SUMMARY OF PROFFESIONAL ACCOMPLISHMENTS

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1. PERSONAL DATA

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2. DIPLOMAS AND SCIENTIFIC DEGREES

- **2004: Ph.D in Agriculture Sciences** in the field of food technology and nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences – SGGW. Ph.D. thesis tittle: Estimation of the adjustment of the level and structure of supply for fruit and vegetables to the food needs of the Polish population (thesis supervisor dr. hab. Krystyna Żelazna, Associate professor WULS-SGGW).
- **1992: Master of Science**; specialization: horticulture; Faculty of Horticulture and Landscape Architecture, Warsaw University of Life Sciences - SGGW. The thesis tittle: Assessment of individuals of *Hippeastrum x hybridum* in the F1 generation (thesis supervisor dr. hab. Henryk Chmiel).

3. INFORMATION ABOUT HITHERTO EMPLOYMENT IN SCIENTIFIC INSTITUTIONS

- **2005 – present**: Assistant professor in Chair of Organic Food – Department of Functional Food, Ecological Food and Commodities, Faculty of Human Nutrition and Consumer Sciences WULS – SGGW
- **1993 – 2005**: Assistant in Chair of Organic Food – Department of Functional Food, Ecological Food and Commodities, Faculty of Human Nutrition and Consumer Sciences WULS – SGGW
- **1992 – 1993**: Independent technical assistant in Division of Farm and Garden Food Production (later Division of Food Raw Materials, and later Chair of Organic Food).

4. ACHIEVEMENT CONSTITUTING BASIS OF HABILITATION PROCEDURE

- The scientific achievement constituting basis of habilitation procedure in accordance with Article 16, Paragraph 2 of the Act of 14 March 2003 on Academic Degrees and Title and Degress and Title in the Arts (consolidated version: Official Journal of Laws of 2014 item 1852 and 2015, item 249 and 1767) is a published body of work in its entirety.

4.1 TITLE OF SCIENTIFIC ACHIEVEMENT

Renata Kazimierczak: The effect of organic and conventional crop production system on selected quality parameters of beetroots, carrots and carrot juices. Warsaw University of Life Sciences Press, Warsaw 2016, p. 1-190.

INTRODUCTION

Root vegetables, including carrots and beetroots, are products often selected by consumers. This is confirmed by the 18% share of these vegetables in the total vegetable consumption in Polish households (GUS, 2014).

These products are rich in compounds with antioxidant properties, including flavonoids, phenolic acids, carotenoids (in carrots) and betalains (in beetroots); they are a very important part of a diet, which can help improve public health.

These compounds prevent the adverse effects of oxidative stress, thereby significantly reducing the risk of many diseases, including cardiovascular diseases and certain cancers (Kidoń and Czapski 2007, Berger et al. 2008, Georgiev et al. 2010).

Nowadays, health and convenience are the most important non-economic factors determining consumer food preferences (Acharya and Molina 2004). At the same time, these preferences are increasingly directed towards food produced is environmentally friendly way, which contributes to the growth in demand for food from the controlled production systems, including organic farming, the quality of which is confirmed by certificates (Czernyszewicz and Pawlak 2012).

Organic food production, both crop and livestock, is undoubtedly more environmentally friendly in comparison to other systems of agricultural production. This is due to the fundamental principles of organic farming, which include food production without synthetic fertilisers, pesticides, hormones, other chemical substances used in food industry and genetically modified organisms (GMO). The other principle is to minimise the use of any external production inputs, while maintaining high standards of care for the soil, biodiversity, protection of natural resources and animal welfare. Organic producers have no impact on the amount of pollution from industry and transport, but they contribute to maintaining the high quality of agricultural environment by using organic production methods (Council Regulation (EC) No 834/2007, Reganold and Wachter 2016). High food quality, associated by consumers with beneficial effects on health, is determined by practices used in organic farming and

supported by a control system of all stages of production, preparation and distribution (Żakowska-Biemans 2013). It has also been confirmed by the results of many studies on laboratory animals and a few on humans (Średnicka-Tober et al. 2015). This is an unique and specific added value of organic food (Meier-Ploeger 2005). Organic food, is perceived by majority of consumers as safe, tasteful and nutritious. Additionaly, consumers believe that its' consumption is more beneficial for health and vitality than food produced according to conventional farming standards. Another important attribute of organic food production methods, especially for conscious consumers, is a respect for the rights of animals and the environment (Matt et al. 2011). As it is known, the key elements influencing yield size is a system and the intensity of agricultural production. That is why intensive farming often uses industrial means of production in the form of fertilisers and plant protection products, which stimulate the growth and yielding. However, intensive way of production can be associated with many hazards for health security and environment (Godfray et al. 2010, Reganold and Wachter 2016). Organic system of agricultural production, on the contrary to intensive one, uses only natural methods and means of production. As a result, crops produced according to organic rules have on average lower yields, but higher quality (higher content of bioactive ingredients and lower content of undesirable compounds, such as pesticide residues and nitrates (Średnicka-Tober et al. 2013, Barański et al. 2014).

As far as safety issues associated with the occurrence of significantly lower pesticide residues and nitrates in organic crops appear to be well explained, the answer to the question whether organic products, including vegetables, are characterised by higher sensory qualities and higher nutritional and biological value, is still subject to discussion of scientists around the world.

Nowadays, a lot of research results presented in reviews and meta-analyses based on papers published by many authors, proved that organic food has a higher nutritional and biological value, and at the same time, lower content of undesirable compounds, mainly pesticides and nitrates.

Some research teams are more sceptical and even if they present data in favour of organic food composition, in summary they conclude that there is no significant difference in quality between organic and conventional crops. These teams are: Bourn and Prescott (2002), Dangour et al. (2009) and Smith-Spangler et al. (2012). Other research teams interpret results of higher content of polyphenols and minerals in raw organic food as an opportunity to improve the overall health of societies (among others: Brandt et al. 2011, Hunter et al. 2011, Matt et al. 2011, Barański et al. 2014).

It should be underlined, however, that there is still not enough longterm complex research, which in a systematic way would include technological aspects, sensory qualities and the content of bioactive compounds in the raw materials produced in organic and conventional way. Scientists agree that in order to clarify whether the raw materials from organic farming have more beneficial composition than raw materials from conventional farming, experiments should be conducted by comparing the production of neighbouring organic and conventional farms. In this approach, the environmental factors associated with the climate are almost identical, what may help to avoid the effects not directly related to the production system. At the same time it is possible in such experiments to indicate which method of production contributes to higher quality of raw materials produced under certain conditions.

4.2 RESEARCH AIM, HYPOTHESES AND SELECTED ELEMENTS OF METHODOLOGY

The aim of this research was to determine and compare the effect of organic and conventional crop production methods on chemical composition, sensory quality and selected parameters of technological and storage quality of two varieties of red beetroots, two varieties of carrots and carrot juices.

The original part of this work was to plan and carry out an experiment with a comprehensive analysis of the quality of the beetroots and carrots roots as well as carrot juice from organic and conventional production and use in the experiment, five pairs of active farms operating under similar conditions of climate and soil. Farms were also comparable in terms of cultivated species and varieties of vegetables and scale of production. This approach made it possible to assess the impact of the management system as a whole on the complex qualitative characteristics of selected raw materials. The reason for carrying out this experiment, was justified by the fact that the majority of research on crops comparing the quality of conventional and organic farming is carried out in experimental conditions: experimental fields. These experiments are reducing the number of factors affecting the nutrient and health-related content of raw materials, but do not give an opportunity to examine the influence of organic and conventional production systems used in existing farms on the physical and biological value of raw materials. An additional advantage of the experiment using pairs of organic and conventional farms, in which environmental factors associated with the climatic conditions are identical, is a possibility to avoid the effects not directly related to the production system and as a result, to answer the question, which production system optimises quality of raw materials produced under certain conditions.

Following hypotheses were formulated as part of the study:

1. Edible parts of beetroots and carrots from organic production are characterised by a higher content of nutrients and bioactive compounds, which have a positive impact on health, as well as a lower content of nitrates(III) and (V) than their conventional counterparts.
2. Higher content of dry matter in organic vegetables promotes better storage, which is associated with lower loss as a result of transpiration, breathing and rotting.
3. Lower water content of edible parts and generally higher content of sugars and organic acids in organic vegetables lead to higher sensory qualities of vegetables.
4. Organic vegetables have lower yields than conventional vegetable. They produce smaller edible parts and could be characterised by a relatively higher losses during the preliminary technological preparation, as well as during storage.

Research material:

The implementation of the research and verification of hypotheses were performed on the test material: two varieties of carrot (*Daucus carota* L.) - Perfekcja and Flacoro and two varieties of beetroots (*Beta vulgaris* L.) - Czerwona Kula and Regulski Cylindryczny, gained from a three-year farm comparison experiment in 2007-2009. In addition, carrot juices made of two selected varieties of carrots, both organic and conventional, were tested. Varietes of carrots (Perfekcja and Flacoro) and beetroots (Czerwona Kula and Regulski Cylindryczny) were chosen due to their popularity in cultivation. Selected varieties of carrots belong to the late maturing group, which can be consumed fresh, processed or stored. Selected beetroots varieties are mid-early varieties, which also could be consumed fresh, processed or stored.

The roots of vegetables were obtained from 5 certified organic farms and 5 conventional farms from Mazowieckie voivodeship. Due to one farmer's withdrawal from the cooperation, since the second year of the experiment vegetables were obtained from 4 pairs of farms. Research results are presented as an average of three years including the data from the first year of the experiment from the 5 pairs of farms, while the second and third year - from 4 pairs of farms. All selected farms were producing vegetables (, organic farms were producing organically for at least 5 years). They were located close to each other and therefore operated under comparable conditions of climate and soil. This structure of the experiment made it possible to minimise the impact of external, non-agricultural factors on the chemical composition of vegetables and enabled the assessment of the impact of organic and conventional farming methods on selected quality parameters.

An important aspect of the experiment was obtaining the research material from the farms that produce vegetables for the purposes of the market, which seems to have a greater cognitive value in comparison to studies carried out on the material obtained from the exeprimental fields. One of the arguments in favour of such a study design, presented by many authors, is the effect of different fertilisation methods used in organic and conventional farming on the differences in the quality of the raw materials obtained. Organic farms applied organic fertilisers for the puproses of crop fertilisation, while conventional farms used synthetic mineral fertilisers.

