestion (**H.2.**)

Type of bread	Total polyphenol content (gallic acid equivalent) - mg/kg	The content of bioavailable polyphenols (equivalent to gallic acid) - mg/kg	C	k	calcHI
Control	674.1±12.1^{bc}	350.5±10.4^{b}	80.5±2.14^{c}	0.24±0.02^{b}	79.1±2.17^{d}
Bread with oat fiber	623.1±14.2^{b}	267.9±14.2^{a}	61.1±1.89^{a}	0.18±0.04^{a}	35.2±2.19^{c}
Bread with flaxseed fiber	541.2±14.4^{a}	362.6±13.7^{b}	64.3±2.14^{a}	0.15±0.06^{a}	19.6±2.14^{a}
Bread with apple fiber	897.2±12.3^{c}	403.7±14.7^{c}	69.4±2.17^{b}	0.14±0.06^{a}	28.5±2.16^{b}

Different letters suggest statistically significant differences at $p \leq 0.05$

Research **H.1.**, showed that the content of vitamin B in bread depends on the content of dietary fiber and its particle size. There are differences in the bioavailability of vitamin B, as well as different trends, so there has been a need for more sophisticated statistical methods to provide sufficient information on what particle size and dietary fiber is the best to increase the bioavailability of all tested vitamins.

Research **H.2.** showed that the use of various sources of dietary fiber may affect the profile of fatty acids, which are characterized by different bioavailability. Different sources of dietary fiber reduce the glycemic index to a different degree, and the use of protein preparations from various sources can affect different levels of polyphenols and change their bioavailability. During studies on the influence of various dietary fibers on the nutritional value in publication **H.1.** and **H.2.,** the idea was born that it would be necessary to conduct research on not only nutritional properties, but also technological dietary fibers obtained by extraction to achieve the highest levels of purity and to exclude the effects of substances found in commercially available cellulose preparations.

2.3.3.2. Extraction of dietary fiber by enzymatic, ultrasound and combined methods and its physical properties

Dietary fiber is a known ingredient used in various food matrices. The ability to retain water and oil, the formation of emulsions and foam are essential for modifying the texture and structure of the food product. The food industry is constantly interested in new sources and methods for extracting dietary fiber. Currently, chemical, enzymatic and chemico-enzymatic extractions of dietary fiber are used.

The extraction conditions lead to a dietary fiber with desired or undesirable nutritional and physicochemical properties. More, there is a continuous need to identify innovative bioactive extraction methods such as emulsifying shearing, jet extrusion, wet milling or microbiological methods (**H.3.**;Ma & Mu, 2016; Yan, Ye, & Chen, 2015). One of the methods that recently attracted attention in food technology is ultrasound extraction, which has been successfully used for the isolation of polysaccharides, proteins, and oils. There is also a need to use specific extraction methods depending on the intentions of obtaining the appropriate fraction of dietary fiber.

One of such factions that is particularly beneficial from the point of view of health is β-glucan. Extraction and purification of β-glucan from cereals are mainly divided into two main groups: wet and dry processes. Extractions under dry conditions are carried out by milling and sieving, and wet conditions usually involve enzymatic treatment, alkaline solvents or ultrasounds. Extraction with wet-β-glucan results in effective purification because it reaches> 80% pure β-glucan depending on various molecular weight distributions, pH and solvents used (60 000 - 2 200 000 g / mol) (**H.4.**; Limberger-Bayer et al., 2014). Water or other solvents are used in the extraction of β-glucan.

However, impurities - protein, polysaccharide or mineral - are present in the solutions during enzymatic treatment. These fine particles can be removed by adding external flocculants that aggregate to solid bodies that form flakes that can be easily removed from solutions (Meraz et al., 2016). Until now, in the scientific literature, the subject has not been met with the use of flocculants during the extraction and purification of β-glucan.

While cereals, vegetables, and fruits were a source of dietary fiber known for many years, the food industry has also expanded its interest in the extraction of dietary fiber within alternative cereals or grasses from the *Poaceae* family. Recently, the use of such plants as quinoa (*Chenopodium quinoa*) or amaranth (*Amaranthus caudatus*) becomes more and more popular. In addition, common millet (*Panicum miliaceum*) is one that is grass rich in dietary fiber and gluten-free, which can also be a source of dietary fiber (**H.3.**).

In the case of publication **H.3.** the focus was on three extraction methods: enzymatic, enzymatic, ultrasound and ultrasound. The obtained dietary fiber extracts were analyzed for the content of the soluble and insoluble fraction of dietary fiber, its physical properties, microscopic analysis and thermal as well as structural properties. The raw material for research was both commercial flour cleaned and full grain quinoa, amaranth, and proso millet. The selected test results obtained during the experiment are described below. The research was conducted in cooperation with the research center at the School of Agriculture and Biology, Shanghai Jiao Tong University, China.

In all types of sources and raw materials, I observed ultrasound assisted enzymatic extraction as the most efficient extraction procedure. Obtained yield results ranged from 18.59% in quinoa from whole grain to 94.22% in dietary fiber derived from millet flour. The least effective method was ultrasound extraction without the addition of any enzymes. However, millet samples had divergent results - ultrasonic extraction was characterized by higher yields than enzymatic extraction. This observation may be the result of a greater amount of dietary fiber in the raw millet material than in quinoa or amaranth (**H.3.**). The ultrasonication method may lead to damage to the cell wall and, on the other hand, may negatively affect the extraction efficiency of DF when large amounts of soluble dietary fiber are present (Zhang et al., 2017).

