Appendix no. 2

Author's summary of scientific achievements

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1. Personal data

1.1. Name and Surname

Eliza Kostyra

1.2. Diplomas and scientific degrees

- **Doctor of Philosophy degree in agricultural sciences** (2003), discipline: Food Technology and Nutrition; Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences - SGGW.
  Title of Ph.D.: Interactions of flavouring additives with food ingredients and their sensory effects (using liquid smoke preparation as an example).
  Supervisor: prof. dr hab. Nina Baryłko-Pikielna
  Reviewers: prof. dr hab. Henryk Kostyra,
  dr hab. Bolesław Kowalski, prof. nadzw. SGGW

- **Master of Science degree in agricultural sciences** (1995), specialization: Food Technology and Human Nutrition, discipline: Human Nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences - SGGW.
  M.Sc. thesis title: Effect of dietary zinc supplementation on metabolism of iron, copper and zinc in laboratory animals.
  Supervisor: prof. dr hab. Anna Brzozowska

1.3. Information about employment in research units

since 2004	**Head of Laboratory of Sensory Analysis**, Laboratory of Food Assessment and Health Diagnostics, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences - SGGW
since 2004	**Adjunct**, Department of Functional Food, Ecological Food and Commodities, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences - SGGW
since 2003	**Assistant**, Department of Dietetics and Functional Food, at present Department of Functional Food, Ecological Food and Commodities, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences - SGGW
1998 - 2003	**Doctoral studies**, Faculty of Food Sciences, Warsaw University of Life Sciences - SGGW
1998 - 2003	**Assistant**, Meat and Fat Research Institute, Warsaw
1996 - 1997	**Assistant**, Food and Nutrition Institute, Warsaw

2. Scientific achievement being the basis of the habilitation procedure

2.1. Title of the scientific achievement

The scientific achievement, in accordance with Article 16, Paragraph 2 of the Act of 14 March 2003 concerning the scientific degrees and titles (Journal of Laws No. 65, item 595, as amended), is the series of 4 publications entitled:

"Application of static and dynamic methods in sensory research on selected food products"

2.2. The list of publications which constitute scientific accomplishment

1. **Kostyra E.**, Wasiak-Zys G., Rambuszek M., Waszkiewicz-Robak B., 2016: Determining the sensory characteristics, associated emotions and degree of liking of the visual attributes of smoked ham. A multifaceted study, LWT - Food Science and Technology, 65, 246-253
   35 pts MSaHE; IF = 2,329; number of cites = 4*

2. **Kostyra E.**, Rambuszek M., Waszkiewicz-Robak B., Laskowski W., Blicharski T., Poławska E., 2016: Consumer facial expression in relation to smoked ham with the use of face reading technology. The methodological aspects and informative value of research results, Meat Science, 119, 22-31
   35 pts MSaHE; IF = 3,126; number of cites = 2

3. Baryłko-Pikielna N., **Kostyra** E., 2007: Sensory interaction of umami substances with model food matrices and its hedonic effect, Food Quality & Preference, 18, 751-758.
   24 pts MSaHE; IF = 1,796; number of cites = 31

4. **Kostyra E.**, Baryłko-Pikielna N., Dąbrowska U., 2010: Relationship of pungency and leading flavour attributes in model food matrices – temporal aspects, Food Quality & Preference, 21, 197-206
   32 pts MSaHE; IF = 3,013; number of cites = 6

The total score of all publications constituting the Main Scientific Achievements is **126** points according to MSaHE journals' rank and total **IF** is **10.264** (IF from the year of publishing). Copies of manuscripts included in the monograph constituting the Main Scientific Achievement together with declarations of co-authors concerning their contribution to each of these manuscripts are enclosed in appendix 4.

* *Web of Science*

2.3. Presentation of research objective and results obtained within the Main Scientific Achievement

2.3.1. Introduction

The uniqueness of sensory analysis is based on the assessment of food quality by means of the human senses. The definition of the term sensory analysis refers on the one hand to measuring and interpreting the reactions of the human senses as a result of contact with the product, while on the other it refers to the conditions of research, the required skills of the assessors carrying them and the use of methods adequate to the purpose of the assessment. Regarding the typology, there are two prominent types of evaluations used, sensory analytical and sensory consumer tests. Amongst other things, they differ in the nature of the results thereby obtained, the type of panelists involved in the research and the undertaken tasks, as well as in the location and conditions of testing. It should be noted that for both such assessments, the food product constitutes the object of research. In the case of analytical research, sensory characteristics of products are performed in objective categories, whereas in consumer test the attention is focused on rating subjective consumer responses to food products and their quality assessment in the affective (hedonic) dimension. The presented classification, depending on the type of assessments and the formulated research goal, also obliges to use appropriate methods. In this respect, the typology of sensory methods refers to different criteria of division, inter alia, to the inclusion of time as an evaluation parameter. This leads to the discernment of two methods (static and dynamic) in sensory and consumer research. Static methods are based on point measurements (e.g. scaling methods, descriptive analysis methods), whilst dynamic methods allow the evaluation of selected attributes in time (e.g. Time-Intensity, Time-Related-Profiling, Temporal Dominance of Sensations[1]).

Measuring sensory responses over time is a vital aspect for assessing the sensory quality of food products. The perception of sensation stimuli in the oral cavity/mouth is a dynamic process depending on the type of product, its consistency (e.g. solid versus liquid) as well as on how a given food sample is prepared for consumption (crushing, mixing with saliva and release of sensory-active substances). It thus follows that sensory perception during when a product is consumed will change over time in terms of quantitative, qualitative and hedonic aspects. The scientific literature stresses that flavour is one of the chief multisensory aspects of everyday experience whenever food products are consumed. This is because the

[1] English method terms do not have official equivalents in Polish. In this context, the English-language method names were used in the document.

perception of flavour is sensory-linked to combinations of various stimuli such as aroma, taste, consistency and somesthetic feelings, together with the acoustic and visual properties which determine whether food products are acceptable to the individual. The importance of measuring the sensations in time is not only important due to the determination of the intensity of key flavour attributes under the influence of dynamic processes occurring in the oral cavity. They also play a fundamental role in measuring the emotions concerning food palatability.