In each year of the experiment, representative samples of plant material were collected from the farms and used to perform the analysis of the chemical composition of raw materials (immediately after harvest and after storage), for sensory assessment and for evaluation of selected parameters of technological value. In case of carrots, carrot juice was produced and used in the above mentioned analyses.

In three years of the experiment, organic and conventional farmers simultaneously grew all the selected varieties of carrots and beetroots. In addition, they were asked to fill out information sheets concerning care, fertilisation and protection treatments used in the cultivation of carrots and beetroot on their farms.

Data concerning meteorological conditions during the experiment in the form of average monthly air temperature, monthly sums of rainfalls and sunshine were made available at the request of the author's by the State Hydrological and Meteorological Service and Meteorological Defence of Civil Aviation, Institute of Meteorology and Water Management - National Research Institute.

The results of this research allowed to determine the impact of organic and conventional production methods and the impact of carrots and beetroot variety on selected parameters of the chemical composition, sensory qualities and technological parameters of vegetables immediately after harvest and after 6-month storage in a cold room (with normal atmosphere). Additionally, the analysis of selected parameters of nutritional and biological value of juices made from carrots derived from the experiment was conducted. Chemical analysis of juices was conducted immediately after preparation, after pasteurisation and after 6-month storage period. In the following three years of the experiment, the analysis of similar characteristics of beetroots, carrots and carrot juice was conducted; therefore the results presented in the study represent the mean values of all years of the experiment. This way of presenting the results is justified by statistical data analysis performed using ANOVA and parametric post hoc Tukey’s test, which indicates no significant interaction between the system of production of vegetables

(as the most important factor from the point of view of the adopted research hypothesis) and experimental year.

Storage conditions of beetroots and carrots:

Part of the collected/sampled roots of fresh beetroots and carrots (approx. 15 kilos of each variety) immediately after harvest and arrival in the Chair of Organic Food were stored in plastic boxes with dimensions of 60x40x25 cm, in a cold room in a normal atmosphere at a temperature of 1°C without adjusting the relative humidity. After six months of storage, healthy roots of beetroots and carrot were selected, and samples were taken to perform their chemical analyses after storage.

Production of carrot juice:

In each year of the experiment, part of the roots of both varieties of carrots from all organic and conventional farms (approximately 10 kg) was processed into juices. Juices were produced in the Department of Technology of Processed Fruit and Vegetables of the Institute of Agricultural and Food Biotechnology in Warsaw using identical methodology for organic and conventional products. Then they were subjected to chemical analysis immediately after preparation, after pasteurisation (at 92-93°C for 20 min) and after 6 months of cold storage (5°C, relative humidity 75%, no light).

Methodology of chemical analyses:

Samples of the roots of both species and vareties of vegetables from the experiment and carrot juices were collected for chemical analyses and freeze-dried using a Labconco lyophiliser with a capacity of 2.5 kg, of ice / day, temp. -40°C and at a pressure of 0.100 mbar. The lyophilised samples were milled and held frozen (in the temperature of -80°C) to prevent loss of biologically active compounds. After the analysis, the content of analised components were converted into fresh weight for the purpose of the experiment.

In the roots of beetroots, carrots and in carrot juice the following parameters were analysed: dry matter content by gravimetric method (acc. to Polish Norm PN-R-04013: 1988), total sugars and directly reducing sugars by Luff-Shoorl method (Fortuna et al. 2003), Vitamin C by titration method (acc. to Polish Norm PN-A-04019: 1998), nitrates (III) and (V) according to Polish Norm (PN-EN 12014-2), carotenoids (only in carrots and carrot juice) using high performance liquid chromatagraphy (Helsper et al. 2003), betalain pigments (only in beetroots) using high performance liquid chromatagraphy (Dóka et al. 2011) and phenolic compounds using high performance liquid chromatagraphy (Hallmann 2012).

Methodology of sensory analysis:

The sensory characteristics of vegetable samples were carried out according to Quantitative Descriptive Analysis (QDA), also called Profile. 17 quality parameters in the case of beetroot and 17 other distinctive on carrots, were selected and defined using the analytical procedure described in the Polish standard PN-EN ISO 13299: 2010. For the evaluation of smell, taste, texture and overall desirability of beetroot and carrot samples, scaling method using 9-point hedonic structured scale was used (by Polish standards ISO 4121: 1998) and boundaries were defined: (feature) undesirable - very desirable. Team of 30 semi-consumers, who were not subjected to any training, representing the adult population of young people, conducted hedonic evaluation of samples.

Methodology of evaluation of selected parameters of the technological value:

Analysis of selected parameters of the technological value includes indication of the weight of fresh roots of beetroots and carrots, and loss (in%) after pre-treatment (peeling vegetables) in the raw material directly after harvesting. The loss in weight of the roots after storage for 6 months in comparison to their initial weight was also determined (Zalewski 1993).

Methodology of statisical analysis:

Statistical analysis was performed using the computer program STATGRAPHICS 5.1. Three -way analysis of variance (ANOVA), followed by the parametric post hoc Tukey's test ($\alpha = 0.05$) was used . The factors in the ANOVA were: cultivation method (organic and conventional), variety (for beetroots: Czerwona Kula and Regulski Cylindryczny, and for carrots: Perfekcja and Flacoro) and a year of the experiment. Additionally we calculated the standard error of the mean (SEM - Standard Error of Mean) for the test. Each analysis was performed three times. The obtained data were presented as an average of the years 2007-2009, which was justified by the fact that in each year of the experiment, similar trends in obtained results concerning the impact of the system of agricultural production on the quality of beetroots and carrots were observed (statistical analysis also showed, in vast majority, no significant interaction between the system and the year of cultivation).

In order to assess the relationship between the doses of nitrogen fertiliser used in the cultivation of vegetables in organic and conventional farms, and selected parameters of the chemical composition of the raw materials, correlation analyss have been applied. Statistically significant correlations between the two variables were set at a significance level of 0.05 and 0.01.

To express the percentage differences in the content of the analysed compounds in raw materials and products from organic farming in relation to raw materials and products from conventional

farming, the folowing formula was used: [(org-conv)/conv]*100%, wg Worthington (2001) (where 'org' means average concentration of the analysed compound in organic samples and 'conv' – average concentration of the analysed compounds in the conventional samples).

Principal Component Analysis – PCA

For multi-feature characterisation of the tested objects (fresh and stored beetroots and carrots and carrot juices from the three-year experiment, two systems of agricultural production) and to evaluate the relationship between characteristics (chemical composition and the properties of the profile and consumer sensory evaluation), principal component analysis (PCA)) was carried out. The results of this analysis are shown in the graphs presenting objects and features using first two principal components (PC1 and PC2), which represent in a synthetic way correlated variables (Jolliffe 2002). PCA analysis was conducted in computer program Statistica 10 (StatSoft 2011).

4.3 RESULTS

The content of dry matter, nutrients and bioactive compounds in beetroots, carrots and carrot juice from organic and conventional production

Production of bioactive compounds in plants depends, among others, on the availability of mineral nitrogen in the soil (Bloksma et al. 2007, Stefanelli 2010). It was observed that increased availability of this macroelement, typical for conventional agriculture, is causing a change in plant metabolism mainly in the direction of vegetative growth, reducing the processes of differentiation and intensity of secondary metabolism, what results in a lower content of phenolic compounds in plant tissues. This phenomenon, resulting in generally higher content of metabolites based on carbon in organic plants, including monosaccharides, disaccharides and a number of secondary metabolites not containing nitrogen, such as terpenoids, phenolic compounds and some colorants and vitamins (eg. vitamin C), is explained in the literature by two theories: ratio of carbon to nitrogen (C/N) (Lerdau and Coley et al. 2002) and growth differentiation balance hypothesis - GBDH (Heeb et al. 2006, Bloksma et al. 2007). Intensive fertilisation stimulates rapid growth of plant biomass in the conventional system, resulting in increased efficiency of crops. This occurs due to the increase of water content in the cells, which also means lower dry matter content in plants. A higher content of water in the raw materials is also connected with dilution of nutrients (Heaton, 2001). Some authors also suggest that plants grown in the ecological system are more exposed to stress factors due to non-application of pesticides and in response to the attack of pathogens they trigger natural

defense systems to induce the synthesis of polyphenol metabolites (Young et al. 2005 Winter and Davis 2006 Capuano et al. 2013). However, there are reports not confirming this correlation. Studies on the protein expression in potatoes grown in the long-term experiment showed that differences in the composition of tubers were mainly related to differences in the method of fertilisation and not the crop protection systems of conventional and organic farming (Lehesranta et al. 2007). Also, another study, which tested the effect of different combinations of organic and conventional fertilisers and pesticides in greenhouse conditions, demonstrated that differences in the content of secondary metabolites were caused by fertilisation and did not depend on the use of pesticides (Zhao et al. 2009). It should also be noted that nutritional value of plants of the same species is not only influenced by agriculture system and its fertilisation, but it is also affected by many other factors, including climatic and soil conditions, period of harvest and storage conditions (Brandt et al. 2011).

In the presented study it was demonstrated significant differences in **dry matter** content in beetroots from organic and conventional production; organic roots, directly after harvest and after storage, had more ($p < 0.0001$) dry matter than conventional beetroots (by 9.6, and 14.11% respectively). However, this was not confirmed in the case of carrots and carrot juices, in which the dry matter content in organic and conventional products did not differ significantly. The obtained results on the dry matter of organic and conventional vegetables are not consistent but the results of many scientific papers based on the literature review confirm the trend of higher dry matter content in raw materials and products from organic farming, mainly in root and leafy vegetables, which is related to doses and the type of fertiliser used in the agricultural system (Brandt and Mølgaard 2001, Lairon 2010, Matt et al. 2011).

This study showed no difference in the **total sugar** concentration between roots of beetroots and carrots from organic and conventional production. **Carrot juice** produced from conventional raw material, in majority contained significantly more total sugars. In the case of beetroots, there was no difference in total sugar concentration between the tested varieties, while among two tested carrot varieties significantly ($p < 0.0001$) more total sugars were found in fresh roots of Perfekcja in comparison to the Flacoro variety, but the differences after storage were not significant. In the case of **reducing sugars**, most of the obtained data showed a significantly higher content in ecological raw materials and juices than in conventional ones. The tested varieties of beetroots and carrots did not differ in terms of the content of reducing sugars. In conclusion, the obtained results demonstrate to some extent that sugars are indicators and signals of certain features of plant physiology and growth, including interaction with

pathogens and environmental stress factors in plants, to which plants in the organic system are more vulnerable (Hanson and Smeekens 2009).