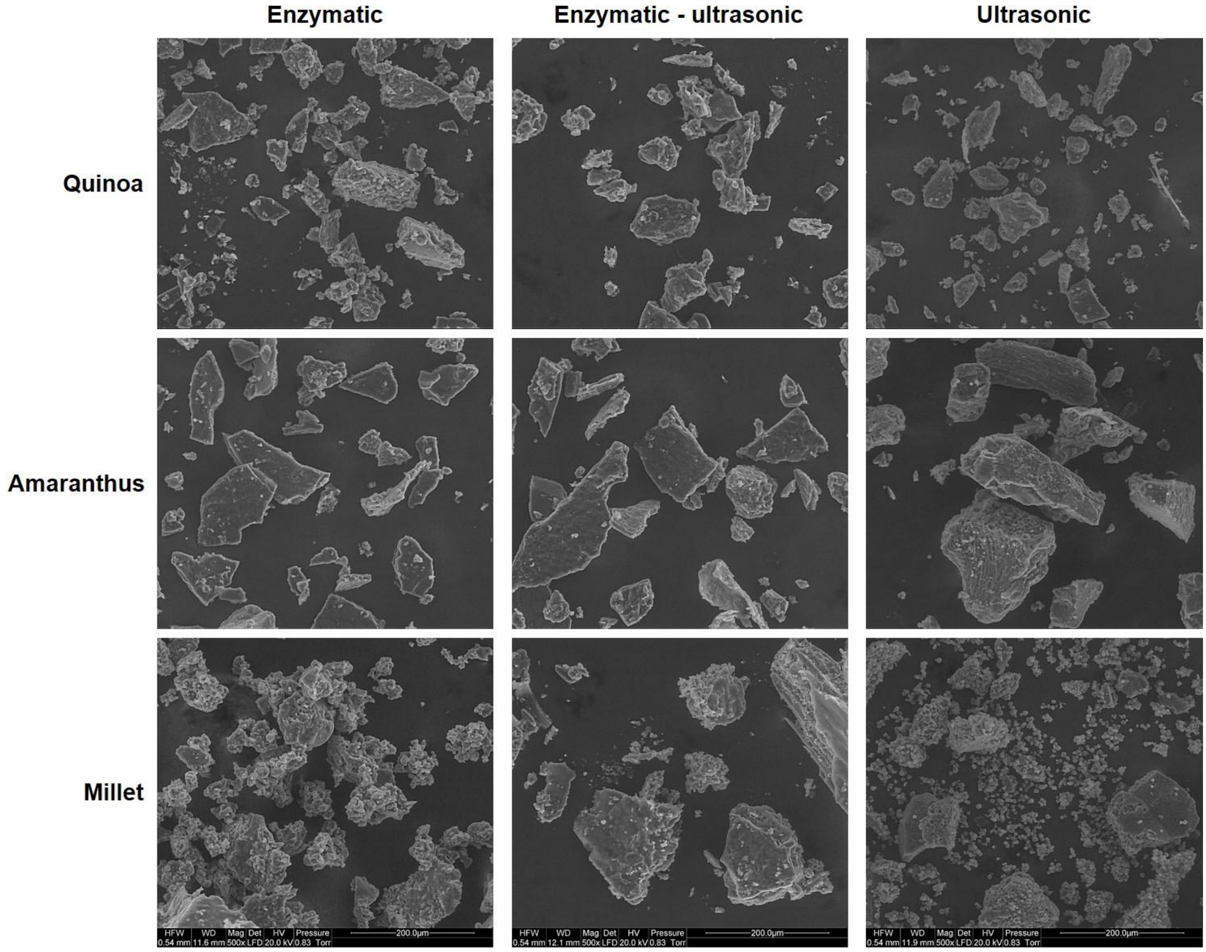
In terms of color, the lightest samples were obtained in the case of quinoa after the extraction of ultrasound with enzymes (L* = 55.64). However, the brightest amaranth samples were observed in ultrasound treatment. Millet samples from enzymatic-ultrasound extraction were more reddish. After ultrasonic treatment, all samples had a reduced yellowness parameter (b*) compared to other extraction methods, indicating that the samples were less yellow (**H.3.**).

Microscopic analysis of SEM showed that the extraction methods did not affect the morphology of the quinoa fiber cellulose samples (Figure 2). The particles had wrinkled surfaces that influenced better water absorption capacity and oil absorption. Amaranth samples of enzymatic and enzymatic-ultrasound were less spatial than samples subjected to ultrasonic treatment. This observation can be explained by the different temperatures at which samples were kept during the extraction process. Other researchers have described similar observations and found that different extraction temperatures can affect the morphology of the dietary fiber (Karaman, Yilmaz, & Tuncel, 2017).

In the chemical structure, the spectra of the obtained dietary fibers reminded each other, because they were all obtained from cereal sources. The broad peak present in the area of 3400cm^{-1} is attributed to the extension of hydrogen bonds to the hydroxyl groups of cellulose and hemicellulose. This observation is justified because large amounts of galacturonic acid, arabinose, galactose, xylose, and glucose are found in amaranth and quinoa. (Lamothe, Srichuwong, Reuhs, & Hamaker, 2015). The weaker absorption bands at 2923 and 2856 cm^{-1} were derived from the C-H group stretching, which is typical for polysaccharide-based polymers.

The peaks observed in all samples at about 1660cm^{-1} correspond to the bending or stretching of aromatic hydrocarbons. Observed peaks of approximately 1040 cm^{-1} are attributed to the C-O stress binding and strain bands in cellulose and hemicellulose. Peaks visible at around 870 cm^{-1} indicate β-glycosidic bonds in polysaccharides, which are consistent with the results of other researchers who have identified β-glucan in the dietary fiber fractions of amaranth (Repo-Carrasco-Valencia, Peña, Kallio, & Salminen, 2009).

Figure 2. Microscopic photographs showing differences in the structure of the obtained dietary fiber particles (**H.3.**)



H.4. work was undertaken related to the use of natural flocculants, such as chitosan, guar gum, and gelatin during β-glucan extraction. The raw material for extraction was wholemeal oat flour and barley flour, which was obtained directly from the grain using a laboratory mill. The flocculants were used in an amount of 0.2 and 0.6% based on the suspension after pre-extraction of β-glucan into the aqueous phase during shaking. Then, enzymatic digestion and protein precipitation were carried out. B-glucan was recovered from the solution using an elevated ethanol concentration. In terms of the parameters studied, the focus was on yield, color, thermal properties, molecular weight, and viscosity. The work was carried out in research cooperation with Norwegian Institute for Food, Fisheries, and Aquaculture Research in Norway. Below is a description of the most important test results.

The total extraction yield was highest for control samples derived from oats and barley, while the extractions carried out with gelatin as the flocculant gave the lowest yield. In oat samples, increasing chitosan concentrations slightly decreased yield, but this was not statistically significant. However, there were significant differences ($p \leq 0.05$) between the samples, where guar gum was used as a flocculant and oat as a raw material because increasing the concentrations of guar gum led to higher extraction efficiency.

Although all three flocculants reduced the overall extraction yield, the β-glucan specific extraction yield increased for both chitosan and guar gum but decreased with gelatin. Β-glucan extracted with 0.6% chitosan had the highest β-glucan content (82.0 $\pm$ 0.23 and 79.0 $\pm$ 0.19, respectively, for barley and oat). Increasing the concentration of chitosan from 0.2 to 0.6% increased the content of β-glucan (barley and oats) and the yield of β-glucan extraction (only barley). In the case of guar gum and gelatin, increased concentrations caused a lower purity of β-glucan extracts. The specific extraction yield was highest in oat samples using 0.6% chitosan, where these values were 96.9%, and the lowest in oat samples using 0.6% gelatin and amounted to 44.4%.

The use of chitosan can be an effective method used in high purity β-glucan extraction protocols. It has been previously shown that the β-glucan extraction from barley sources is almost 100%, but there is no information about the exact enzyme protocol (Mikkelsen et al., 2017). Gelatin was not considered an effective tool for removing impurities during β-glucan extraction, because the β-glucan content in the resulting extracts was even lower than in the control samples. The β-glucan content in the barley control samples was quite similar to the results of Limberger-Bayer et al. (2014), where the optimal maximum content of β-glucan was 53.4%. Higher purity of samples obtained with chitosan can be associated with the chitosan charge. Chitosan is a cation and has a high molecular weight, which means it flocculates via a charge neutralization mechanism (Rojas-Reyna et al., 2010).

Gelatin was the only polysaccharide-free flocculant used in this study. Gelatin is used as an effective clarifying agent during wine production. The key factor that influenced the effect of wine clarification by gelatin is that it is positively charged due to the basic amino acid residues such as arginine and lysine and can be easily used in various pH ranges (**H.4.**).