The literature emphasises that sensory characteristics can evoke different emotions and thereby condition the preferences of the consumer. Upon more profoundly considing the role of time in sensory and consumer research the importance of the time dimension in the various situations encountered everyday can be demonstrated, such as in the decision-making whenever food products are purchased, prepared/cooked in the home and then eaten. When such factors are taken into account, food science studies conducted in such various thematic areas can thus establish the importance of time in sensory and consumer research as well as for consumer expectations and their attitudes. This approach is fully justified from both cognitive and application aspects.

New sensory and consumer methods have been developed intensely over the last decade in which are contained the so-called Rapid Sensory Methods (e.g. Napping, Flash Profile, Check-All-That-Apply, Temporal Dominance of Sensations, Free Sorting). This has broadened the range of available methods, (both for static and dynamic measurements), and has paved the way for allowing measurements to be made that were previously not possible. Furthermore, innovative devices have been developed based on new technologies and customised software enabling consumer reactions in relation to food product that include those responses as measured by facial expressions (FaceReader) and visual perception through tracking eye movement (Eye Tracking). Both techniques (FaceReader and Eye Tracking) permit impressions to be measured over time, e.g. they take into account the dynamic aspect of perception, which is so important in evaluating the sensory quality of foodstuffs. These tools have an enormous research potential for elucidating and analysing those factors related to consumer acceptability of food products.

The need for carrying out scientific studies through using modern technologies and advanced analytical methods has been pointed out by numerous scientific publications so that guidelines can be developed for their optimal use in both research and industrial practice. Attention is also drawn to gathering sufficient experimental evidence in making recommendations for the following: understanding those cognitive processes responsible for

product evaluation, developing the tools necessary for achieving repeatability of outcomes and identifying any limitations of these new methodologies.

Sensory and consumer research studies employing traditional and new methods are used to resolve various issues which include, *inter-alia*, optimising the perceived sensory qualities of food products. Experimental models of varying complexity are used in circumstances where various sensory-active substances are applied that condition the sensory characteristics of food products; these forming an important element in determining interactions at various levels such as the physicochemical, physiological and psychological. These aspects are especially important whenever the composition of raw material ingredients are modified or if new products are placed onto the market (including the pro-health ones). They also play a fundamental role in the development of sensory analysis.

2.3.2. The aims and study hypothesis

The aim of the presented scientific achievement is to assess the applicability of selected static and dynamic methods in sensory research using both model matrices and exemplary food products with a full recipe composition.

Objectives:

1. To evaluate whether a methodological approach can be comprehensively applied to determine the sensory characteristics of food products through the combined use of both innovative dynamic methods (using FaceReader and Eye Tracking) and traditional static methods (quantitative descriptive analysis, scaling method); this includes investigating the relationship between the degree of liking, the type of emotions evoked and the visual perception of key product characteristics.
2. To evaluate an innovative approach for identifying the type and extent of emotions evoked by the taste of food products together with determining such changes over time and the individual reactions of consumers (using FaceReader).
3. To determine whether the ranking method is suitable for examining changes in palatability in model food matrices under the influence of the addition of umami substances.

4. To investigate if the modified Time-Intensity method, of enabling sensations over time to be measured, can be used to determine changes in the intensity of key flavor attributes in model food matrices that evoke pungency sensations.

On the basis of the above-mentioned goals, the following research hypotheses have been formulated:

1. The sensory evaluation of food products within cognitive (quantitative-qualitative) and affective (hedonic) categories, which includes emotional reactions and visual perception, requires a comprehensive methodological approach using both the traditional static and innovative dynamic methods.
2. In order to determine if modern research methods can be applied in the presented case, a thorough analysis of the experimental data is needed for entirely evaluating the type and extent of emotions over time, that also take into account any changes in the individual reactions of consumers.
3. The use of static and dynamic methods in research of model matrices enables the magnitude of changes in their sensory characteristics to be verified as well as any sensory interactions to be determined, depending on the variables studied for any given experiment.

2.3.3. Results

2.3.3.1. Sensory quality of products and its impact on perception in cognitive, hedonic and emotional categories

Publications[2]

I.B.1. Kostyra E., Wasiak-Zys G., Rambuszek M., Waszkiewicz-Robak B., 2016: Determining the sensory characteristics, associated emotions and degree of liking of the visual attributes of smoked ham. A multifaceted study, LWT - Food Science and Technology, 65, 246-253,
35 pts MSaHE; IF = 2,329

[2] Publications were done as part of research carried out in the project "BIOFOOD"- innovative, functional products of animal origin no.POIG.01.01.02-014-090/09 co-financed by the European Union from the European Regional Development Fund within the Innovative Economy Operational Programme 2007-2013.