Significantly higher concentration of **organic acids** was found in the roots of beetroots from organic production (about 13.8-15.6%) and in organic fresh carrot juice (11.2%) compared with conventional counterparts. In the case of carrot roots and pasteurised carrot juice after storage, the opposite trend was found, more organic acids were found in conventional products. Based on the theory of the balance of C/N, higher content of organic acids in certain organic samples may be due to the lower availability of nutrients in organic farming, as well as higher levels of nitrogen fertilisation in conventional crops. However, in the case of the contents of organic acids in carrot juice and carrots, results are not consistent with this explanation, which may indicate a more complex mechanism responsible for differences between organic and conventional products.

Most of the results regarding **vitamin C** in the tested products show significantly higher content in beetroots and carrots and carrot juices from organic production compared to conventional products and raw materials, which concerns both fresh products and after storage; differences ranging from 7.5 to 18% in favor of organic raw materials and products. Based on the analysis carried out by Herencia et al. (2011) it is known that about 58% of research on the effects of production methods on vitamin C synthesis in fruits and vegetables show higher vitamin C content in organic raw materials than in conventional ones. It is determined also by lower nitrogen availability during the growing period in organic farming, which usually results in a higher synthesis of ascorbic acid. However, the plant response could be variable depending on the climatic conditions, other environmental factors and the type of used fertiliser (Lee and Kader 2000, Brandt and Mølgaard 2001). The research also demonstrated that the loss of vitamin C, which occurred as a result of blending and pasteurisation of carrot juice averaged 18.6% in organic products and 25.8% in conventional, and after storage, respectively, 32% and 38.1%. As a result, higher content of this vitamin in the raw material and lower losses due to pasteurisation and storing resulted in a higher content of vitamin C in the final organic products, thus allowing a potential higher supply to the consumers.

There were significant differences in the content of **total polyphenols**, including **flavonoids and phenolic acids** in favor of the organic beetroots, which contained more of these compounds than conventional beetroot (about 14.5-44%). In the case of carrots and carrot juices, results were not so evident, and their relatively high variation resulted in statistical insignificance of the differences in the case of most of the analysed parameters. It showed only an insignificant tendency to higher content of phenolic acids in organic carrots and carrot juice in most of the

analises. In the case of rutinoside-3-O-quercetin analysed in carrots, there were significant differences in favor of the organic raw material (about 23-63%). The positive impact of organic production system on the content of phenolic compounds in agricultural crops has been described previously and is associated with differences in the method of fertilisation. This phenomenon is also explained by another theory - hypothesis PCM (Protein Competition Model): when the plant biomass increases in response to the concentration of nitrogen, polyphenols level falls because of increased demand for protein synthesis during growth, limiting differentiation to polyphenols. A possible cause of this phenomenon is that the polyphenols are synthesised from the amino acid: phenylalanine, which in case of plant rapid growth will be primarily used for protein synthesis (Li et al. 2008). However, in the addition to the type of fertiliser used in various cultivation systems, as mentioned above, the differences in the synthesis of polyphenols by plants may be determined by a method of protection, as indicated by tests of Young et al. (2005), Winter and Davies (2006) and Capuano et al. (2013). Comparison of phenolic compounds losses in carrots and beetroots after storage and carrot juice after processing and storage showed that both species of vegetables after storing recorded lower loss of phenolic acids in the roots of organic than conventional (losses of beet 25.6 and 30.7%; in carrot - 5.9 and 12.8%). At the same time, increase in the level of total flavonoids was observed in organic beetroots after storage, which was higher than in conventional beetroots (respectively 21.4 and 12.1%). Slightly higher losses of phenolic acids in organic products than conventional (respectively 50.9 and 46.5%) were observed in the carrot juices. Significantly lower decrease in the content of phenolic acids in the carrot than the beetroots observed in the experiment is a result of much higher abundance of carrots in chlorogenic acid, which could be increased up to 7 times under the conditions of storage stress (Kondratowicz-Pietruszka 2006). So strong relationship is not observed in the beetroots. In general, the content of chlorogenic acid, which is the major phenolic acid present in vegetables, during storage is considerably reduced (Podsędek 2007). The pace and scope of these processes are dependent, among others, on temperature, oxygen availability, and activity of the water contained in the cells (Gumul et al. 2005). According to Oszmiański (2007), the content of phenolic acids, including chlorogenic acid, is significantly reduced in processing in the manufacturing process. This is affected not only by the temperature but also by mechanical processing, in which oxidation of phenolic compounds occurs and their remaining could be left in pomace.

Organic carrots compared to conventional were characterised by lower (about 37.1-46%) content of **total carotenoids**. The analysis conducted by Seljåsena et al. (2001) showed that organic production system leads to reducing the synthesis of carotenoids in carrot roots, but the

results of research in this area are not consistent and suggest that carotenoids content may be affected to a greater degree by factors other than production. Kopsell et al. (2007) in their studies have found that the amount of β-carotene, lutein and zeaxanthin in the tissues of the plant is increased when there is more nitrogen in soil. Therefore, the total carotenoid content will also grow with the addition of easily assimilable nitrogen. Generally, the content of carotenoids as plant secondary metabolites not involved in the system of protection against pathogens, could be increased due to higher levels of nitrogen fertilisation (Welch 1997), although there are exceptions to this rule (Gajewski et al. 2010). Metaanalysis conducted by Stracke'a et al. (2009) concerning a comparison of carotenoids in vegetables from organic and conventional system, pointed inconsistencies in this respect. It suggests that the carotenoid content may be influenced by factors other than production (eg. variety, microclimate, maturity and soil conditions). Many of mentioned studies did not take into account these factors, and therefore the results are not clear, which is an important premise for the need to continue a well -designed research (especially methodology) on the impact of different production practices in organic and conventional farming on accumulation of carotenoids in agricultural crops. According to the presented own study, in the case of fresh raw material, losses of beta-carotene after storage were more pronounced in organic carrots (content decrease 73.1%) in comparison to conventional carrot (content decrease 63.5%). At the same time, loss of beta-carotene in the case of juice, was comparable. These results suggest greater carotenoids sensitivity to degradation during the storage of organic compared to conventional raw materials. In the case of the tested juices, blending process, pasteurisation and then storage affected the degradation of beta-carotene of 9.1% in the case of organic juice and 4.6% in the case of conventional juice. At the same time, these processes have resulted in higher levels of lycopene in organic and conventional juices, respectively by 12.2 and 21.7%. Thermal treatment of foods rich in carotenoids and in particular beta-carotene and lycopene has relatively small impact on the loss of these compounds (Gumul et al. 2005). This is due to the fact that part of the carotenoids in carrots is in a bound form with eg. proteins, polysaccharides or phenolic acids, what increases their thermal stability (Kondratowicz-Pietruszka 2006).

The study found no significant effect of the production system on the content of **betanin**, the primary betalain pigment in beetroots. However, the content of bethanidine, present in smaller amounts in beetroots, was significantly higher (24-32.6%) in organic ones. The results are therefore only partially compliant with the thesis presented in the literature concerning an increase in the synthesis of betalain pigment with lower doses of nitrogen for crop (Moreno et al. 2008). Betalains are unstable pigments, which react with molecular oxygen, so the storage

period follows the degradation in raw materials. Degradation of betalains is accelerated by increased temperature and light, which is important in storage of raw materials and products that contain them (Strack et al. 2003, Azeredo 2009). Results on the losses of betalains due to the storage indicate slightly higher losses in conventional beetroots compared with organic ones. They were respectively 33.6 and 27.3% in the case of betanin and 36.3 and 28.6% for bethanidine. This phenomenon can be explained by higher content of vitamin C in organic raw materials. According to Herby et al. (2006) L-ascorbic acid significantly affect the increased stability of pigments in this group due to a mechanism of oxygen removal and cellular environment pH decrease.

The analysis of the linear correlation of selected parameters of the chemical composition of the tested materials and doses of nitrogen fertiliser used in organic and conventional production demonstrated, in the case of beetroots, significant negative correlation between the levels of nitrogen fertilisation and the content of dry weight, sugars, organic acids and polyphenolic compounds in the edible parts. In case of carrots, significant negative relation between the dose of nitrogen used in the cultivation and a reducing sugar content and a positive relations to the content of carotenoids in the roots were found.

Analysis of the impact of varietal factors on selected elements of the chemical composition of vegetables and carrot juices found that the beetroots of Czerwona Kula variety had significantly higher contents of most of the analysed compoundss than Regulski Cylindryczny variety. In case of carrots weaker relation between the chemical composition of roots and variety was found. In case of carrot, it was found that the variety, which reacted better under studied condition of cultivation, was Perfekcja variety. Also, the juices of this variety usually contained more carotenoids and phenolic compounds than juice obtained from variaty Flacoro.

Nitrates(III) and (V) content

Most of the results confirm the higher nitrate content in conventional raw materials than in organic ones. The level of these compounds was almost twice as high in beetroots compared to carrots, both in the raw material immediately after harvest and after storage. Organic vegetables contained significantly less nitrates(V) (6.8-28%) compared to conventional ones. In the case of nitrates(III) significantly lower contents were found in the organic raw materials only immediately after harvest; after a storage period there were no significant differences in the content of nitrates(III) between organic and conventional vegetables. As evidenced by research, 50-80% of nitrates in food intake come from vegetables (Wojciechowska 2005), therefore the quality of these raw materials is one of the most important factors for the avoidance of

consumption of these substances with the diet. Excess of nitrates in food is dangerous for consumers because of the transformation of relatively not harmful form of nitrates(V) to the much more toxic form of nitrates(III). This is a fairly serious problem, especially in the case of carrots, which are the most commonly used raw materials for the production of baby foods. Poisoning of nitrate(III) causes oxidation of ferrous ion (Fe^{2+}) hemoglobin into ferric state (Fe^{3+}), resulting in inability to carry oxygen by hemoglobin, called methemoglobinemia. The greatest danger associated with the formation of methemoglobin applies to infants up to 10 months of age, whose blood is oxidised easier (Chan 2011). Pearson product-moment correlation between doses of nitrogen used in organic and conventional cultivation of beetroots and carrots and the concentration of nitrates in roots showed a statistically significant positive association between the tested variables; in both species, an increase in accumulation of nitrate(V) in vegetable roots, along with increasing doses of nitrogen delivered to plants during cultivation, was observed.