The molecular weight (MW) of β-glucan is an important parameter related to its physiological properties. High molecular weight Β-glucan plays an important role in lowering cholesterol and blood glucose levels through a variety of mechanisms (Brummer, Duss, Wolever, & Tosh, 2012). In the barley samples, the highest MW was in control samples (64 873 g / mol), and the use of flocculants resulted in a lower MW. This may be related to a longer extraction process due to the additional flocculation step during which β-glucanases present in barley flour can degrade β-glucan. The lowest MW was observed in guar gum samples (34 648 g / mol). The growth tendency of Mw caused by an increase in the concentration of flocculant was observed in samples with guar gum and gelatin.

Another trend was observed in oat samples in which β-glucan MW was higher for flocculant extraction. The highest MW was observed in oat with chitosan 0.6 (551 000 g / mol) and the lowest in the control sample (280 515 g / mol). In general, MW in oat samples was higher than in barley samples, which indicates the presence of β-glucanase in barley, which was still active during extraction processes (**H.4.**).

The viscosity of β-glucan-containing food products during in vitro digestion can be linked to their potential to lower postprandial glucose levels (Rieder, Knutsen, & Ballance, 2017). The lowest viscosity was observed in samples with gelatin as the flocculant, and the highest in the sample with chitosan 0.2% (21.02 Pas). The increasing concentration of chitosan in barley samples caused a slight decrease in viscosity. This trend was different in oat samples, which means that chitosan interacted with some ingredients found only in oats (**H.4.**).

Summarizing both publications, which included studies of various extraction methods both for the extraction of total fiber and a particular fraction, which is β-glucan, it can be concluded that extraction methods must match the desired effect. The highest yields of fiber extraction were observed in samples obtained by enzymatic-ultrasonic extraction. Surprisingly, more dietary fiber was extracted from commercial flour than from grain because there were fewer interfering substances in the commercial flour.

The largest differences in the color between the raw material and dietary fiber were observed in the quinoa samples. Dietary fibers from amaranth, quinoa, and millet were not only nutritionally valuable due to the high content of TDF, but also from the capture of free radicals. In general, quinoa, amaranth, and millet can be used in a variety of foods. Further testing may evaluate other important nutritional properties, including caloric value, bile acid or glycemic index (**H.3.**).

Chitosan and guar gum used as flocculants during β-glucan extraction increased the purity of extracts obtained from oat and barley flour, while gelatin was not effective. The use of flocculants caused a reduction in the number of proteins (chitosan, guar gum) and mineral (all three) impurities. Despite considerable differences in the β-glucan content and molecular weight, all extracts showed high water retention capacity, which makes them suitable for the industry in which β-glucan thickening agents are sought. The use of biodegradable and consumable polymers, such as chitosan or guar gum, may be an environmentally friendly and friendly improvement in β-glucan extraction. The completed study is very innovative because until now flocculants have not been considered as agents that can be used in the extraction of β-glucan in such a way as to change its properties (**H.4.**). Research into the possibilities of using β-glucan led to another publication forming part of this scientific achievement (**H.5.**).

2.3.3.3. The use of extracted dietary fiber as a coating material in microencapsulation of fish oil

Microencapsulation is a process that creates a barrier between the core and the coating material to prevent chemical and physical changes. The basic substances that form the core of microencapsulation are ingredients such as flavors, sweeteners, dyes or vitamins. Bioactive compounds are in the field of interest in food science and technology in terms of microencapsulation (Becker, Damiani, de Melo, Borges, & de Barros Vilas Boas, 2014). Encapsulation can be used to maintain the proper physicochemical properties of molecules, as well as their biological activity. There is an opinion that one-component coating material is not enough to fully protect the core (**H.5.**).

Many clinical and epidemiological studies have shown the positive effects of n3 fatty acids, which are mainly present in fish oil. The main fatty acids present in fish oil are polyunsaturated with the predominant docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). Fish oil is known for its strong smell, poor stability in water and aqueous solutions (emulsions) and is very susceptible to oxidation during storage (Li, Xiong, Wang, Regenstein, & Liu, 2015). Oxidation during processing and storage reduces the nutritional and sensory value of fish oil as a result of the disruption of lipid hydroperoxides (Zia, Zia, Ali, Rehman, & Zuber, 2016).

A high content of polyunsaturated acids (PUFA) in fish oil is very susceptible to oxidation due to their structure. Thus, there is a need to overcome this problem by changing the form of fish oil to powder or microparticles and protecting its surface from the environment. One of the technologies that can be used to avoid the deterioration of highly nutritious fish oil is microencapsulation.

The use of β-glucan as a coating material for microencapsulation is valuable from the physicochemical and nutritional point of view. Due to the high viscosity of β-D glucan solutions, it can act as a viscosity enhancing agent, and thus form a film on oil droplets. However, high molecular weight β-glucan is responsible for the formation of high viscosity in solutions, so there is a need to combine it with other carbohydrates to obtain an optimal ratio of wall-core (Shah, Gani, Ahmad, Ashwar, & Masoodi, 2016).

There are several studies that use β-glucan as a wall material for encapsulation of lactic bacteria, anthocyanins or borage oil (Ahmad, Ashraf, Gani, & Gani, 2018; R. Y. Li & Shi, 2018; Shah et al., 2016). However, there is a continuing need to investigate how a combination of two carbohydrates: modified starch and β-glucan could act as an encapsulating agent for the most commonly used core microencapsulation processes, i.e. fish oil. To the best of my knowledge, no such results were published, so in this study, I created fish oil emulsions with a cornstarch / β-glucan complex, and spray dried to get microcapsules.

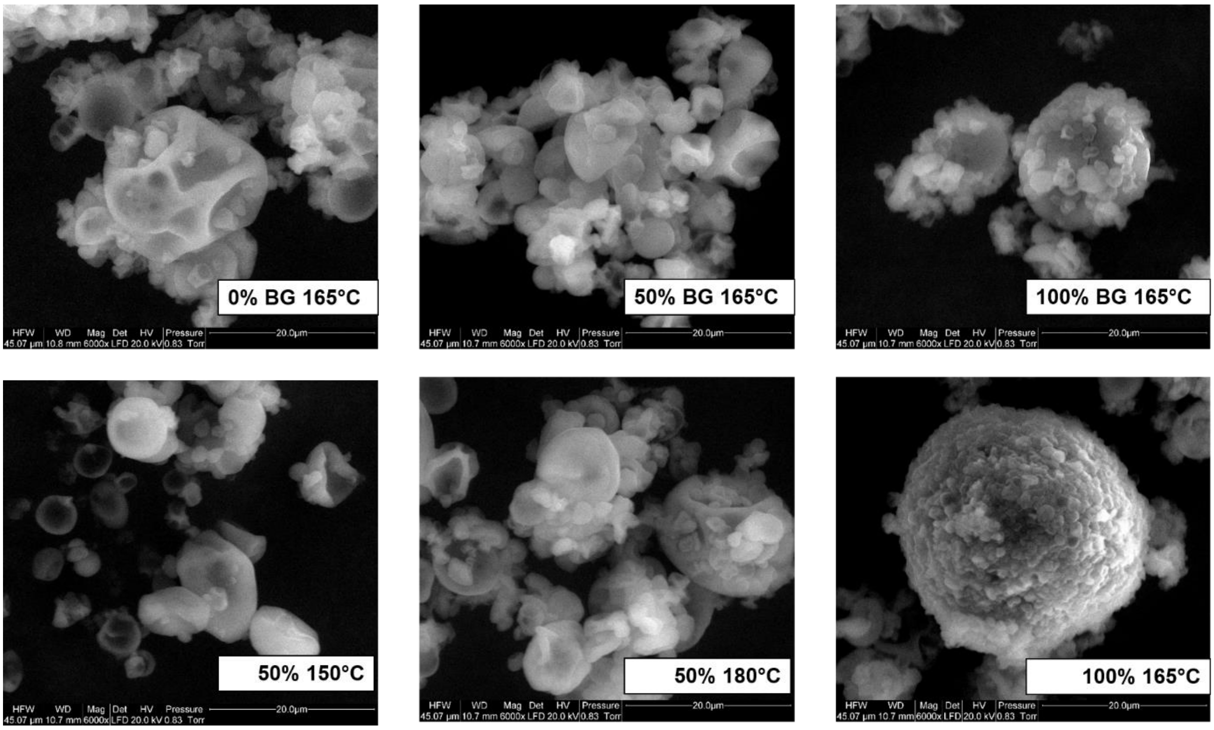
The main objective of the research was to examine the physicochemical properties of microcapsules from fish oil produced at different temperatures and to estimate the optimal ratio of β-glucan and modified starch and the temperature of spray drying. The method of β-glucan extraction was identical to the control sample from the **H.4** publication. Despite the previously indicated benefits of using chitosan as a flocculant supporting the β-glucan extraction processes, it was decided to remain with the enzymatic extraction method while changing the extraction raw material, which was commercial a barley β-glucan preparation with a content of 25.6%, which significantly improved the extraction capacity.