I.B.2. Kostyra E., Rambuszek M., Waszkiewicz-Robak B., Laskowski W., Blicharski T., Poławska E., 2016: Consumer facial expression in relation to smoked ham with the use of face reading technology. The methodological aspects and informative value of research results, Meat Science, 119, 22-31,
35 pts MSaHE; IF = 3,126

Sensory characteristics of products (hams) including the degree of liking, type of evoked emotions and visual perception of key features related to the external appearance

The literature emphasizes that the expectation of liking and emotions play an important role in the choice of food products by consumers. The expectations are associated with quality cues, such as the intrinsic (the sensory and physical characteristics of the products) and extrinsic (the brand name, price, packaging labelling) attributes of the product, which are crucial for the pork purchasing decisions of consumers (Verbeke et al., 2005;Grunert, 2002; Morales et al., 2008). According to Bello Acebrón and Calvo Dopico (2000), visual impressions are based on the perceived extrinsic cues and provide essential input that may induce quality expectations for meat products. While a product is being consumed, its sensory properties are experienced by the senses and then together with the expectation are involved in a global product-quality evaluation (Lange, Issanchou, & Combris, 2000).

The emotions evoked by a food product may be associated with both its sensory qualities and functionality, previous consumer experiences and the anticipated effects of product usage or ownership (Schifferstein & Desmet, 2010). It is noted that the emotion can be evaluated prior to, during and/or after consumption of the product (King, & Meiselman, 2010). The most appropriate time to measure emotions is during the consumers' exposure to a stimulus or immediately afterward, when the direct reaction to the product occurs.

Sensory properties (taste, odour, texture, appearance), type of food (starchy food, meat, snack, beverage, herbs and spices) as well as the individual's characteristics (food familiarity, gender, personal disposition, food association due to various eating habits) are among the factors that can elicit emotional responses to food products (Jiang, King, & Prinyawiwatkul (2014). Foods of various sensory features may evoke different emotional responses from consumers. Among all food product properties, smell and taste (41.9%) are most often quoted as eliciting emotion, food quality (23.3%) and experience of eating food or anticipated consequence (14.6%) (Desmet & Schifferstein, 2008)

In the case of products of animal origin, the criteria for their selection by consumers are particularly complex and emotionally charged, so it is important to know more about their sensory characteristics in quantitative, qualitative, degree of liking and emotional terms. It is

also interesting to investigate consumers' reactions in relation to the visual characteristics of product that are crucial at the moment of product purchase. In the last decade new device-aided measurement techniques as FaceReader and Eye Tracking were introduced in this area (King i Meiselman, 2010; Graham, Orquin i Visschers, 2012).

Taking into account the above aspects, the aims of the present study were the following: 1) to describe the similarities and differences in the sensory profiles of smoked hams; 2) to evaluate consumers' sensory liking of the tested hams and to observe the relationship between the expected and experienced liking and related emotions before and after consumption of the products; 3) to conduct a preliminary study on determining the type of emotion experienced by the consumers in respect to solid samples (as opposed to liquid or semi-solid foods) with FaceReader measurements, including changes in time and analysis of individual emotional reactions of consumers; 4) to observe the consumers' visual perception of the external features of the selected hams by Eye Tracking technique and compare the results with the liking scores of the visual attributes of the hams. The studies include methodological issues related to the possible use of devices such as FaceReader and Eye tracking to determine, respectively, emotions and visual perceptions regarding meat products, represented by the ham.

The assessment involved smoked hams made from meat of different initial qualities, e.g., meat from pigs of the PBZ breed (Polish Landrace Breed, pol. *Polska Biała Zwisłoucha*) (R1) and cross-breeds of PBZ x Duroc (R2) and the way of feeding. The animals were on standard feed with 1 mg of organic selenium/1 kg of feed and vitamin E at either 100 mg (D1) or 200 mg (D2). The control sample (RK) for a smoked ham was made from meat in which pigs only received 2% rapeseed oil with their feed.

To achieve the stated objectives, various sensory and consumer methods were used, including static and dynamic, taking into account the multifaceted dimension of research. The sensory characteristics of the smoked hams were assessed by the Quantitative Descriptive Analysis method according to ISO 13299:2010a requirements. The mentioned method is used in sensory analytical research, often also as a standard (reference method) in relation to other newly developed sensory methods in research. The application of the method allowed to obtain a sensory profile of the evaluated products including many attributes relating to the external appearance, odour, textures and taste/flavours.

Because the study was focused on methodological issues, it was acceptable to use fewer respondents (30-40), who declared regular consumption of meat products, including hams. The average age of respondents was 23 years and 70% of them were female.

Consumers participated in all types of tests using different methods. To assess the degree of liking and emotions before and after tasting the samples, the scaling method was applied using a 9-point hedonic structured scale (ISO 4121:2010b), which is the most commonly used classical scale in consumer study. The same scale was applied to assess the consumers' visual liking of several attributes (colour, surface, fatness, consistency, freshness, overall liking and emotion) when looking at the photo-images of slices of ham displayed on a computer monitor.

An innovative methodical approach in this research was to determine the type and level of consumer emotions, such as *happy*, *sad*, *angry*, *surprised*, *scared*, *disgusted* and *neutral* during the duration of the impression in relation to a given product using FaceReader 4 software. The scaling effect of these emotional reactions from 0 (not present at all) to 1 (maximum intensity of the fitted model) were measured, based on the analysis of 491 facial expressions of each person participating in the tests. To minimise artefacts due to tasting and chewing the products, the emotions of the consumers were determined within 30 s after they had consumed a particular piece of ham. The timing of the emotional reaction was established during the preliminary study using Time-Intensity assessment of the saltiness and intensity of smoked-flavour in ham samples. The procedure for measuring the emotional reaction of consumers using FaceReader was standardized and filmed using specialized Media Recorder software (Noldus Information Technology, Wageningen, Holandia). The video was taken only for full frontal face of consumer and the camera was directly placed above the screen of the laptop facing the participants. The position of camera was slightly below the eye level of the participant in accordance of the guidelines specified in the instructions by the manufacturer. The particular distance of respondent from the camera was 50-60 cm. Before analyzing facial expression, we selected the face model "General". During research the strong shadow or reflection were eliminated to produce reliable results. Additionally, two USB LED lights (to either side of the monitor) to illuminate the test participants face were used. During the test, people were sitting and receiving samples of a certain size (3 mm thick, 1.5 cm x 3.0 cm). A set of 35 172 records (records) was obtained for statistical analysis of the results, showing data from the measurement of the intensity of the seven types of emotions caused by the tastiness/flavour of products. This study results was deepened based on Kohonen's neural networks for the classification of occurrences, e.g., emotional states in subsequent moments from the start of the taste/flavour impression after swallowing of the sample by consumer.