Nitrate(III) and (V) content in plants also depend significantly on genetic factors. In the case of beetroots, significantly higher level of both nitrates(V) and (III) was found in a variety Czerwona Kula, whereas in the case of carrots - Perfekcja.

The parameters of technological and storage quality

There were no significant differences in the **average weight of fresh roots** of beetroots and carrots between the raw materials from organic and conventional production. In the case of beetroot, significantly higher weight of roots was characterised by variety Regulski Cylindryczny thanCzerwona Kula, and in higher carrot root mass was characterized by a variety Flacoro than perfection. The results on varietal differences are obvious due to their genotypic characteristics. Variety beetroot Regulski cylindrical belongs to varieties with cylindrical roots whose mass is greater than the mass of varieties of roots round, as the Red Ball. For carrots variety Flacoro usually has a better yield, and larger than the roots variety perfection.

The quality of beetroots from organic and conventional farms linked with **percentage loss of raw material** during peeling was similar. In both cases, the loss during pre-treatment was around 20%. At the same time, it was found that higher losses occured in the variety Czerwona Kula than in Regulski Cylindryczny variety.

For carrots, higher losses during peeling roots were found in conventional crops than organic. Higher percentage of loss of raw material during peeling was found in carrots than beetroots, due to the fact that roots of carrots are smaller than beetroots.

Storage ability of beetroots from conventional farms was significantly lower than from organic farms, as evidenced by a higher percentage of weight loss of roots after storage. Higher losses in weight were related to variation Czerwona Kula than Regulski Cylindryczny. For carrots, storage ability of organic and conventional roots it was similar, there was also no difference between varieties in terms of percentage weight loss of roots after storage. Storage losses in the case of carrots were higher than in the case of beetroots, because of thin skin tissue covering the root of carrot, which consists only 4-8 layers of cells of periderm. Thin skin does not sufficiently protect the tissues, because it is susceptible to damage during the harvest, as well as is the cause of increased water loss through evaporation (Fikselová et al. 2011).
It was found that in beetroots, carrots and juice made out of these carrots there was less loss of nutrients and bioactive compounds when these raw materials came from organic farms compared to conventional ones. It concerns mainly total sugars, organic acids, vitamin C and phenolic acids. At the same time, higher losses of nitrate (V) were found in the conventional vegetables than the in ecological ones, but it was not enough to level the difference between organic and conventional vegetables in this respect; still organic raw materials contained significantly less nitrates (V) after storage than conventional ones.

Sensory quality

Sensory quality of beetroots evaluated by a panel of experts using quantitative descriptive analysis and assessed by consumers using hedonic method was comparable, because in both studies the characteristics of "overall quality" / "overall desirability" of beetroots from organic farms have obtained significantly higher scores compared to conventional beetroots. Evaluators, in the profile analysis, significantly higher assessed the softness and sweet taste of oragnic beetroots, while the smell and taste of burnt was frequently affirmed in relation to conventional beetroots. According to semi-consumers assessment, results showed a significantly higher rating preference of colour, smell and taste of organic beetroots compared to conventional ones.

The obtained scores in the evaluation carried out by sensory profiling suggests that total quality of the beetroots is decided mainly by texture and flavour of the beetroots, beetroot and sweet smell, while in consumer studies - mostly the colour of vegetables.

The profile analysis of the overall quality of tested beetroots varieties was similar, while consumers significantly higher assessed in terms of overall desirability variation Czerwona Kula than Regulski Cylindryczny.

The results of overall quality of carrots from organic and conventional farms in the assessment of experts did not differ significantly. This assessment also showed higher scores for conventional raw material in terms of colour, especially its homogeneity and juiciness and the smell of the "other". Organic carrot only received higher scores for a characteristic: smell of "green." According to the profile analysis, there is no difference in overall quality between varieties, but in the case of attributes: taste and smell of "green", bitter taste and stinging taste higher marks obtained variety Flacoro than Perfekcja.

Taking into account scores obtained in sensory evaluation carried out by profiling analysis, the overall quality of carrot has been decided mainly by characteristic: colour, texture, carrot and sweet taste and smell of fresh carrots and sweet smell, and in the consumer research - colour, smell and texture of vegetables.

Higher scores of colour, flavor and texture desirability and overall desirability received a carrot from conventional farms than organic carrots in the consumers' research. Desirability of tested varieties of carrots in a consumer test was similar, there were no significant differences between the varieties Flacoro and Perfekcja.

To recapitulate the obtained results, it should be emphasised that research on determinants of quality of raw materials and plant products, including vegetables and their products from the organic and conventional system should be carried out comprehensively taking into account the entire spectrum of factors that may determine the value, in order to determine the intensity of the effect of individual variables.

Thus, it is clear that in terms of beetroots and carrots quality, a combination of chemical and sensory analysis and evaluation by consumers is of great practical qualities because it allows you to get results that can be extremely helpful for manufacturers and agricultural producers in the area of selection appropriate varieties in terms of good qualities from the nutritional point of view, and biological, as well as sensory and technology for use in organic and conventional production. This is particularly important from the point of view of organic farming, because in Poland no one has been carring out work on varieties of vegetables for the exclusive use in organic production, based on the research of varieties used in conventional agriculture in the direction of their suitability in the organic system. It should be emphasised that in these studies, attention is primarily on the production results, paying less attention to the quality of the crops. Therefore, complex research taking into account different criteria of quality of organic and conventional products, enables multi-objective assessment of raw materials produced in similar

conditions of climate and soil, and consequently the ability to choose varieties with higher quality parameters, depending on the use.

4.4 CONCLUSIONS

Presented results, their statistical analysis and interpretation justifies the following conclusions:

- Selected qualities of vegetables from organic and conventional production were affected not only by factors related to the farming system, but also by varietal and post-harvest (storage) factors; there were also found some differences in the results of the years of the experiment, which may indicate the influence of weather factors (sunshine duration, precipitation and air temperature during the growing season) on the examined parameters.
- Higher levels of the compounds from the group of polyphenols in the organic raw materials and products than in conventional ones, were much more explicit in the case of beetroots than carrots and carrot juices, while the results for the vitamin C content indicate more clearly the differences in favour of organic crops for carrots and carrot juices than in the case of beetroots.
- In the context of the results, the theory of growth and differentiation (GDBH) has been confirmed, whereby not only a form but also a dose of fertiliser influence the level of bioactive compounds in plants - the higher dose of nitrogen contributed to the reduction of the content of these substances, particularly of polyphenols in the tested vegetables.
- Most research hypothesis concerning differences in quality in favour of the organic raw materials and products compared to their conventional counterparts, especially as to the content of vitamin C, sugars, phenolic compounds and nitrate (V) were confirmed. Also, the trend towards more favourable parameters of sensory, technology and storage quality of organic raw materials in comparison to ones from conventional agriculture, which concerns especially beetroots, was confirmed.

APPLICABLE CONCLUSION

- Results of the study should be a prerequisite to promote the consumption of vegetables from organic production, and at the same time, to increase the availability of this category of products to consumers, so that these products can become an important part of diet of largest part of the population. In order to increase the attractiveness of the commercial offer of raw materials from organic production, research aimed to select suitable varieties for organic farming, characterised by high parameters of nutritional, biological, technological and sensory quality is necessary.

4.5 SUMMARY

Research on beetroots, carrots and carrot juice, from organic and conventional production presented in the discussed monograph contributes to deepening an understanding of the impact of conditions associated with the production system to many aspects of quality, including the content of biologically active compounds, nitrate (III) and (V) and sensory quality and selected parameters of technological quality of root vegetables grown in Polish agronomic conditions.

The study indicates that a far better quality could and should be expected from organic crops. Therefore, it must be emphasised that the development of organic methods of agricultural production in our country is desirable because it provides better health promoting parameters of plant materials, which is important in the nutrition of the society, with particular attention to small children, elderly and chronically ill people. The lower nitrate content in organic raw materials together with a higher content of antioxidants can have significant health benefits due to cancer prevention. This is indicated by some studies confirming that regular consumption of organic food determines the well-being and has a beneficial effect on human and animal health. However, this thesis requires further verification in epidemiological and intervention studies in animals and in humans. It is worth noting that organic production can be important for vegetarians who eat a lot more fruits and vegetables than those not using this diet, they are potentially more likely to consume larger amounts of nitrates in food. In conclusion, it should be emphasised that the use of organic methods of production not only provides food of good quality, but also has a positive effect on the environment and is the practical application of many of the principles of sustainable development in rural areas.

5. OVERVIEW OF THE OTHER SCIENTIFIC AND RESEARCH ACHIEVEMENTS

Having graduated my Master's studies at the Faculty of Horticulture at Warsaw University of Life Sciences (WULS) in 1992, I started working at the university as an independent technical assistant (1992-1993) and then as an assistant in the Division of Farm and Garden Food Production (later Division of Food Raw Materials, and then Chair of Organic Food) at the Faculty of Human Nutrition and Consumer Sciences (FHNCS) at WULS. In 2004, I presented to the Council of the FHNCS my dissertation entitled: Estimation of the adjustment of the level and structure of supply for fruit and vegetables to the food needs of the Polish population. The doctoral dissertation received positive reviews and after completing of all exams and defending the dissertation in public, I have gained the title of doctor of agricultural sciences in the field of food technology and nutrition. From 2005 till today I am employed as an assistant professor in

the Chair of Organic Food, Department of Functional Food, Ecological Food and Commodities at WULS.

Profile of my research interests after obtaining a doctoral degree, apart from the research presented in scientific achievement as the basis of this application, included the following issues:

1. Evaluation of the level and structure of supply of fruit and vegetables and its adjustment to the food needs of the consumers in Poland and an assessment of the level of consumption of these products in Polish households (publications in this area are the result of research related to the doctoral thesis);
2. Assessment of a possibility of agritourism development in rural areas in conjunction with the assessment of the offer proposed by Polish service providers and their preparation for providing services in agritourism;
3. Relationships between organic and non-organic production methods in agriculture and the quality of the yields;
4. Assessment of an environmental awareness of agricultural producers and aspects of lifestyle and health self-assessment of consumers of organic and non-organic food;
5. The nutritional value and health benefits of food, including organic food;
6. Aspects concerning sales, product assortment and organic food consumers;
7. Knowledge transfer and advisory service in the organic farming sector.