To optimize the emulsification process by choosing the appropriate ratio of β-glucan to modified starch and the temperature of spray drying, the methodology of the response surface was used using the same steps as in publication **H.1**. The most important results of this study are described below.

Bulk density was significantly changed by β-glucan and by the interactive effect of β-glucan and temperature. The higher content of β-glucan was responsible for the lower bulk density. These results are consistent with the size of the microcapsule particles - those that were denser with smaller particle sizes. The interaction between high temperature and β-glucan content led to lower density, which can be explained by the expansion of the particles during spray drying (Botrel et al., 2017). β-glucan can act as a factor that combines modified starch and does not allow particles to break down. The lower density of microcapsules leads to a smaller surface that is exposed to oxidation.

The effectiveness of encapsulation reflects the protective capacity of the coating material on the core. The highest value of the effectiveness of encapsulation was observed in samples in which the β-glucan content, was 100% and the spray drying temperature was maintained at 165 ° C. Increasing the temperature of spray drying also increased the efficiency of encapsulation, which is the result of a faster formation of a stable shell around the core, and thus a higher retention of the core. The addition of β-glucan to the wall material also increased the efficiency of encapsulation, which can be caused by crosslinking the polymer and increasing the integrity of the wall material. β-glucan is a known carbohydrate polymer that can form viscous gels (Premi & Sharma, 2017).

Figure 3. Morphology of fish oil microcapsule particles with a starch-β-glucan complex as a coating material (**H.5.**)



The increasing content of β-glucan caused a more spherical shape of capsules dried at the same temperature (Figure 3). The surfaces were not spherical when a larger amount of starch was present as a coating material, but all the capsules had no cracks or holes, so they are good protection against environmental conditions. Some of the particles were spherical and larger, but they were not smooth on the surface. To the best of our knowledge, this phenomenon has not previously been described in the literature that β-glucan forms very small particles (1 μm) and sticks to the surface of the oil drops.

This is a promising phenomenon that can be applied to the controlled release of core materials because the coating material is damaged particle by particle rather than being smashed over the entire surface (Bandeira et al., 2015). TBARS are the products of secondary oxidation from the degradation of oxidized PUFA, and therefore this measurement is a useful tool in monitoring lipid peroxidation in matrices in which mainly PUFA is present. In contrast to the primary products of lipid oxidation, secondary malodor is responsible for the formation of unpleasant odors. β-glucan as a carbohydrate is a good coating material in terms of preventing oxidation.

It was observed that the lowest content of TBARS was determined when the β-glucan in the coating material was at a relatively high level (85%) using a moderate temperature (154°C) - 0.56 mg malonicaldehyde/kg powder. β-glucan reduced TBARS content and significantly prevented oxidation.

After examining all the runs of the experiment, we conducted an optimization study to obtain the composition of coating materials and the temperature of the spray drying that would be most suitable for microencapsulation of fish oil. Optimization revealed that the best solution is to use 85% β-glucan as a wall material and 154 ° C as spray-drying. A verification study was carried out, and the effectiveness of encapsulation was analyzed as 79.9%, with a TBARS value of 1.16 mg / kg of powder. The obtained results showed that the model was able to describe the effect of β-glucan content as a coating material and spray drying, as well as interactive effects (**H.5.**).

In summary, the complex of β-glucan and barley starch is a solution that enables the microencapsulation of fish oil to be effectively microencapsulated. Therefore, the study developed a highly nutrient microcapsule, because both coating materials and the core have a positive effect on health. In addition, β-glucan caused a lower bulk density and oxidation of fish oil, and at the same time resulted in a higher efficiency of encapsulation and particle size.

2.3.4. Summary

The series of scientific publications presented in the course allowed to deepen the knowledge of the use of dietary fiber in food production, both in terms of its impact on nutritional properties, as well as functional and technological properties. The research goals were implemented in the work positively verified research hypotheses.

First, the influence of the use of dietary fiber of various origins in the model food matrix (wheat bread) on the nutritional value and bioavailability of nutrients was examined. By using the decreasing size of dietary fiber used to bake bread, you can get a product with satisfactory quality characteristics. However, the decreasing particle size leads to the development of the surface and the reduced bioavailability of the nutrients by their attachment to dietary fiber particles. There was no item in the literature to determine the extent to which B group vitamins (which are often the source of cereal production) are susceptible to reducing their bioavailability.

Research **H.1.**, showed that the content of vitamin B in bread depends on the content of dietary fiber and its particle size. Thanks to the methodology of the response surface, particle size, and fiber addition were optimized, which minimally reduced the bioaccessibility of selected vitamins while maintaining a high content of dietary fiber in the product. While lowering the bioavailability of vitamins is a negative phenomenon from a nutritional point of view, the lowering of the bioavailability of starch or fat is a positive phenomenon. **H.2**. study showed that the use of various sources of dietary fiber may affect the profile of fatty acids, which are characterized by different bioavailability through varying oil-consumption of the fiber used in the bread. At the same time, it is worth noting that the use of dietary fiber has reduced the glycemic index of bread. The use of protein preparations from various sources can affect different polyphenol contents and simultaneously model their bioavailability measured in vitro.

To summarize the publications, which included studies of various extraction methods for both total fiber extraction and a particular fraction, which is β-glucan, it can be concluded that the extraction methods must be adapted to the desired effect. In studies **H.3.** describes the effect of three different extraction methods on the functional properties of dietary fiber derived from gluten-free sources, such as quinoa, amaranth or millet. It is a position that fills the gap in world literature in terms of fiber obtained from these sources by three different methods.

In the **H.4**. study the focus was on developing the enzymatic method of β-glucan extraction to obtain its extract of the highest purity while maintaining functional properties. Thanks to this study, it was discovered that the use of chitosan as a flocculant increases the efficiency of extraction and has a significant effect on the molecular mass of β-glucan. The use of biodegradable and consumable polymers such as chitosan or guar gum may be an environmentally friendly improvement in β-glucan extraction. The completed study is very innovative because up to now flocculants have not been considered as agents that can be used in β-glucan extraction.