The original approach in this research was also to determine the visual perception of participants in relation to product images (hams) using Eye Tracking (SMI iView X E software). Each image was presented on a computer screen for 10.000 ms. The eye-movement

monitor was calibrated (9-point calibration) before a visual tracking study was performed. The time and the level of visual concentration of participants on the features of the external appearance of the product were measured. The value that was analysed was the sum of the duration (ms) of all fixations (normally referred to as the total fixation duration), which was calculated for whole areas of the presented slice of smoked ham.

The procedure for assessing measurements using FaceReader and Eye Tracking software has been presented in detail to consumers prior to conducting the proper tests. The standard method of sample preparation and presentation for testing using various methods has been developed.

The quantitative-qualitative characteristics of the products

On the basis of the quantitative descriptive analysis (profile method), it was found that the tested ham samples differed in the sensory quality and formed two separate clusters.

The variability of the evaluated samples was related to the colour, tenderness, ease of chewing, softness and salty taste. The RK, R1D1 and R2D2 formed one cluster of smoked-ham samples which were similar to each other in tenderness, ease of chewing, softness and saltiness and they differed from the R2D1 and R1D2 samples that concentrated near the colour, odour and flavour fatty and fibrousness (the second cluster). The results indicated that colour and texture attributes were the key factors determining the sensory characteristics of the hams. Also the intensity of flavour (e.g. fatty, smoky, meaty) and taste attributes (e.g. proper saltiness) created the quality of examined samples.

In the available literature, there are no research in the field of sensory quality assessment of hams, but one can find study that focuses on determining the characteristics of the dry-cured hams. According to the study of Pham et al. (2008), the dry-cured ham products that received higher consumer acceptability scores had more intense „sweet", „smoky", „caramelised" and „molasses" flavour and aroma attributes. In contrast, the dry-cured hams that obtained lower consumer acceptability scores had more intense „rancid", „cured", „fermented", „earthy", „bitter", „salty" and „aftertaste" flavour and aroma attributes. In addition, for consumers of this type of products, it was important to reduce the impression hardness, dryness, fibrousness and chewiness (Ruiz i wsp., 2002).

Expected and experienced sensory quality in terms of the degree of liking and emotions in relation to the products

The literature states that the expected acceptability is the result of the visual impression based on the perceived sensory attributes, whereas the experienced acceptability is the effect of the hedonic assessment of the product at the moment of its consumption (Morales i wsp., 2013). In own studies it was observed that ham samples (RK, R1D2, R2D2) represented similar levels of the expected liking (before tasting) and the experienced liking (after tasting). In the case of R1D1 and R2D1 ham samples, tasting significantly ($p \leq 0.05$) decreased their degree of liking. Regarding the emotion that was determined before and after tasting, there was a slight tendency toward increase scores after the RK and R1D2 samples were tasted. It was also observed the decrease of emotional response after the R1D1 and R2D1 products have been consumed. The level of disconfirmation (the average difference between the expected and experienced liking and the emotion before and after tasting) was highest for the R1D1 and R2D1 samples. Some evidence has suggested that expectations are rather stable cognitive structures that persist despite disconfirmation, which is defined as the occurrence of a mismatch between the expected and the experienced evaluations of a product. Disconfirmation may determine product perception, attitude formation and future purchasing intentions (Cardello and Sawyer 1992; Sabbe *et al.* 2009). Probably, the difference between liking and emotion before and after consumption of the products in the present study was due to higher consumer expectations with respect to some samples. There was no difference in liking of hams in respect of appearance and texture, as opposed to the degree of liking their odour and taste/flavour. The products that received lower experienced liking and emotional (associations) scores after being tasted also obtained lower odour/flavour liking scores and, based on the descriptive analysis, had a slightly lower intensity of fatty odour/flavour (R1D1) or lower level of smoked odour/flavour and salty taste (R2D1) (different breeds/the same level of vitamin E). The statistically significant differences ($p \leq 0.05$) among the smoked hams in the texture profiling attributes did not affect the liking results by consumers. This result suggests that the texture-related impressions (tenderness, juiciness, softness, chewing, and fibrousness) were optimal (remained in consonance[3]) for the sensory quality of the ham samples and did not negatively affect consumer perception.

[3] Consonanse - Quality compliance of individual stimuli in creating an integrated effect in comprehensive flavour (Baryłko-Pikielna i Matuszewska, 2009).

Relations between the degree of liking and the level of emotional reactions of consumers

Generally, there was no correlation between the liking of the attributes of the hams and the intensity of the facial expression. It was observed a tendency in negative correlation between the *surprised* facial expression and liking, which could be the result of significantly reduced degree of liking odour, taste/flavour and overall liking scores of products. However, considering the differences in the emotional reactions of individual consumers, the results obtained in this study should be interpreted with caution. Danner, Sidorkina, Joechl, & Duerrschmid (2014) evaluating orange juices divided the participants into two groups. One of them included the participants who showed clearly visible facial reactions when tasting the samples (approximately 75% of the participants) and the other containing those who had a „poker face", showing little to almost no facial reaction (approximately 25%). According to the authors, the lack of a positive facial expression for liked stimuli might be caused by a quite weak effect of the positive stimuli or be the result of the concentration and analytical thinking of the participant, which can suppress positive emotions/facial expressions to a certain degree (Danner *et al.* 2014).