A. Discussion of publications in thematic groups

(*numering by Appendix no. 3, point II A and II D*)

1. THEMATIC GROUP A1: 1. Evaluation of the level and structure of supply of fruit and vegetables and its adjustment to the food needs of the consumers in Poland and an assessment of the level of consumption of these products in Polish households

Thematic group A1 includes the publications of research conducted as a part of the doctoral thesis (published after the doctorate). They concern the analysis of changes in domestic production of fruit and vegetables, their import and export, level of consumption in different types of households and consumer behaviours in the market of these products, as well as the analysis of the adjustment of supply of fruit and vegetable products to consumer expectations. The material gathered in the study came from secondary sources (data from Central Statistical

Office - CSO) and primary (survey). In the survey, I included issues like: fruits and vegetables intake, the frequency and attendant circumstances of consumption, the species structure and the processing methods, the seasonality of consumption and sources of supply of these products by respondents. Also I took into account the factors determining the level and structure of consumption of fruit and vegetables and their products. In order to assess the degree of satisfaction of the needs of fruits and vegetables I used data from survey and CSO and elasticity income coefficients of consumption of fruit, vegetables and their products evaluating a pace of approaching towards saturation level of consumption, or conduced to assess a degree of satisfaction of the needs in relation to the level of saturation.

As a result of these studies, I have found that the size of the supply of fruit and vegetables was decided mainly by the size of domestic production, thereby impacting significantly on the level of consumption. It noted the existence of seasonal fluctuations in the supply of fruit resulting from fluctuations in domestic production, which were compensated by increasing imports. This was reflected in the decreasing seasonal fluctuations in consumption of fruit and observed trends to its systematic, but slow, growth. The level of consumption of fruit significantly differ from the average level in the European Union, and at the same time was characterised by a very slow growth rate, due to not only supply factors, but also due to established habits and dietary preferences, as well as the level of prices of certain products. In case of vegetables, I have found an average level (in comparison with EU countries) in terms of quantity of vegetable consumption in Polish households. However, it was not very diversified, which resulted largely from the structure of vegetable production and rreflected in the product range offered on the market. A certain level of needs in terms of fruit and vegetables turned out to be far from saturation level. As a result of data analysis of the satisfy level of these needs in the tested period, I determined that on the one hand, the importance of imports of these products (especially fruit) has increased, on the other hand, the share of natural consumption has decreased. Consequently, this has led to positive changes in consumption - in case of fruit affecting the diversity through increasing the share in the consumption of tropical fruits, while in the consumption of vegetables, in reducing the dominant position of cabbage and carrots for tomatoes and cucumbers in all socio-economic groups of households. It should also be added, that in relation to particular species of fruit and vegetables, I have observed differences between the frequency of consumption and consumer preferences. They proved to be more visible in the case of fruit than vegetables. This may indicate that the structure of supply, availability during the year, as well as economic factors, were limiting to a greater degree a free choice of fruit

than vegetables. The consumption of vegetables was determined more by consumer preferences than by factors of an economic nature, which may be connect with the level of prices, generally lower than in the case of fruit. Detailed results concerning the level, structure and determinants of consumption of fruit and vegetables have been described in five publications **(IID1 1, IID1 2, IID1 3, IID1 4, IID1 57)**.

2. THEMATIC GROUP A2: Assessment of possibility of agritourism development in rural areas

Publications included in the thematic group A2 concerns the organisation and improvements of a recreation taking place in rural areas of agricultural character, based on a range of accommodation, nutrition and activity facilities associated with a farm or equivalent and its surroundings, which is a big opportunity to improve the farmers income situation. It is assessed that in at least 1/3 of municipalities and Polish regions there are real opportunities for development of agritourism, as a form of an activity which creates additional job opportunities, takes a chance to use housing, uses food produced on farms, while raising the general level of culture, infrastructure, protection of environment and historical monuments and natural and landscape qualities (Świetlikowska 2000). The interest in this area took place at the threshold of my scientific activity and was inspired by prof. dr hab. Urszula Świetlikowska, at that time, she was a Head of the Division of Food Raw Materials, where I was employed, and at the same time she was a Head of Postgraduate Studies in the Field of Agritourism Organisation implemented by the project FAPA. This area of my scientific activity resulted in being a co -author of a scientific monograph as a final result of the project (before obtaining my PhD degree). Then I participated as an executor in the subject of research "Analysis of adjustment activities to agritourism service provision in selected farms in the Gostynin-Włocławek Landscape Park" in the framework of research on "Agritourism activity as a factor supporting the improvement of the conditions of rural communities". The results of research carried out, are described in five publications on the farmstead development for the puproses of rural tourism needs **(IID4 1, IID4 3, IID4 7, IID4 8, IID4 12)** and in two on the implementation of the nutritional offer and rules of proper nutrition for this purpose **(IID4 2 , IID4 4)**. The results of these researches confirmed that the management of abode on farms providing services in agritourism was generally correct. Proposed improvements were mainly related to replacement and maintenance of recreational equipment, proper waste protection and the development of resting area, ensuring of the recreational needs of visitors. In the assessment of the

implementation of nutritional offer, I found that service providers usually offer their guests' dinners, serving regional, vegetarian and light cuisine. In addition, the hosts gave an instant access to a kitchen, where guests could prepare their own meals from products coming from the farms. As Rokicki and Roman (2012) emphasised, an important component of services in agritourism, in addition to accommodation, is food offer, which is usually associated with food production on the farm. Especially in smallholder farms, multi-plant and multi-animal production, predisposed to this type of service activity, there is a possibility of production of both raw materials and products of plant origin and animal origin within their own farm. Use of these products to feed tourists and offering their purchase may be on one hand a source of additional income for farm owners, and on the other hand, a source of fresh and good quality food for tourists.

3. THEMATIC GROUP A3: Relationships between organic and non-organic production methods in agriculture and the quality of the yields

The ability to produce high quality crops is now increasingly important in the light of growing health risks resulting from anthropopressure, industrialisation and intensification of agriculture. Directing my interests on quality issues of organic food was caused by dynamic development of organic sector, growing interest in organic food by consumers, as well as the fact that Division of Food Raw materials, where I was employed, jointed Division of Ecology and Chair of Organic Food WULS was created. From the beginning, I focused on the impact of the methods used in organic and non-organic farming on quality of plant origin products, because I could use theoretical knowledge of horticulture gained in the course of my Master, in practice. Then, as part of teamwork of my Department, I began cooperation with Department of Potato Agronomy of Plant Breeding and Acclimatization Institute - National Research Institute in Jadwisin. Research carried out in 2004-2006 aimed to compare selected quality features of crops, nutritional value and sensory quality of different potatoe varieties, differed in terms of earliness and coming from three production systems: conventional, integrated and organic. In effect, the aim of this study was to determine the optimal conditions for cultivation, ensuring the best quality feauters of cultivated potatoe varieties, including determining the most favourable varieties for organic production. In the context of the chemical composition, dry matter, starch, vitamin C, polyphenols, phenolic acids, solanine and nitrates were determined in the raw materials. In addition, the size and quality of yields of particular potatoe varieties from three production systems were evaluated, including tuber struck by scab, pests and the

occurrence of red flesh spotting. The varieties studied were also subjected to sensory analysis, including analysis by experts panel (quantitative descriptive analysis QDA) and by consumers (hedonic method). The summary of this cycle of research were four publications **(IID3 1, IID4 5, 6 IID4, IID4 10)**, in which together with co-authors, I claimed, inter alia, significant differences in the nutritional value of potatoes from organic, integrated and conventional production, as well as between the varieties tested. Potatoes from organic system were generally more abundant in the dry matter, starch and vitamin C. The nitrate content was also significantly correlated with the production system; the least of these compounds contained potatoes from integrated production in comparison to organic and conventional. In terms of size and quality of the yields, the best parameters characterised potatoes from conventional production. As a result of consumers' evaluation, best rates of most sensory quality parameters gained organic potatoes, among which particularly stood out Syrena and Gracja varieties.

The next stage of my research on quality of raw materials and products from organic farming, compared to non-organic products, was to direct my interest in berries and their products. Berries are rich in vitamin C, anthocyanins and phenolic compounds, which as antioxidants have very important impact on human health. The aim of the study was to compare the selected elements of the chemical composition of berries originating from different production systems. In my research, I dealt with different varieties of black currants and fruits of blueberries, raspberries, wild strawberries and blackberries, which came from certified organic production and from conventional production. I acquired raw materials for research directly from producers. In a two-year study (2006-2007) of black currant, beyond the analysis of raw materials, I made jams from fruit, which were also chemically analysed. The results of these studies I concluded in a four publications **(IID2 3, IID2 5, IID2 8, IID4 9)**. In both, fresh fruits and their products, I assayed a dry matter and content of total and reducing sugars, organic acids, flavonols, total anthocyanins and vitamin C. In these publications, it was found that the content of most of the analysed compounds in black currant fruit and their products, significatlly depended on production system and variety tested. Organic currants and jams were characterised by a higher content of flavonoids, anthocyanins and vitamin C in comparison to conventional products. As a result of this research, it could be concluded that organic fruit and jams from organic black currants could be recommended as a better source of compounds with antioxidant properties than their conventional counterparts.

In the following studies of berries, high performance liquid chromatography HPLC was applied in the analysis of the content of antioxidant substances in fruit from organic and conventional

farms, produced in similar climate and soil conditions. In the study of raspberries, blackberries, blueberries and wild strawberries, research factors were: cultivation method (organic and conventional) and the species of the fruit. I have shown the impact of the production system, as weell as species, on the chemical composition of the fruits tested. Fruits from organic production contained significantly more phenolic acids, flavonoids and anthocyanins, and fruits from conventional crops were characterised by higher vitamin C content. The highest content of phenolic acids and anthocyanins characterised blueberry fruits, whereas a species of a highest content of vitamin C and flavonoids was in wild strawberry fruits, which contained also the most of dry matter. Identification of phenolic compounds in fruits carried out using the HPLC technique, showed that the most diversified composition of flavonoids and phenolic acids characterised blueberry fruits. Highest content of most of compounds determined found in organic berries, have confirmed that they can provide a significant source of antioxidants in the diet and thus contribute to the prevention of health (**IID3 2**). I conducted also the study of selected species of berries from cultivation and from the natural state (**IID4 17**). I found that berries coming from the natural state compared to the cultivated ones, can be considered comparable in terms of the vitamin C content and a better source of polyphenolic components. Among the wild species, special attention deserves fruits of bilberry, which belongs to the richest in anthocyanins and flavonols species, as well as wild strawberries - richest in phenolic acids. In another study the subjects of analysis were the fruits of two varieties of raspberries (Polka and Polana), from organic and conventional farms. Both varieties are important in the horticultural production, because they give a good harvest in organic and conventional systems. The results of the analysis showed significant differences between the raspberries from organic and conventional production in terms of the content of total flavonols, phenolic acids and anthocyanins. Organic raspberries contained significantly more of total flavonols, total phenolic acids and total anthocyanin compared to conventional raspberries. I found no differences in dry matter and vitamin C content in organic and conventional raspberries. The raspberry varieties also differed each other. More total anthocyanin occurred in a Polana variety, while the more prosperous in vitamin C was determined in the Polka variety. Comparing the levels of individual phenolic compounds, I have indicated that organic raspberries contained significantly more of all identified compounds from the anthocyanins and phenolic acids groups as well as most of flavonols than conventional raspberries. Some differences in the content of the individual compounds I also noted between the two varieties of raspberries. It can therefore be concluded that Polka and Polana raspberry varieties grown under comparable conditions of

climate and soil produced more abundant fruit when derived from organic production (**IID2 21**).