Earned in the **H.4.** study experience in β-glucan extraction has been used in the study of microencapsulation of fish oil (**H.5.**) - the most often microencapsulated core material. The optimal ratio of β-glucan to modified starch, which served as an auxiliary in microencapsulation, as well as the optimal temperature to obtain microcapsules with the longest durability and high encapsulation capacity was developed.

The results described above fully correspond to the main achievement goal, which was the analysis of the possibility of using dietary fiber in food production and considering its impact on nutritional value and technological properties.

2.3.5. Literature

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3. DESCRIPTION OF OTHER RESEARCH AND SCIENTIFIC ACHIEVEMENTS

In the years 2008-2013, I was a student in the field of food technology and human nutrition at the Faculty of Human Nutrition and Consumer Sciences at the Warsaw University of Life Sciences. I completed this stage of my education with my master's thesis: "Application of liquid chromatography coupled with tandem mass spectrometer (LC-MS-APCI-IT) in the study of changes in vitamin E content in pork", promoted by dr hab. Arkadiusz Szterk. The master's thesis was the result of work in the scientific project "**BIOFOOD** - innovative, functional products of animal origin" and was rated as very good.

Already during my studies, I carried out scientific research as part of the project "Optimization of beef production in Poland, according to the strategy" from the fork to the farm"(*ProOptiBeef*)" co-financed from the European Regional Development Fund. In 2010, I completed an apprenticeship at the Institute of Food and Nutrition at the Independent Food Nutrition Laboratory and carried out work related to the 7th Framework Program project: FACET - Flavours, additives and food contact material exposure task".

The result of this experience was an internship trip at the **University of Nottingham** (07.-09.2011), Food Science Division, where I carried out research related to the encapsulation of water and oil droplets as a method of stabilizing emulsions used for parenteral nutrition.

From September 2013, I worked as a scientific assistant at the Department of Technique and Food Development, at the Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences. For the first two years of my work, I was employed to work for the Project **BIOPRODUCTS**, innovative technologies to produce healthy bakery products and pasta with reduced caloric value". In 2014, I was re-employed in the *ProOptiBeef* project as a research worker in connection with the task of developing methods for the determination of fatty acids by means of gas chromatography.

In April 2015, I opened a doctoral thesis that was closed during the public defense of my doctoral thesis, "The effect of the additive and the degree of micronization of fiber preparations on the formation of selected quality attributes of bread". My promoter was prof. dr hab. Agnieszka Wierzbicka, while the auxiliary promoter, dr inż. Jarosław Wyrwisz. The doctoral dissertation was awarded by both reviewers, as well as the Council of the Faculty for the high application value of the work, as well as the high intensity of work during its preparation, as the defense took place twenty-one months before the planned completion of doctoral studies.

In the period of 07-09.2015, I was an intern of the prestigious program **TOP500 Innovators** aimed at improving the qualifications of scientists in the field of cooperation with the economy, management of scientific research and commercialization of their results. The internship took place under the auspices of two leading international research institutions - the

University of Cambridge and the **University of Oxford** and significantly contributed to the increase of knowledge on the commercialization of research results. From 11.2016 I am employed as a research and didactic adjunct at the Department of Technique and Food Development at Warsaw University of Life Sciences, while from 01.2017, I am the manager of a research project financed by the National Center for Research and Development under the LIDER program. The title of the project is: "Microencapsulation as a technique for increasing the application of beta-glucan in the food industry". It is a thirty-six-month project with a total co-financing amount: PLN 1 095 399.71.

During the period of employment as an adjunct, I did two didactic internships as part of the Erasmus + program. In 2017, I lectured at the **University of British Columbia** in Vancouver, Canada and in 2018, **Tel Hai Academic College** in Qiryat Shemona, Israel.

Among my scientific interests, the following research topics can be specified (numbering publication in accordance with point II) List of other (not included in the achievement mentioned in point I) published scientific papers and scientific performance indicators) of Annex 3:

Thematic group 1. The effect of β-glucan addition on the quality of bakery products (publications II.A.1.; II.A.6.; II.A.15. II.A.17.).

Thematic group 2. Analysis of the quality of confectionery products with the addition of dietary fiber and sweeteners (publications II.A.2.; II.A.4.; II.A.7.).

Thematic group 3. Analysis of the effects of animal diet, aging, storage and heat treatment on the physicochemical properties of meat (publications II.A.3; II.A.8; II.A.18; II.B.1.1.).

Thematic group 4. The quality of bakery products depending on the flour and dietary fiber used (publications II.A.5; II.B.2.1.).

Thematic group 5. The impact of dietary fiber on the quality of pasta (publications II.A.9.; II.A.13.; II.A.16.).

Thematic group 6. The particle size of dietary fiber and its effect on the physical properties of fiber and the quality of bakery products (publications II.A.10.; II.A.11.; II.A.12.; II.A.14.)

3.1. Description of work in thematic groups

3.1.1. The effect of β-glucan addition on the quality of bakery products

Increased consumer awareness of health issues causes food producers to meet the need to provide functional products to the market. Bakery products are one of the most frequently consumed products in the world. Over the last decade, these products have been examined for the development of their function for human health (Mudgil et al., 2016). One of the substances that can increase the functionality of bakery products is β-glucan. In this thematic group, I focused on the description of research focused on the use of this fraction of soluble fiber on the quality of bakery products - bread and rolls.

The literature has initially described the fact that the addition of β-glucan has a negative effect on the quality of the bread. There are various methods to describe processes that can prevent it, such as milling, hydrothermal treatment or enzymatic treatment (Benito-Roman et al., 2013). However, there is no comprehensive study on the use of various initial processes acting on β-glucan on the quality of enriched wheat bread. Therefore, I decided to present in this study the application of freezing, mixing, cooking and mixing of these treatments with each other during the pre-treatment of the preparation of β-glucan before enriching wheat bread (**II.A.1.**). Bread containing hydrated or dry β-glucan preparations showed lower specific volume values than controls. On the other hand, the preparation of β-glucan, which was cooked has been thermally treated in an aqueous environment at 95 ° C-100 ° C or mixed after freezing, has a higher specific volume. showed a higher specific volume of bread. The hardest bread was the one obtained by adding the β-glucan preparation which was hydrated and the least hard after using the frozen mixed preparation. In our study, I investigated the effect of pre-treatment of the β-glucan preparation on the concentration of this compound. Our bread contains from 1.62 to 1.99 g of β-glucan / 100 g of product. It seems that the best way to pre-treat is drying, freezing or cooking after freezing the β-glucan preparation. In general, the best method was cooking the β-glucan preparation before adding to the dough.

In addition to the treatment of the β-glucan preparation itself, it is also worth paying attention to the fact that it is necessary to refine the water content during the kneading, which translates directly to the quality of the bread as well as its durability. The stoving of stale bread is mainly influenced by the retrogradation of starch during storage. Retrogradation is a process that takes place as a function of time and depends on the reassembly of the crystal structure (Li et al., 2016), which results in changes in the relation of water binding in the bakery product and, as a result, its loss and hardening of the so-called texture. staling. This process can be slowed down by maintaining the ratio of water to starch. Due to the ability of β-glucan to hold water, it can be a reservoir of water in bread to maintain this ratio.