Type and level of emotions in relation to the flavour of products, changes in the time of impression and individual reactions of consumers

The facial expression results measured using FaceReader indicated that the product samples evoked significantly different emotions among consumers. Based on the general analysis of the results, it was found that in addition to *neutral* reactions (level 0.58), the emotion of sadness (0.22) was most evident, followed by *scared* (0.13) and *happiness* (0.09). The other emotions did not appear; they were only at the margins of the overall emotional reactions. A relatively large number of negative emotions with a small range of positive reactions (satisfaction) could be related to higher consumer expectations regarding the flavour of products (Danner *et al.* 2014). In the study with the use of FaceReader, products that did not evoke positive or negative reactions in most cases were identified with neutral so-called baseline emotional state. A significant level of this type of reaction was represented by product R1D1, while the lowest intensity of *neutral* emotion was noted in the variant of RK. In terms of the type of expression and intensity, the products tested explained this relationship to a moderate degree. The correlation for each emotion reflecting the share of between-group variance in the total variance revealed that only *happiness* clearly depended on a product, followed by *anger*.

It was found that the control sample caused relatively many positive impressions related to *happiness* and showed relatively low levels of negative emotions. A similar profile was represented by sample R2D2 (the product made of meat of animals of a mixed breed PBZ x Duroc with an increased level of vitamin E); however, it had a slightly lower level of *happiness*, *sadness*, and a slightly higher level of *scared*. In turn, the product profile of R1D2 (product made of meat of animals of PBZ breed with an increased level of vitamin E) has obtained few reactions described as *happiness* and a lot of negative feelings (including emotions referring to sadness).

The observed general variability of emotions in the group of respondents influences to a great extent the variability of reactions to the same product (ham sample). A certain minority but non-marginal group of respondents revealed a great variation in the range of emotions identified as *sadness* and *scared*. On the other hand, many people represented restraint in expressing emotions, but there was not also a shortage of participants „spontaneously" reacting to the flavour of the product (after its consumption). A more accurate statistical analysis revealed that the overall emotional variability was explained to a great extent if we considered the human factor. The correlation measurement takes the level exceeding 0.5; and in the case of *sadness* and *scared*, it was close to 0.9. In a multiple relation system, e.g., the simultaneous influence of a product and a person's characteristics, it is only moderately higher, which strongly suggests that consumer perception of a product is dictated by individual, personal conditioning. The literature emphasizes that emotions are considered to be subjective and individuals will differ in their emotional responses with regard to a product. Likewise, products more often evoke mixed emotions than a single one and also multiple emotions may occur at the same time (Desmet & Schifferstein, 2008).

At present work it was verified the impact of time (during the research) on the emotional states of consumers. The nominal observation time was 30 seconds, during which the number of the distinguished emotional reaction states appearing on the face exceeded 300. Three subperiods were distinguished throughout the observation period, analyzed every 100 measurements. It turned out that while time passes from the start of the impression (after consumption), *happiness* was reduced, while the level of reactions identified as *sadness* increased. However, this rule is not absolute. It is accompanied by a correlation of 0.03 (emotions associated with *sadness*) to 0.18 (reaction regarding *happiness*).

In the next stage of the analysis, five consumer emotional profiles were distinguished using Kohonen's neural networks to classify emotional states in subsequent moments of impressions after the consumption of product. A characteristic feature of the greatest cluster

(44% of registered emotional states) was the dominance of *neutrality*, and therefore a large reticence in revealing emotions by consumers. The second cluster was characterized by a relatively high intensity of *sadness*; whereas a very high level of emotions related to *scared* was noted in the third cluster. At the same time, it was found that the fourth cluster showed moderately high intensity of reactions referring to *scared*, and the fifth cluster was characterized by a very high intensity of emotions identified as *happiness*. The statistical analysis taking into account the type of product and the emotional occurrence to the cluster showed that clearly more positive reactions appeared in the case of the control product and R2D2.

Visual perception of the external appearance of products using Eye Tracking and their level of liking

The focus map related to consumers' perception of the external appearance (as reactions to the images) of selected ham samples using Eye Tracking has been determined. The darker the pattern (e.g., red), the more time the consumers spent looking at an area of the ham sample. The longest time spent looking at the main areas of the visually perceptible features of the RK ham were 1038.4 ms (red area), 955.4 ms (orange area) and 785.8 ms/771.8 ms (two yellow blocks). In the case of the R1D1 ham, the longest time the consumers spent looking at the perceptible cues were 1489.7 ms (red area), 1194.5 (orange area) and 1124.1 (yellow area). It was observed that the consumers mainly focused on „the damaged area", perforation in the ham slices, colour changes and marbling.

In examining the results for the degree of liking, it was found that the RK sample received lower scores for liking the fatness and consistency, the overall liking and emotions (association) as compared to R1D1 sample. There were no significant differences in the visual perception-based liking of the freshness and surface of the ham samples. The RK ham sample received a higher score for colour liking than did the R1D1 sample. The perforation of the slice of RK ham at the junction of muscles did not affect the surface-liking score.

Generally, eye-tracking methodology was developed and used to assess consumers' attention to nutritional labels or to evaluate novel packaging solutions (Piqueras-Fiszman, Velasco, Salgado-Montejo, & Spence, 2013; Graham, Orquin. & Visschers, 2012). Eye Tracking provides valuable information about the consumers' focus of attention – information that would be very hard to obtain using any other method. It should be noted that researchers can see what people are looking at but not why they are looking at these things (Graham, Orquin, & Visschers, 2012).