Other studies in this thematic group also focused on the analysis and comparison of the content of biologically active compounds in fresh herbs and dried herbal spices from organic and conventional production. My interest in herb products arose due to the lack of scientific evidence of higher bioactive compounds content in herbs from organic and conventional production system. The previous comparative empirical studies were carried out mainly on organic and conventional vegetables and fruits, but very little of this type of experiments were conducted on herbal plants, which are indisputable important for human health, because of the high content of bioactive compounds per biomass unit. In eight publications, the method of extraction and the influence of crop production system mainly on the content of polyphenolic compounds, and in some products - carotenoids and chlorophylls in herbs (**IIA 4, IID2 11, IID2 12, IID2 15, IID2 16**) and spices (**IID2 9, IID2 14, IID4 13**) were illustrated. As a part of this research area in 2009-2013 I became interested in herbal spices derived from the market and herbal plants, which I acquired personally in cooperation with conventional and organic farms specialised in the production of herbs and lettuces on the market. Herbal spices in dried form, such as basil, tarragon, oregano, marjoram, parsley, thyme, lovage and cumin were bought in specialist organic shops and conventional stores. In the work IID2 9 I presented the results of the analysis of bioactive compounds carried out by spectrophotometry, and in the work IID2 IID4 14 and 13 for analysis of phenolic acids and flavonoids, I used HPLC technique with the identification of individual compounds according to standards (Fluca and Sigma Aldrich). The results obtained were not always clear, but for most of spices, I noted higher abundance, especially in vitamin C and polyphenolic compounds of organic products.

In studies of fresh herbs I worked (in 2009-2011) with two farms (organic and conventional), which were located in close proximity, which allows to obtain the research material originating from similar climate and soil conditions; the main differentiating factor was the system of production. In these studies I used the following species of herbs: peppermint, sage, lemon balm, rosemary, lovage, thyme and mint. The results showed that the production system has the most significant effect on the polyphenols content of the tested species of herbs. In the studied group, in terms of total polyphenol content the rosemary species stood out, while the richest in phenolic acids was sage, in flavonoids - thyme, and vitamin C - lovage. Based on the results obtained, it can be concluded that the herbs derived from organic production, usually contained more phenolic compounds as compared to the herbs from conventional production. However,

not all results clearly confirm this relationship, which is the reason to continue the well-planned research in this area.

As part of the thematic group A3, I undertook research on the impact of production methods on the quality of some vegetables (tomatoes and beetroots). Comparison of the effect of organic and conventional farming system on the nutritional value of beetroots, with particular focus on the content of biologically active compounds was presented in the paper **IID2 13**. The collected results indicated that both cultivation method and the vegetables variety have an impact on the accumulation of nutrients in beetroots. Organic beetroots had a significantly higher content of dry matter, reducing sugars and organic acids as compared to the conventionally cultivated beetroots. The level of total sugars was similar in beetroots from both cultivation systems. With respect to other compounds, only a tendency towards a slightly higher content of phenolic acids, flavonols and vitamin C in organic beetrots compared to conventional ones was found.

Another vegetable species covered by the study, as part of this series of publications, was a tomato. I described research in this area in the publication **IIA 2**, which is the result of cooperation within my three-month scientific internship in Estonian University of Life Sciences, which took place between November 2011 and January 2012. The study involved comparison of polyphenol content and antioxidant capacity of tomatoe fruits grown under organic and conventional conditions. Together with co-authors, I prooved that a significant impact on the differences in content of polyphenols, total phenolic compounds and free radical scavenging ability in tomato fruit had a cultivation year and variety. Only the contents of a few polyphenols in particular years, significantly depended on the production system. The results also showed that tomatoes of a Gartenfreude variety cherry type clearly differred from other varieties included in the study. Tomatoes of this variety characterised by the highest free radical scavenging ability, content of total polyphenols and certain individual compounds from this group. This phenomenon can be explained by the smaller dimensions of fruits of this variety and polyphenols accumulation, mainly in the skin (Guidi et al. 1998).

Other research in the thematic group A3 concerned the comparison of different teas that come from certified organic production and teas from conventional production. Tea is made from the youngest leaves and buds from the top of the *Camellia sinensis* plants, and is one the best source of tannin and phenolic compounds such as phenolic acids and flavonoids with strong antioxidant activity among plants. Nowadays, when the pace of life is fast and stress, poor diet and pollution contribute to the increased incidence of various diseases, the use of a diet rich in antioxidant compounds appears to be a very important factor in the prevention of these diseases.

In my research, I focused on green, black and white teas. Black tea is subjected to a fermentation process; the green tea and white tea belong to the partially fermented or not fermented teas (Negishi et al., 2004). For the production of green tea, freshly picked, undamaged leaves are used. The leaves are subjected to steam for a few seconds. This process avoids the fermentation and degradation of the vitamins, which allows to obtain a product with a composition similar to fresh leaves. White tea is not subjected to any processes, is produced from young, still immature flower buds. Harvesting takes place only once a year, in spring and exclusively by hand. Immediately after harvesting, white tea is dried (Perucka 2001). For my study of green tea, I used five organic and five non-organic products from the market in the form of leaf and teabags (**IIA 1**). In teas, I determined the content of total polyphenolic compounds using the Folin-Ciocalteu method, phenolic acids using spectrophotometric method with Arnova reagent, flavonols - spectrophotometric method, tannins - titration method and theine – HPLC tehinque. The antioxidant properties of infusions I identified by the activity of 'scavenging' ABTS cation radicals. Tested teas were characterised by different content of biologically active compounds, organic production method had a positive influence on the content of flavonols and tannins, while the conventional production on content of phenolic acids and teine. I found almost complete linear correlation between the antioxidant activity of green tea infusions and the polyphenolic compounds content. In the next study of different types of teas, described in the publication **IID4 15,** I determined teine and phenolic compounds content using HPLC with identification of phenolic compounds and teine. I have found that the products of organic origin had a significantly higher content of phenolic acids and flavonoids, as well as the individual identified compounds over the conventional teas, which were richer in teine and kaempferol. The different types of teas also differed among themselves. White tea contains the most catechins and epigallocatechins and quercetin-3-O-glucoside, green tea - flavon-3-ols, epicatechins, quercetins and myricetins, and black tea - phenolic acids, flavonols and flavanones and teine, gallic acid, epigallocatechin gallate, rutin, kaempferol and naringin in comparison to the other kinds of teas. The presented publications on organic and non-organic teas are relatively few in this area and are an important supplement to comparative studies of products from different agricultural production systems. This is very important, due to the fact that in recent years, a lot of attention has been paid to plant antioxidants, which by neutralising free radicals, could prevent some diseases, and tea, especially green, can be a great source of them.

During a described cycle of research, I confirmed many times, that the quality of agricultural products, including the content of phytochemicals in plants, is affected by many factors, and the system of production plays an important role. This impact is reflected in greater supply of some compounds, for example, polyphenolic compounds and vitamin C, in certain conditions of plant growth. This is largely related to reduced supply of mineral nitrogen in the soil and exploitation, in his absence, of organic fertilisers, what takes place in organic farming. As a result, crops produced in organic production systems are characterised by high quality, due to higher content of bioactive, pro-healthy components with a lower content of undesirable constituents, such as pesticides and nitrates. General issues regarding the quality of organic food, based on a literature review, were included in four publications (**IID2 1, IID2 26, IID4 16, IID4 14**). Additionaly, among the publications on this subject, there were three monographic articles that discuss the principles of organic food processing (**IID2 7**), organic honey production (**IID2 6**) and nutritional value of spelt (**IID4 16**).

General conclusions from the analysis of literature and several years of comparative research of organic and conventional crops, allow for generalisation that the largest qualitative differences between the raw materials with comparable farming systems occur when comparing the raw materials from organic farms with raw materials from intensive conventional farms, using high doses of synthetic inputs. When the reference point for organic products are crops from conventional farms with moderate use of chemicals, demonstrated differences are usually smaller. It should be noted, however, that organic crops, even in comparison to raw materials from conventional farms using less intensive production, usually have significantly lower nitrate content, higher content of vitamin C, dry matter and higher sensory quality. The scientific explanation of this fact, in relation to bioactive compounds found in organic and non -organic vegetables, confirms of the growth and differentiation balance hypothesis (GDBH) described in literature. However, the quality features, such as dry matter content and content of nitrates(V) and (III), vitamin C, polyphenols, carotenoids or betalains, quite differ sometimes considerably, depending on the production year and the variety. Besides of organic production method, significant impacts on the listed features have the weather conditions during the growing season and genetic varietal characteristics.