The aim of my research was to optimize the content of β-glucan and water to obtain high-quality bread, and then to examine it in terms of staling, comparing it with a control bread. (**II.A.6.**). Using the central composite rotary design, I have developed an optimal β-glucan additive of 1.24% with 63.48% water in the flour-fiber mixture to achieve a final product with a minimum hardness and maximum porosity, elasticity and β-glucan content. The analysis of staling kinetics has shown that this optimized content can prevent bread staling for up to 7 days of storage.

I also undertook research within this thematic group on the use of various types of wheat flour used in the production of bread with a high content of β-glucan. The article discusses the issue of the influence of the type of wheat flour on the quality of wheat bread enriched with β-glucan from oat grains (**II.A.17.**). I observed that increasing the type of flour resulted in an increase in the storage module and the loss modulus. However, the bread made from different flours was smaller in volume after the addition of β-glucan, although the yield increased.

The color of the bread crumb with the added β-glucan was darker than without the participation of β-glucan. . The control samples had a higher hardness than the samples after the addition of β-glucan, which simultaneously had a reduced porosity. The results showed that using a very strong flour with a high protein content results in a high-quality β-glucan bread with a higher nutritional value due to its high content of dietary fiber and β-glucan.

In addition to the selection of the right water content, type of flour, the topic group also describes the influence of microwaves on the preservation of quality of bread enriched with β-glucan. There is a large microwave processed food market and one of the potentially important growth areas of this market are microwave baked products; however, the main task of scientists is to improve the quality of these products baked using microwaves (Wiggins & Cauvain, 2015).

The aim of the research was to check the methodology of the response surface to optimize the content of β-glucan and microwave power during baking of wheat rolls (**II.A.15**.). The growing content of β-glucan in wheat buns resulted in a shorter baking time. The β-glucan content in a linear approach had a significant influence on the hardness of the breadcrumbs and was not influenced by the intensity of the microwaves. The β-glucan content in the final product was the highest in products obtained in the medium microwave range. The surface response methodology has been used to optimize β-glucan and microwaves to produce the best quality product.

The research group described by me is a series of publications on the use of various forms of β-glucan, matching the water content and the effect on bread tinning, as well as fine-tuning the type of flour or the use of microwaves. The obtained results confirmed the thesis that it is possible to use β-glucan in the bread, while maintaining high quality, however, certain technological processes should be used to preserve or obtain this quality.

Literature:

- Benito-Román, Ó., Alonso, E., Gairola, K., & Cocero, M. J. (2013). Fixed-bed extraction of β-glucan from cereals by means of pressurized hot water. *The Journal of Supercritical Fluids*, *82*, 122-128.
- Li, W., Li, C., Gu, Z., Qiu, Y., Cheng, L., Hong, Y., & Li, Z. (2016). Relationship between structure and retrogradation properties of corn starch treated with 1, 4-α-glucan branching enzyme. *Food Hydrocolloids*, *52*, 868-875.
- Mudgil, D., Barak, S., & Khatkar, B. S. (2016). Optimization of textural properties of noodles with soluble fiber, dough mixing time and different water levels. *Journal of Cereal Science*, *69*, 104-110.
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3.1.2. Analysis of the quality of confectionery products with the addition of dietary fiber and sweeteners

As part of this thematic group, articles on the use of dietary fiber and sweeteners in pastry products were developed. An example of such a product that combined all publications within the group was a muffin.

According to the WHO 2015 report on obesity, around 17% of children and over 30% of adults are currently considered obese, so the obesity epidemic remains one of the most serious health problems. One way to prevent this disease is to reduce fat or sugar intake and comparability with conventional products according to consumer acceptance (Struck et al., 2016). Therefore, in this study, I have developed an innovative packaging system, in which muffins are characterized by an increased content of fiber and an increased level of antioxidants to maintain their healthy value (**II.A.2.**).

Four different dietary fibers were examined: oat fiber (AS), apple fiber (MD), carrot fiber (DC) and cocoa fiber (TC) and a control sample. The muffins were made to obtain more than 6g of dietary fiber per 100g of the final product. Each fiber-coated muffin was packaged in a modified atmosphere (MAP) with an initial gas mixture of 25% CO_2, 50% CO_2, 75% CO_2, 100% CO_2, using nitrogen as an inert gas in the MAP system. The quality of muffins was tested on the first and fifteenth day of packaging. I noticed that the hardness of the control sample was mainly dependent on the CO_2 concentration in MAP. The level of CO_2 had the greatest impact on the hardness of MD samples. Conversely, it was with AS samples, where elasticity was significantly dependent on the interaction between CO_2 and N_2 interaction, similar to TC. An optimized gas composition for the MAP for each muffin with fiber was developed.

The next stage of work in connection with the positive effect of work on the optimization of the composition of muffins with dietary fiber was the development of a technology enabling the use of sweeteners and dietary fiber. The growing demand for low-calorie foods with reduced sugar and fat content is also a consequence of the epidemic of obesity, diabetes and other civilization diseases. It is also related to the nutritional awareness of consumers (McVay et al., 2016).

Nevertheless, fat and sugar play a key role in the development of texture and sensory quality of food products, in particular, sweet bakery products. The study involved a partial replacement of sucrose (20%) with steviol glycosides and complete replacement of cocoa powder with cocoa fiber preparation in muffins (**II.A.4.**). There were three levels of dietary fiber supplement - 3%, 6%, and 12%. Physical analysis of texture, color, cooking efficiency, and porosity was carried out. In addition, a chemical analysis of total dietary fiber (TDF) and total content of phenolic compounds (TPC) was also performed. Sensory evaluation was also carried out in two parts. The experiment revealed the increase in hardness, porosity, TDF and TCP as well as reduction of elasticity, coherence, and lightness in samples with dietary fiber. From the consumer point of view, the most appreciated were muffins with 6% TDF sweetened with sugar and stevia. Stevia additionally strengthened the cocoa and sweet flavor of the tested muffins.

The last study within this research group were studies focused on the physical properties of muffins sweetened with steviol glycosides as substitutes for sucrose (**II.A.7.**). The aim of this study was to determine the effect of replacing sucrose with steviol glycosides on the quality of pastry products. Analysis of texture, color, cooking performance, browning index and sensory analysis of the muffin was carried out. The study showed that a 25% sweetener addition (as a substitute for sucrose) was the most suitable modification of the basic recipe. The resulting muffins have gained sensual attractiveness and health properties. What's more, the study showed that reducing the sucrose content by more than 50% had a negative impact on the quality of muffins and their sensory profiles.

Summarizing the entire thematic group, it can be concluded that dietary fiber is possible for use in pastry products. Increased production costs of such products can be compensated by longer durability by using atmosphere modification. The use of sweeteners, such as, for example, cereal glycosides in combination with an increased content of dietary fiber, may be one of the methods that are part of the general trend of food production consisting in lowering the calorie of pastry products.