In the present study, determining the visual time-way perception of elements (features) in images of smoked ham by the consumers was attempted using Eye Tracking. Additional assessment of the consumers liking the appearance of the hams allowed a deeper analysis of the results. The samples varied in appearance and received different degrees of liking the visual attributes that affect liking and emotions (hedonic study) and visual perception during Eye Tracking evaluation. According to Du and Sun (2006), the main parameters of the quality of pre-sliced hams determining their acceptability and the buying decisions of consumers are not only an attractive and stable colour. Equally important is the amount and size distribution of other appearance features, such as pores, marbling or fat/connective tissue (Sánchez et al., 2008).

Summary and means for exploiting study outcomes

The planned methodological approach allowed to identify very important issues relating, on the one hand, to the comprehensive characterization of products in various dimensions, including quantitative-qualitative and hedonic ones, taking into account emotions and visual perception, while on the other it enabled analyzing the results in the context of their mutual impact on the evaluation of sensory values products tested. A significant part of this investigation was to consider the relationship between expected and experienced qualities (e.g. as sensory confirmed), thus revealing the extent to which a product is liked by consumers and their expectations. Understanding the emotions of consumers in relation to the palatability of products is an additional element that significantly determines the choice of products (including declared health benefits) and the willingness to consume them.

Innovative software such as FaceReader and Eye Tracking are useful for determining the emotional and visual response of consumers to tested products. Hams are heterogeneous products, and as such their many sensory attributes perceived by consumers (e.g. colour, surface conditions, fattiness, marbling, freshness) may condition their acceptability and the decision-making processes of consumers when buying.

Considering the practical dimension of research, it is very important to use new methods to study facial expression and to determine visual perception in research projects due to the different nature of information related to the sensory quality of products. It is also important for developing guidelines or recommendations to the methodological steps used in this type of experimental research.

2.3.3.2. Interactions of ingredients in model food matrices and their impact on sensory characteristics in affective and cognitive categories

Publications

I.B.3. Baryłko-Pikielna N., Kostyra E., 2007: Sensory interaction of umami substances with model food matrices and its hedonic effect, Food Quality & Preference, 18, 751-758
24 pkt. MNiSW; IF = 1,796
I.B.4. Kostyra E., Baryłko-Pikielna N., Dąbrowska U., 2010: Relationship of pungency and leading flavour attributes in model food matrices – temporal aspects, Food Quality & Preference, 21, 197-206
32 pkt. MNiSW; IF = 3,013

The character of changes in the palatability of model matrices as a result of addition umami substances

Umami substances (monosodium glutamate - MSG, disodium inosinate - IMP, disodium guanylate - GMP) are widely used for various product and meals (like soup and sauces concentrates, vegetable juices, frozen lunch dishes, canned vegetables and meat, processed cheese and others). Their property is to strengthen continuity, fullness and harmonization and the apparent density of some products and culinary dishes (Yamaguchi, 1998). Umami substances evoke a special impression called a distinct basic quality of taste – umami (Yamaguchi, 1998). Umami has the property of interacting with other flavours of food (Fuke and Ueda, 1996), but the effect of these interactions depends on the type of product (Yamaguchi, 1998) and can be observed in the quantitative aspect (enhancing the intensity of some flavour properties or masking others), qualitative (positive modulation of taste) and time (extension of the duration of the impression). These issues affect the enhancement of the taste of products and dishes with the addition of an appropriate amount of potentiators, which may affect their acceptance and nutritional effects (Bellisle, 1999).

In the numerous literature sources on umami flavour enhancing and pleasantness-increasing effect in foods there is surprisingly few quantitative data, showing how much the palatability is affected by rising MSG and 5'-nucleotides amount and their combination when added to real food (or model food matrices), varying in type and composition. In the majority of studies, the hedonic effect of MSG and 5'-nucleotides added to food products was evaluated in a bimodal system (samples with the addition of taste enhancers versus samples without their addition) (Roininen, Lähteenmäki i Tuorila, 1996; Schiffman, 2000).

Taking this into account, the research was carried out in a factor design (4 x 4) to determine the effect of the addition level of potentiators (MSG, IMP, GMP) and their

combinations on consumer palatability of various model products with strictly standard raw material composition (including salt addition on 0.6%) and processing procedure. The originality of the methodical approach was to determine the character of changes in the palatability of seven model products (matrices), including clear soups (chicken broth, mushroom soup, red beet soup), cream soups (vegetable soup, asparagus soup, green peas soup) and mashed potatoes under the influence of varying concentrations of MSG (0%, 0.1%, 0.3%, 0.5%), IMP and GMP (0%, 0.005%, 0.01% and 0.015%). In the experiment, IMP and GMP (I + G) were a mixture of these compounds in a 1:1 ratio.

The experiment design allowed to determine the interaction between the food matrix and umami substances and their variability caused by the different composition of the matrix. To verify changes in the palatability of products under the examined factors a classical (static) ranking method was applied. This method has the intermediate place between difference methods and scaling method. The choice of the method was based on the fact that the ability to discriminate small differences between products by the assessors is higher in the method of ranking compared to the method of scaling.

In my own research it was noted that the character of changes in hedonic response (palatability) depended on the type and concentration of the umami substances and its interaction with the food matrices and differed significantly even among products of the same type (such as clear or cream soups). It was observed that the highest degree of liking in the examined matrices resulted in a different level and the MSG/I+G ratio. For different matrices the dynamics of palatability increase varied from very strong (in chicken broth and mushroom soup), to very slight or even negative (in mashed potato and green peas soup). The remaining three soups revealed a moderate, but individually different hedonic response pattern. The increase of palatability was estimated as a magnitude of hedonic changes against the respective reference (unsupplemented) sample. It was found, that an interaction between the composition of food matrix and its character and the umami additives (their level and mutual ratio) played a key role of the final hedonic effect in the particular product. In the application aspect, it should be taken into account that the optimal relationship obtained for one product (e.g. the soup) not necessarily would appear optimal for another one. Therefore the extrapolation of supplementation results from one matrix to another should be made with a great caution.