4. THEMATIC GROUP A4: Assessment of an environmental awareness of agricultural producers and aspects of lifestyle and health self-assessment of consumers of organic and non-organic food

Agriculture has a significant impact on the environment, because it directly uses its resources in production processes. Numerous environmental hazards in areas used for agriculture are the result of excessive intensification of agricultural production, which primary goal is to achieve greater yields at the cost of natural environment. A lot of damage to nature is caused due to the lack of expertise of farmers about the proper methods of cultivation, improper use and storage of fertilisers and chemical pesticides, or improper management of waste and sewage produced on the farm. Insufficient awareness of environmental hazards for many farmers, their lack of interest in environmental issues, as well as poor infrastructure in rural areas, are a significant barrier to achieve sustainable development in rural areas (Beam 2009). Given the significant increase of interest of agricultural producers in organic production methods, it is worth to look closer into views and actions represented by the farmers, because it is their expertise, awareness and environmental sensitivity should be the biggest motivation to change the way of farming into a more environmentally friendly. A series of publications included in the thematic group A4 relate mainly to a comparison of environmental awareness organic and conventional farmers and an assessment of pro-environmental attitudes represented by farmers in both groups (**IID2 10, IID2 22, IID4 11**), as well as, an analysis of relationships between lifestyle including the consumption of organic food and environmental awareness and consumer health self -assessment (**IID2 IID2 2 and 4**). The survey questionnaires concerning environmental awareness were distributed among a group of organic and conventional farmers from Mazowieckie and Podlaskie voivodeship and farmers engaged in agritourism in Świętokrzyskie voivodeship. Analysis of the results revealed that the level of knowledge of conventional farmers on agricultural sources of pollution was lower than organic farmers. Respondents, who have organic farms, represent a fairly high level of environmental awareness, however, it should be noted that in this group they were also farmers, whose knowledge on agri-environmental issues was insufficient. Respondents from both groups declared similar behaviours and attitudes towards the environment, but there were clear differences between their declared and actual behaviour. The results of research in group of agritourism service providers also showed deficiencies in environmental education, its problems and opportunities to prevent them. This leads to the conclusion that among farmers, especially providing services in agritourism, promotion of healthy lifestyles taking into account the production and consumption of organic

food should be combined with the dissemination of knowledge of the environment in order to sensitise the public on the overall relationship between nature, health and quality of life. In a study described in publications IID2 2 and IID2 4 consumers regularly consuming organic and conventional food were compared. The results of the work showed that organic consumers rated their health status significantly higher than conventional consumers. Daily menu of organic consumers was much closer to the recommendations of proper nutrition than diet of conventional consumers. In addition, organic consumers lifestyle was healthier, which manifested it in sporting activities and frequent contact with nature in their spare time.

Based on research conducted within this thematic group, it should be concluded that broaden environmental and nutritional education of consumers and food producers is necessary, due to its important role in determining an appropriate level of environmental awareness and nutrition quality.

5. THEMATIC GROUP A5: Evaluation of nutritional value and health benefits of vegetable juices

Research in this thematic group was conducted in 2010-2011 as a part of two research projects co-funded by the Ministry of Agriculture and Rural Development concerning an assessment of nutritional and anti-cancer value of vegetable juices from organic production (RRre-029-7 -2809/10 and PKre-029-31-28/11(71). Part of the results included in the work has also been developed in cooperation with the Estonian University of Life Sciences (during my research internship), where metabolomics analysis of tested products was completed. The study was undertaken due to the fact that in recent years the interest in the influence of nutrition on human health was observed. Of particular interest is an active role of some nutrients in shaping good health and longevity, and in the processes of induction, growth and inhibition of diseases, particularly cancer and cardiovascular diseases (Cotelle 2001, Grajek 2004). Epidemiological studies show a lower mortality and cancer and cardiovascular disease morbidity among populations whose diet is rich in fruits and vegetables (Stintzing and Carle 2004). This type of chemoprevention is aimed at preventing, inhibiting or reversing the process of carcinogenesis, especially in early stages. Time from initiating of changes leading to the formation of a tumor till developing clinical symptoms of a disease is very long. This allows early nutritional intervention (Chirumbolo 2012). The raw material selected for the study was a beetroot, which belongs to the most powerful antioxidant properties products (Zitnanova et al. 2006 Georgiev et al. 2010). It is a source of phenolic compounds and water-soluble betalain pigments

(betacyanins), which show, among others, antibacterial and antiviral activity, and also inhibit the proliferation of tumor cells and prevent cardiovascular disease (Ravichandran et al. 2012). Use of lactic acid fermentation in beetroot juice production preserves about 75% betacyjanins in relation to their original concentration (Havlíková et al. 1983). In addition, this process promotes increasing antioxidant activity and avoids the negative effect of juice sterilisation, which lowers antioxidant content (Kusznierewicz et al. 2008). In most studies *in vitro* and *in vivo* concerning anti-tumor properties of vegetable origin substances pure compounds alone or in combination 2-3 simultaneously are used, and the dose is strictly determined. It is known that, an action of compounds administered together is a result of individual activities and their interactions in the investigated processes. Activity of a mixture is not possible to be predicted on the basis of a biological activity of individually tested compounds included in this mixture. Therefore, it was considered as an appropriate to determine anticancer properties of natural foods. In the presented study we hypothesised a higher content of bioactive compounds in beetroots and fermented beetroot juices from organic production compared to conventional products. At the same time, we hypothesised stronger anti-cancer properties of beetroot juices from organic than from conventional production. An additional the aim of this study was to investigate whether the profile of the compounds (fingerprinting) of organic beetroots and beetroot juices differs from conventional products. The composition of the metabolome of each species reflects the uniqueness of physiological and biochemical processes during their development and determines the impact of external factors on life processes. Therefore, profiling method could be an excellent way of confirming the authenticity of organic raw materials and products and providing credibility to their origin from different agricultural production systems (Capuano et al. 2013). The results obtained in the two-year study (**IIA 3**), demonstrated an significant ffect of cultivation and the level of fertilisation on quality parameters, such as content of dry matter, vitamin C, and certain phenolic compounds. Organic juices and juices made from raw materials fertilised with low doses of nitrogen, showed a stronger anticancer effect (induction of apoptosis) against tumor cell lines AGS (gastric adenocarcinoma) under *in vitro* conditions. Furthermore, chemometric analysis of metabolomic data of beetroots and beetroot juices allowed, with high probability to confirm organic origin of fermented juices, in case of fresh beetroots, allowed the identification in less extent. The combined results indicated that beetroots and naturally fermented beetroot juice from organic production, could be a good source of phenolic compounds and betacyjaninn in a human diet, and can be one of very useful agents in cancer prevention. These unique studies indicate a need to continue this type of research due to their complexity and cognitive importance.

Another research in this cycle (**IIA 5**) is a result of collaboration with the College of Life and Environmental Sciences, Sport and Health Sciences, University of Exeter, Devon, UK and the University of Exeter Medical School and NIHR Exeter Clinical Research Facility, Royal Devon and Exeter Hospital, Exeter, Devon, UK. This cooperation was a valuable experience for me, which in the future may result in other studies of the impact of certain types of food on the human health. As a part of the joint research, led by a team of researchers from the UK, it was assessed whether nitrate supplementation causing a reduce the oxygen cost of exercise and enhance exercise tolerance in healthy individuals produces similar effects in people with type 2 diabetes. My participation, as well as other co-authors from the Chair of Organic Food, in this study was to carry out chemical analysis of beetroot juice used in the study, statistical evaluation of the results, as well as participation in preparing the manuscript. 48 people with type 2 diabetes were involved in a randomised, double-blind, controlled, crossover experience. Their diet was supplemented for four days with beetroot juice rich in nitrates or juice free of nitrates, as a placebo. After each intervention period, concentrations of nitrates and nitrites in plasma of participants were measured after completion a moderate pace walk. Then, gas exchange in the lungs was measured, in order to evaluate the oxygen consumption during exercise. After a period of rest, participants performed again six-minute walk test. The results showed that nitrate supplementation had no effect on oxygen consumption during moderate exercise and on increasing performance during six-minute walk. These results indicate that supplementation with nitrates does not modulate the stress response in people with type 2 diabetes. The lack of effects of dietary nitrate supplementation in individuals with type 2 diabets may be explained by increased oxidative stress and its impact on the bioavailability of nitric oxide, or an elevated ‘baseline’ plasma nitrite concentration which reduces the scope for the beneficial effects reported in other populations.

A review concerning the impact of organic food on health (**IID2 23**), which provides an overview of recently published research on the health benefits of organic foods, was included in thematic group A5. The results of human studies of the effects of organic food on health carried out so far are inconclusive. Based on the available data you, irrefutable conclusions cannot be drawn. However, large-scale epidemiological studies of human populations showed a negative relationship between the consumption of organic foods and the risk of skin allergies. In addition, recently published results of a large cohort study, indicate a relationship between organic diet and lower incidence of non-Hodgkin lymphoma, which sheds new light on the issues of the health effects of consuming organic food. As the results of research on this subject,

undoubtedly arouse great social interest, there is a need for more comprehensive, well-designed observational and intervention studies in humans.

6. THEMATIC GROUP A6: Aspects concerning distribution, product assortment and preferences of organic food consumers

Research topic specified in group A6 concerned accessing more information on sales channels of organic raw materials and obtaining producers views about functioning of distribution channels, sales structure and evaluating the role of producer groups in improving sales. In addition, this cycle included research on the analysis of an organic product assortment in retail units, as well as an elaboration based on literature review concerning the characterisation of organic food consumers. In order to assess the reality of organic products sale, survey among organic producers was conducted (**IID2 17, IID2 19**). Using the method of questionnaire, survey was conducted among farmers producing cereals, vegetables and animal raw materials from Mazowieckie voivodeship and among producers of organic fruits. It was found that a direct channel constitutes a big share of organic products sales. At the same time, it has been observed that a large percentage of the respondents are the farmers whose products do not reach the market; these products are designated for personal use. Moroever, little interest in the formation of producer groups in the study group of farmers was observed. In the case of organic fruit producers, it has been indicated that one of the most important issues identified by respondents was very limited market for their products. A lot of fruit certified as organic, was sold as conventional ones, due to lack of access to organic processing plants and collecting centers. Nevertheless, due to the nature of production, fruit producers have had a much better position in terms of exports and cooperation with processing plants. Presented problems of organic farmers associated with sales through various sales channels are partly a result of a specific nature of Polish agriculture and organic food market. A feature of organic food market in Poland is a relatively small number of special shops with organic food, when farmers could be offer their products, and the products range is also limited. What is more, poorly developed are also specialised warehouses, which usually offer mainly processed fruits, vegetables, cereals and milk, and much less fresh fruits and vegetables (Żakowska-Biemans 2013 Smoluk-Sikorska and Łuczka-Bakuła 2014). An opportunity for producers could be an export, but more economically beneficial is an export of processed products than raw materials, which are characterised by low recognition. Therefore, it is important to increase the number of organic processing plants, which can produce products from raw materials available in Poland.