Literature:

- McVay, M. A., Voils, C. I., Geiselman, P. J., Smith, V. A., Coffman, C. J., Mayer, S., & Yancy Jr, W. S. (2016). Food preferences and weight change during low-fat and low-carbohydrate diets. *Appetite*, *103*, 336-343.
- Struck, S., Jaros, D., Brennan, C. S., & Rohm, H. (2014). Sugar replacement in sweetened bakery goods. *International Journal of Food Science & Technology*, *49*(9), 1963-1976

3.1.3. Analysis of the effects of animal diet, aging, storage and heat treatment on the physicochemical properties of meat

Another research group that I dealt with during my scientific work was meat technology. As part of this research group, I was co-researcher in three publications in the field of beef and pork.

One of the effects of the work in this research group was a review article aimed at describing the current knowledge of dietary supplementation of pigs with oilseeds and their impact on the nutritional value and quality of pork (**II.A.3.**). The use of PUFA-rich feeds in the diet of pigs, including those rich in vegetable oils, such as linseed, rapeseed or sunflower, is beneficial to the health of consumers, as these acids improve the nutritional value of the meat. They particularly increase the proportions of n-3 fatty acids, such as linolenic acid in pork, but do not affect the content of DHA and EPA. Of the oilseeds, especially flaxseed seems to be a good source of n-3 PUFA, as well as the content of ALA (50% fatty acids).

However, the higher proportion of PUFA has a negative impact on the technological properties of pork meat and its oxidative stability, as well as sensory characteristics. Therefore, the use of antioxidants in the pig diet, including vitamins A, C, E, and selenium, may reduce the formation of lipid radicals and protect the unsaturated fatty acids in pork against increased lipid oxidation.

Another study that I took part in was the study of the effect of meat ripening in vacuum for twenty-one days on the color, blooming and cutting power (WBSF) of the semi-bovine bovine muscle. Maturation is one of the most commonly used methods of improving beef quality. During the maturation process, there are many biochemical processes that are responsible for improving quality, mainly tenderness (Moczkowska, Półtorak, Wierzbicka, 2015) and flavor development. Different muscles differ in color stability (Apple et al., 2014).

Muscle with greater color stability is characterized by lower oxygen consumption and lower lipid oxidation, which is also associated with the type of muscle fiber. The aim of the study was to assess color changes, myoglobin form and concentration, and WBSF values during twenty-one-day wet aging (**II.A.8.**). There were significant changes in brightness, redness, yellowing and hue angle during puberty. The proportions of myoglobin forms changed on the seventh day of puberty. Maturation generally reduced WBSF, but a significant decrease was observed after day fourteen of aging. It was found that the best qualitative features can be obtained after an optimal time of flowering and meat aging.

During the research work, I also had a modest contribution to the research aimed at describing the profile and concentration of heterocyclic aromatic amines (HAA) formed in beef during various heat treatments, which depend on the time of maturation and muscle type

(**II.A.18.**). In this study, a new, very accurate and precise HAA analytical method was developed. The results can help optimize the meat processing technology to reduce the concentration of HAA generated during heat treatment, including the most carcinogenic: IQ, IQx, MeIQx and PhIP amines.

The summary of cooperation in research in the field of meat technology was the participation in the creation of a chapter in an outstanding scientific monograph on the role and systems of beef production and methods for verifying their quality (II.B.1.1.) During my scientific work, I participated in research to describe the impact of various stages of obtaining meat for its quality - from supplementation of diet to thermal treatment and description of production quality systems.

Literature:

- Apple, J. K., Machete, J. B., Stackhouse, R. J., Johnson, T. M., Keys, C. A., & Yancey, J. W. (2014). Color stability and tenderness variations within the gluteus medius from beef top sirloin butts. *Meat Science*, *96*(1), 56-64.
- Moczkowska, M., Półtorak, A., & Wierzbicka, A. (2015). Impact of the ageing process on the intensity of post mortem proteolysis and tenderness of beef from crossbreeds. *Bulletin of the Veterinary Institute in Pulawy*, *59*(3), 361-367.

3.1.4. The quality of bakery products depending on the flour and dietary fiber used

In my research, apart from the use of dietary fiber, I also researched the use of various wheat flours in bakery. The result of this work is a publication that is a comparative study of pastry rheology and the quality of bread baked from flours rich and rich in fiber (**II.A.5.**).

As the demand for high-fiber foods increases with the number of consumers aware of the health benefits, the intake of high-fiber foods increases. From a nutritional point of view, consumers prefer flour from grinding whole grain, but most of them prefer the taste and physical properties of white wheat flour. When consumers are asked to indicate the benefits of whole grain bread, they most often refer to dietary fiber (Schaffer-Lequart i in., 2015). In addition, one of the alternatives to enriched and whole wheat bread is bread made of spelled flour, which has the same set of genomes as wheat bread. It has gained interest over the last 20-30 years due to its high nutritional potential and low production costs.

Spelled is known for its high fiber and protein content. The tests evaluated the rheological properties of dough and the quality of bread, as a function of time, of purified wheat flour, enriched with dietary fiber oat in two shares, spelled flour and two types of flour: whole grain (full milling - kernels with a husk allowing to obtain the maximum amount of minerals, vitamins and fiber, equal to a husked peel) and wholemeal (one-stage grinding - hulled grains that allow obtaining a very high amount of minerals, vitamins and fiber, minimally lower than in kernels and hulls, as wholemeal milling involves the grinding of grains without hulls). The lowest specific volume was observed in whole grain bread (0.82 cm^3/g), while the highest was observed in the control sample of white bread (1.60 cm^3/g). The fastest loss of moisture appeared in white bread. The content of water was significantly influenced by the type of flour, the storage day and the interaction between these two variables ($p \leq 0.01$). The hardest was a sample of wholemeal bread on the first and third day. However, considering the qualitative factors of the dough, bread and consumer rating, the most consistent of the quality remained a sample with a 12% dietary fiber added on the way of fortifications.

As part of this thematic group, a review article was also prepared, in which I described the impact of dietary fiber on rheology produced liquids non-Newtonian visco-plastic (rye dough) and visco-elastic (wheat dough) and the quality of the heat treated final product.. The review showed the dependence of the use of dietary fiber in the production of bread in terms of changes in physical parameters of bread, durability and sensory characteristics of bread (**II.B.2.1.**)

Literature:

- Schaffer-Lequart, C., Lehmann, U., Ross, A. B., Roger, O., Eldridge, A. L., Ananta, E., ... & Wavreille, A. S. (2017). Whole grain in manufactured foods: current use, challenges and the way forward. *Critical reviews in food science and nutrition*, *57*(8), 1562-1568.

3.1.5. The impact of dietary fiber on the quality of pasta

In my research, dietary fiber has not only been used in baked products, such as bread and cookies, but also in products made using non-thermal methods, such as pasta. As part of the work, I participated in studies on the influence of the type of drying (conventional, vacuum and high temperature) on the quality of pasta enriched with dietary fiber. The drying conditions play a key role in the pasta production process. They define the final quality of the product, including the appearance and behavior during cooking (Mercier, Villeneuve, Mondor, & Des Marchais, 2011).

The aim of this study was to assess the effect of adding fiber-rich oat preparation and vacuum drying to the hydration properties and color of the pasta. The durum wheat semolina was replaced with 0, 4, 8, 12, 16 and 20 g / 100 g of oatmeal with high fiber content. The noodles were processed from wheat semolina and dried at a very high temperature in a conventional drying system and using a vacuum dryer. The results showed that the drying method and the level of oat fiber powder addition had a significant effect on the color and moisture properties of the pasta ($P \leq 0.05$).