Analyzing the effect of adding flavor potentiators to model food matrices, it was found that in the majority of products the main impact on the shaping of taste had the increasing level of MSG than I + G, the impact of which was complementary to MSG. At the same time,

it was not found that the ratio of the added amount of MSG and I + G influenced significantly the synergism of their interaction (increasing the palatability). The results of own research indicate, that the phenomenon of the synergy of above two umami substances (representing two different "families" of them), clearly demonstrated in the simple solution (Yamaguchi, 1998) become indistinct, vague, when umami substances interact with such complex matrix as food.

The original cognitive value of this study was an attempt to explain changes in the desirability of model matrices under the influence of the addition of various concentrations of MSG and I + G and their combinations. It was found that this effect was the result of a combined stimulation of the sum of the added umami substances and those naturally occurring in the products. Within the experiment, the level of natural amino acids was determined, which varied depending on the type of matrix. A positive correlation was found between the natural content of endogenous free glutamic acid and the assessment of the palatability of the reference samples within the test food matrices (with the exception of the asparagus soup). It should be pointed out that the content of natural (endogenic) free glutamic acid in investigated food matrices was varied within the range of 9.22-45.37 mg/100g; it was much less than added MSG which varied between 100-500 mg/100g. Above proportions indicate the prevalent quantity of added MSG over the natural one – suggesting its main effect on hedonic changes. In the matrices of the highest natural glutamic acid content (e.g. green peas soup) final hedonic effect might be affected by umami substances from both sources (natural and added). However, one should keep in mind the fact that changes in the palatability-enhancement effect may be conditioned not only by the amount of free glutamic acid, but also by the level of remaining endogenous free amino acids, the natural content of 5'-nucleotides and the level of other sensory active substances in products.

Changes in the duration of pungency impression and key attributes of flavour in model food matrices evoked by irritant substances

Many consumers when they are asked why they like hot-spiced food~~, they~~ answered that because "hotness" contributes to the greater sensory variety and diversity of foods and their combinations, and because hot spices add extra dimension to different products and meals, making them more interesting and generally more "good tasting" (Rozin, 1990; Reinbach et al., 2007). „Hotness" of food is defined as total intensity and duration of burn sensation in the throat and in the month (tongue, palate and chick mucosa) perceived during and after ingestion (Reinbach et al., 2007).

Pungency sensations belong to a separate stimulating system (chemesthesia), and their reception takes place via the trigeminal nerve. Chemesthetic sensations develop slower than do tastes and smells and last much longer to the decay. "Hotness" is evoked by the presence of hot-inducing irritants, like capsaicin (in chili pepper), piperine (in black pepper) or cinnamic aldehyde (in cinnamon). Although all of them induce a feeling of burn (pungency), each has different qualitative and temporal characteristics of burn sensation (Cliff and Heyman, 1992; 1993). Palatability or hedonic value of hot foods depends much on the harmony (congruence) and good balance between hotness, taste and flavour attributes – those, which define the identity or typicality of the product. It rises the question how heat and burn intensity evoked by rising concentration of the irritant (e.g. capsaicin) affects the intensity of taste and flavour attributes in the product matrix which is usually quite complex one. In the available literature, the research on qualitative and quantitative relation between pungency and tastes and flavours in complex food matrices is very limited.

The objective of this study was to characterize temporal aspects and interaction effect of pungency evoked by capsaicin/chili and leading flavour[4] attributes in model food matrices. In particular, it was determined: 1) the effect of the matrix (carrier) complexity on time-intensity characteristics of capsaicin/chili evoked pungency (hotness); 2) the effect of pungency level on the perception of leading flavour attributes in various food matrices; 3) the changes of qualitative characteristics and spacial distribution of perceived „hotness" over time. To realize the presented goal in the context of obtaining a detailed image of the time changes in the sensory characteristics of the model products as a result of the addition of pungency substances required experience in a controlled factor design, allowing to analyze the dependencies according to the developed methodology, which was the original achievement of this work.

The research has been divided into two stages (experiments) that allow to verify the influence of the addition of irritants (pungency substances) to model matrices for temporary quantitative and qualitative changes in sensory perception. The first experiment determined the pungency sensation caused by various concentrations of capsaicin (0.5 ppm, 25 ppm, 125 ppm) to matrices with increasing complexity: water solution, potato starch gruel and tomato soup and sauce. The second experiment investigated the effect of adding chilli powder (0%, 0.03%, 0.08%, 0.2%) to six model matrices, including tomato soup and sauce, chicken soup and sauce and mushroom soup and sauce on the pungency sensation and the intensity of the

[4] In Polish, the attributes associated with the flavour of products are commonly referred to as the taste (ang. tomato flavour).

leading attributes related to taste and flavor depending on the type of product. All matrices had the same level of NaCl (0.6%); while sauces contained 2% of potato starch.

To implement the research objectives in this work, the Time-Related-Profiling (TRP) dynamic method was used, which is a modification of the Time-Intensity (Baryłko-Pikielna *et al.*, 2004) method. The choice of the TRP method was dictated by the fact of possibility to measure of several key sensory attributes during the evaluation, which significantly translates into the perception of sensations and differences in the intensity of features in products including interactions by the influence of dynamic processes in the oral cavity (including product mixing with saliva, release of sensory active substances and their contact with taste receptors). Time intervals between single measurements have been adjusted to the dynamics of intensity changes of attributes, measured in preliminary studies.