An alternative form of organic products sale, which could help farmers to reach more customers, is the Internet sales. This is an opportunity, especially for small farms, to establish cooperation with individual customers, who could be encouraged by the high quality products and become permanent customers.

Next three publications (**IID2 18, IID2 24, IID3 4**) refer to an organic food assortment offered in specialised shops with organic food, as well as the diversity of selected groups of products, their availability in conventional and organic retail stores and consumers preferences of selected product groups. In the research of specialised shops located in Piaseczno near Warsaw, I found that the best represented group of products were cereals. In ¾ of the surveyed shops, the share of imported products was higher than domestic ones on the shelves. The leading countries from which organic products were imported were Germany and Italy. It is worth noting also that the prices of organic products in the surveyed stores were often several times higher than the prices of conventional food, which constitutes a real barrier to the development of this sector of the market. In the product range in shops was lacking products for children, delicatessens and meat and dairy products. The results showed, that assortment of specialised shops needs to be improved, what could increase both attractiveness of this type of stores as well as interest from consumers. In the study of a product range of organic and conventional carrot and beetroot juices, three categories of stores: large-scale, specialised organic, as well as online were analysed. In addition, a comparative consumer sensory analysis of selected products was conducted. There is a large assortment diversity of carrot juices on the Polish food market. Particularly popular are conventional juices in comparison to the organic ones. Taste variants selected most frequently by producers are: carrot-apple-banana and carrot-apple-peach. In case of beetroot juices, their assortment in grocery stores was lower and less diverse than in comparison to carrot juices. In the surveyed shops, products of one conventional and one organic brand dominated, what limited the choice. Consumers, on average, assessed both organic carrot juices and beetroot juices available for purchase, worse than their conventional counterparts. It was decided mainly by the taste of these products. Gutkowska et al. (2014) on the basis of the conducted qualitative research, found that the most important to consumers are taste preferences while making decisions concerning buying and food products consumption. Another factor is the freshness and naturalness. This leads to the conclusion that organic juices, which undoubtedly are natural products, should also have a high taste quality. In the context of the obtained results, it should be noted that it is necessary to analyse the reasons for low

assessment of organic carrot and beetroot juices and exchange of views between consumers and producers about these products to improve their sensory quality.

7. THEMATIC GROUP A7: Knowledge transfer and advisory service in the organic farming sector

Publications (**IID2 20, IID3 3**) included in the thematic group A7 are the result of a project under the: Lifelong Learning Programme Leonardo da Vinci Partnerships: Creating a platform for communication between science and practice in organic food system (acronym: LOVEt), in which I was the main executor of surveys among organic farmers and people involved in advisory service in organic farming area in Poland. The aim of the study was to evaluate the use of existing advisory services in the field of organic production among Polish farmers, as well as, to identify the needs of improvement of different fields of consultancy to support the development of organic agriculture and rural development in selected areas in Poland. Based on the results of Polish research (IID2 20) we found that the majority of organic farmers regularly used the advisory service, usually Agricultural Advisory Centres, and also the growing role of private counseling was observed. Farmers most often declared the need for help in the sale of products, disease and pests control and soil fertlisation, and the least - in the field of health and animal breeds. This was due to the specificity of the study group of farmers, most of whom did not have animals at their farms. Although farmers moderately positively evaluated the existing agricultural advisory service and willingly used its help, there is an urgent need to improve the quality of advisory service in Poland, which applies to both public and private ones. Greatest demand concerned a need to develop specialised and individual advice. It is also necessary to increase the use of the Internet by farmers as a source of information and a tool for education. As part of the same project, a survey of the role of scientists in the dialogue between them and practitioners in the field of organic production had been carried out. Another important aim of this study was to identify the best models of such dialogue, to be used by others. The results of these studies (IID3 3) conducted in 12 countries involved (6 countries of so-called "old" EU and 6 countries of "new") had shown that there is little difference between scientists from the "old" and "new" EU member states in most of the analysed areas. The main difference was that scientists from the "new" EU member states provide more training for practitioners outside their institution in relation to the scientists of the "old" EU member states. The results also showed relatively low levels of activity of researchers in carrying out implementation projects and writing popular articles, which concern both "old" and "new" EU

member states. On the one hand the need for more applied projects clearly interferes with the increasing demand of universities for more scientific outputs and approvals. On the other hand the knowledge transfer is very much dependent on engaged scientists, in specific when governmental institutions outside universities are missing for the conversion and transmission of existing scientific knowledge. Beside adequate political and academic environment the financial issue can be emphasized as the most urgent factor for the promotion and improvement of better knowledge transfer from science to practice.

B. Summary of scientific and research work

My scientific achievement consists of a total of 112 papers, including 89 scientific papers and 23 popular science articles (including 12 internet publications). I am an author of 52 original creative works, including 5 published in journals indexed in the Web of Science database, 26 in journals from the B list of Ministry of Science and Higher Education (MSHE) and 21 published as chapters in scientific monographs (including the publication "The effect of organic and conventional agricultural production system on selected quality parameters of beetroot, carrot and carrot juice" - the scientific achievement). I am also an author of 15 reviews in scientific journals and monographs in Polish and English language, 13 reviewed abstracts in conference publicationss, 7 chapters in student scripts and 2 chapters in collective publications documenting research grants.

My total Impact Factor is: 12,573, the Hirsch index: 2, and the number of citations in the database Web of Science: 9.

From the total of 89 different items of scientific achievements, 80 were published after the defense of my doctoral dissertation (including 5 arising from the results of the studies included in the dissertation), which represents about 90% of all items.

The point value of all publications and elaborations (according to the MSHE list of journals applicable in the year of publication) is 475 points, 455 points after obtaining a doctoral degree. In the majority of items, I was the first author and one of the main topic executors. Publications were published in prestigious journals such as: Journal of the Science of Food and Agriculture, Biological Agriculture & Horticulture: An International Journal for Sustainable Production Systems, Renewable Agriculture and Food Systems, Journal of Agricultural and Food Chemistry, Free Radical Biology & Medicine, Journal of Research and Applications in Agricultural Engineering, Electronic Journal of Polish Agricultural Universities, Polish Journal of Natural Sciences, Medicina Sportiva, New Medicine, Vegetable Crops Research Bulletin,

Handel Wewnętrzny, Żywienie Człowieka i Metabolizm, Postępy Techniki Przetwórstwa Spożywczego, Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Zeszyty Naukowe Uniwersytetu Ekonomicznego w Poznaniu, Problemy Zarządzania, Acta Fytotechnica et Zootechnica.

I presented my work at numerous scientific conferences, participating in 28 national conferences and 3 international. My active participation in these conferences included 51 presentations in the form of posters and scientific reports, including 14 scientific reports presented personally.

While working in the Faculty of Human Nutrition and Consumer Sciences, I received three awards of HM Rector of WULS, including two for scientific achievements awarded in 2012 and 2014 and one for teaching achievements, granted in 1996, and a diploma of merit of HM Rector of WULS for educational achievements in 2015.

During my academic career, I was (and I am now) an executor in 11 research projects, including 5 international research projects (II I1, II I2, II I5, II I12 and II I14) and in 6 projects financed from domestic sources (II I3, II I4, II I7, II I8, II I9 and II I10). In addition, I was actively involved in two international projects in the framework of the "Lifelong Learning Programme Leonardo da Vinci Partnerships" (II I6 and II I11) and one ongoing project "Erasmus + Strategic Partnership" (II I13) (*numbering according to Appendix no. 3, point I*).

SUMMARY OF SCIENTIFIC ACHIEVEMENT

Category	Number of papers	IF [a]	*IF* [b]	Points by MSHE [a]	*Points by MSHE* [c]
PUBLICATIONS PUBLISHED BEFORE OBTAINING PhD					
Publications in reviewed journals (B list)					
J. Res. Appl. Agric. Engng	2	-	-	4	*24*
Publications in scientific monographs					
In Polish language	6	-	-	12	*16*
In English language	1	-	-	4	*5*
Together	**9**	**-**	**-**	**20**	***45***
PUBLICATIONS PUBLISHED AFTER OBTAINING PhD CONCERNING THE RESULTS INCLUDED IN DOCTORAL DISSERTATION					
Publications in reviewed journals (B list)					
J. Res. Appl. Agric. Engng	1	-	-	6	*12*
Handel Wewnętrzny (suppl.)	1	-	-	6	*12*
Żyw. Człow. Metab.	2	-	-	4	*16*
Pol. J. Natur. Sc. (suppl.)	1	-	-	2	*8*
Together	**5**	**-**	**-**	**18**	***48***
PUBLICATIONS PUBLISHED AFTER OBTAINING PhD					
Original publications according to the Journal Citation Report (A list)					
J. Sci. Food Agr.	1	1,714	*1,99*	35	*35*
Biol. Agric. Hortic.	1	0.681	*0,61*	20	*20*
Renew. Agr. Food Syst.	1	1,53	*1,40*	35	*35*
J. Agr. Food Chem.	1	2,912	*3,27*	45	*40*
Free Radic. Biol. Med.	1	5,736	*5,86*	40	*40*
Publications in reviewed national journals (B list)					
J. Res. Appl. Agric. Engng	13	-	-	89	*156*
Medicina Sportiva	1	-	-	4	*12*
Veget. Crops Research Bull.	1	-	-	9	*7*
Post. Techniki Przetw. Spoż.	5	-	-	22	*30*
Prace Naukowe UE we Wrocławiu	1	-	-	9	*10*
Zeszyty Naukowe UE w Poznaniu	1	-	-	6	*10*
Problemy Zarządzania	1	-	-	11	*11*
EJPAU	1	-	-	4	*12*
New Medicine	1	-	-	4	*8*
Publications in reviewed foreign journals not included in MSHE list (B list)					
Acta Fytotechn. Zootechn. (sp. issue)	1	-	-	4	*4*
Publications in scientific monographs					
In Polish language	17	-	-	60	*68*
In English language	4	-	-	20	*20*
Other					
Scientifis monography - **achievement**	1	-	-	20	*20*
Chapters in student scripts	7	-	-	-	-
Documentation of scientific research	2	-	-	-	-
Abstracts in reviewed conference materials	13	-	-	-	-
Together	**75**	12.573	*13.13*	**437**	***538***
Together (all publications)	**89**	**12.573**	***13.13***	**475**	***631***

[a] – applicable in the year of publication
[b] – five-year average IF
[c] – in accordance with the currently applicable list of journals

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