The water intake was higher in samples containing oat preparation than in the control sample. Water uptake and swelling ratio were higher in vacuum dried samples. The optimal cooking time decreased with the increasing level of oat powder addition. The drying curve indicated that vacuum drying allows faster evaporation of water than atmospheric drying. Pasta with oat powder was darker, softer and less sticky than semolina pasta. Vacuum drying gave a bright yellow pasta characterized by high hardness, low stickiness, high water consumption, and low losses during cooking. The results of the research indicate the beneficial effects of vacuum drying on the physical properties of the pasta (**II.A.9.; II.A.13; II.A.16.**).

Literature:

- Mercier, S., Villeneuve, S., Mondor, M., & Des Marchais, L. P. (2011). Evolution of porosity, shrinkage and density of pasta fortified with pea protein concentrate during drying. *LWT-Food Science and Technology*, *44*(4), 883-890.

3.1.6. The particle size of dietary fiber and its effect on the physical properties of fiber and the quality of bakery products

The research area, which consisted of the particle size of dietary fiber, was part of my doctoral thesis and research work immediately after its defense (**II.A.10.; II.A.11.; II.A.12.**). Scientific reports on the health-promoting effects of individual fractions of dietary fiber increase the interest in the implementation of fiber preparations in bakery production.

However, replacing the flour with a fiber preparation has an adverse effect on the quality of the final product. It fragmentates, for example, the gluten-starch structure in one of the dimensions of the system (especially insoluble fractions). This results in a change in the viscoelastic properties of the dough and has different effects on other technological properties such as bread volume or hardness (Rosell & Santos, 2010). This problem has been addressed in scientific studies that analyze the processes of making cellulose preparations in terms of improving the quality of bread.

These methods have been divided into thermal, enzymatic and mechanical. One of the mechanical methods of preparation of cellulose preparations used in bakery production is micronization. This process causes the fiber structure to be opened by mechanical abrasion under controlled temperature conditions. Free hydroxyl groups are released, which contributes to the increased water absorption by developing the surface of their action. In addition, due to the smaller particle size, the cellulose preparation is more closely incorporated into the bakery product dough structure (Choi et al., 2008).

Physicochemical studies of bread enriched with dietary fiber were carried out, both with a high proportion of insoluble and soluble fractions. Due to the lowering of fiber particle size, bakery products with the best quality properties were obtained; both using a preparation with a high content of soluble and insoluble fractions. Specific application recommendations for application in industrial practice have been developed. They relate to the use of an appropriate type of flour, supplement, as well as the particle size of the oat fiber preparation while maintaining the high quality of bakery products to which consumers are accustomed. Addition of oat fiber preparation with smaller particles results in obtaining a product with rheological parameters and color, which more closely resemble a control sample.

During studies on the properties of food fiber particles, I developed a methodology to describe the water-absorbent properties using automatic static image analysis, which until now has not been mentioned in the literature as a method that may have such application (**II.A.14.**)

Literature:

- Choi I., Chun A., Suh S.-J., Ryu G.-H., Chun J., Kim J.H. (2008). Effects of extrusion conditions on physicochemical properties of a mutant rice cultivar, goami2 – high in nondigestible carbohydrates. *Journal of Food Quality*, 31(5), 571–585. DOI: 10.1111/j.1745-4557.2008.00221.x.
- Rosell C.M., Santos E. (2010). Impact of fibers on physical characteristics of fresh and staled bake off bread. *Journal of Food Engineering*, 98(2), 273–281. DOI: 10.1016/j.jfoodeng.2010.01.008

3.2. Summary of the scientific and research work

Publication	Number of publications		Number of points according to Ministry*	Sum of points according to Ministry**	Impact Factor from year	5-year Impact Factor
	Before Ph.D.	After Ph.D.				
A. Scientific publications in magazines in the journals in Journal Citation Reports (JRC)						
Animal Science Papers and Reports		1	25	25	0.710	0.845
Carbohydrate Polymers		1	40	40	5.158	5.326
CyTA-Journal of Food	2	2	15	60	1.180	1.056
Food Hydrocolloids		1	45	45	5.089	5.501
Food Science and Biotechnology		1	20	20	0.699	0.859
Food Science and Technology (Campinas) (2015)[1]	1	1	15	30	0.729	0.749
Food Science and Technology (Campinas) (2018)		1	15	15	1.084	1.268
Food Technology and Biotechnology		1	25	25	0.891	1.349
International Journal of Food Science & Technology (2015)	1		25	25	1.640	1.755
International Journal of Food Science & Technology (2017)		1	25	25	1.504	1.669
International Journal of Biological Macromolecules		1	35	35	3.909	3.256
Journal of Cereal Science		2	35	70	2.302	2.904
Journal of Food Process Engineering		1	20	20	1.370	1.283
Journal of Food Science and Technology		1	35	35	1.797	1.604
LWT-Food Science and Technology (2015)	1		35	35	3.129	3.455
LWT-Food Science and Technology (2017)		1	35	35	2.711	3.290
Meat Science (2012)	1		40	40	2.754	3.039
Meat Science (2016)		1	35	35	3.126	3.313
B. Scientific monographs						
Chapters in scientific monographs recognized as outstanding in Polish		1	10	10	-	-
C. Scientific publications in journals listed in part B of the list of scientific journals						
British Journal of Applied Science & Technology	1		5	5	-	-
Journal of Food Processing and Technology	1		7	7	-	-

Publication	Number of publications		Number of points according to Ministry*	Sum of points according to Ministry**	Impact Factor from year	5-year Impact Factor
D. Scientific communications						
At international conferences	11	10	0	0	-	-
At national conferences		4	0	0	-	-
G. Collective studies, catalogs of collections, documentation of research works, expert opinions, works and artistic works, and others						
Ready-to-use solutions	-	2	0	0	-	-
Patent applications	3	-	0	0	-	-
H. Publikacje popularnonaukowe						
Szef Kuchni	-	23	0	0	-	-
Przegląd Piekarski i Cukierniczy	-	1	0	0	-	-
SUMMARY				Sum of points according to Ministry	Impact Factor from year	5-year Impact Factor
SUM OF PUBLICATIONS	**80**		**SUM OF POINTS**	**637**	**46.353**	**49.342**

[1] – in the case of two or more publications from different years, the year of publication is given in the same journal

* - The number of points according to the scoring list of journals Communications by the Minister of Science and Higher Education on the list of journals by year of publication or the latest available list of 26.01.2017. In the case of a monograph: Regulation of the Minister of Science and Higher Education of December 12, 2016 on the awarding of a scientific category to scientific units and universities in which, according to their statutes, basic organizational units have not been separated - Annex 7

** - The sum of points according to the list of magazines scored by the Ministry of Science and Higher Education multiplied by the appropriate number of publications

- I am the author of **23 scientific publications** in journals indexed by the Journal Citation Report published in 2012-2018, of which **in 14 I am the first and correspondent author**.
- The number of publications cited according to the **Web of Science database is: 98**; according to **Google Scholar: 157**.
- Hirsch Index according to **Web of Science: 6**; according to **Google Scholar: 7** (date: 13.09.2018)
- **The sum of points according to the lists of the Ministry of Science and Higher Education is 637, including 480 obtained after doctoral thesis. The total Impact Factor of all publications is 45.353.**