The measurement of intensity of sensations was determined at intervals of 5 s, 15 s, 30 s, 1min, and then every 3 min up to 27 minutes (the moment when the pungency sensation decreases in the mouth), signaled to the assessor by time announcements. Studies using the TRP method required the preparation of a detailed procedure related to the sensory assessment technique. Due to the specificity of the method and the complex assessment task (related to tracking changes in the intensity of the impression over time), several training sessions with the panelists were carried out before conducting the appropriate tests. Following T-I parameters were analysed for pungency and leading flavour/taste attributes: T_{Imax} - time to reach maximum intensity, I_{max} - maximum intenstity, $T_{plateau}$ - duration of maximum intensity and T_{tot} - total duration of the sensation. Qualitative changes of pungency between every two time points of intensity measurement were observed and recorded (in the paper questionnaire).

In contrast to the majority of experimental research on chemesthesis and its relationship with flavour and taste sensations performed in aqueous environment, in this study model food matrices were used as carriers. They were complex enough to mimic "real foods" (soups and sauces) in their main sensory features and simplified enough to be fully controlled and analyze the impact of variability factors on changes in sensory impressions over time. Another detail which should be mentioned here is relatively wide range of capsaicin or chili concentrations used in this study as compared with the experiments of other authors (Baron and Penfield, 1996; Prescott and Stevenson, 1995; Prescott et al., 1993). This approach helped to see clearer trends or tendencies of changes in time - intensity characteristics related to pungency agent concentration and complexity of the carrier/matrix, as well as its interaction with flavours and tastes, and/or sensations of other sensory modality (e.g. viscosity).

The results of the first experiment revealed, that changing the carrier from water to potato starch gruel resulted in strong suppression of pungency perception over the time, especially evident by low and moderate capsaicin concentration. The maximum intensity (I_{max}) of the pungency sensation decreased with growing complexity of the carrier by all capsaicin levels. However the time to reach maximum intensity (T_{Imax}) and the time in which pungency intensity was maintained on the highest level ($T_{plateau}$) was affected primarily by carrier complexity. The differences in the pungency perception time for these parameters were particularly evident between the water solution and the tomato sauce. The results indicated, that sensory effect of the same concentration of capsaicin in various carriers may evoke quite different irritation effect (pungency intensity and its time-course). Independent suppression effect of increased viscosity on pungency has been confirmed on three different soup/sauce pairs with rising levels of pungency (chili). Pungency intensity over time was regularly lower in sauces (of higher viscosity) than in soups. It was also related to the sensory profile of the matrix: slightly higher in chicken soup/sauce than in mushroom and tomato ones. One may speculate that higher viscosity of the carrier makes the contact of capsaicin with nociceptors less available.

The expected and positive effect of hot spices as chili in foods is to add "sharp touch" to their profile but without changing their sensory identity or typicality. The results of the second experiment have shown that leading flavour attributes (tomato, chicken and mushroom) get slightly suppressed by increasing chili level, but not to the same degree: the suppressing effect was much stronger in tomato soup than in two others (chicken soup and mushroom soup). The effect was also weaker in sauces (by the lowest chili levels - none) than in their soup counterparts, probably because of higher pungency suppression in this environment. Above results suggest, that "hotness" of chili affects only moderately the flavour - what is in agreement with earlier results obtained by other authors (Prescott and Stevensons, 1995).

In the present study the effect of pungency on various tastes in this study could not be compared across different matrices because various tastes were traced in each of them (with the exception of salty taste evaluated in all matrices). It was stated that intensity of acidic taste in tomato soup changed in non-linear manner: sharply decreased already by the lowest chili level (0.03%, as compared with control sample) and get lower further with growing amount of added chili. Similar pattern of changes was observed in tomato sauce, but decrease of acidic taste intensity with rising chili level was less pronounced. Slight bitterness in mushroom soup/sauce (typical taste note for dry mushroom) was practically unaffected by pungency of

increasing chili amount added to the mentioned matrices. Different effect of pungency on various taste quality (in water solutions) was earlier observed by Prescott and Stevenson (1995).

The only taste quality evaluated in all matrices was saltiness resulted by fixed amount of NaCl (0.6%) added to all investigated matrices. Surprisingly dramatic differences of perceived saltiness intensity in various soups with no chili (control samples) certainly affected its changes evoked by rising chili level. It illustrates enormous complexity of intramodal (e.g. the relationship between taste stimuli) and intermodal interactions (the relationship between taste, odour and texture stimuli) of sensory active components, which final result is experienced and judged by human senses. Qualitative and migration changes of pungency during long time of its perception contribute additionally to the above complexity. For example, the quality of the impression varied from the strong sensation of pungency over the entire surface of the tongue (the beginning of the assessment), followed by migrating the impression and its perception in the throat, on the palate, the tip of the tongue and around the lips, until persistent numbness at the end of the sensory evaluation.

Summary and means for exploiting study outcomes

This study concludes that its outcomes significantly complement data concerning the impact of sensory active substances, these being referred to as flavour enhancers and those compounds responsible for pungency sensations on the sensory properties of various model matrices used that imitate real food products (like soups and sauces). By using a factorial design, the experiments have allowed control over the effect that individual factor variables have on the final effects of changes in sensory characteristics that come under the influence of intramodal and intermodal interactions. Understanding such relationships is important for preparing food recipes as well as in optimizing and modifying the sensory quality of various food products and dishes; whilst also accounting for consumer preferences. The application of ranking method in this study, (based on static measurements for detection and the hierarchy of differences), contributed to determining the character of changes in the palatability of model products with the addition of umami substances in the context of obtaining different hedonic effects. However, when measuring the pungency sensations together with the leading taste and flavour attributes, it was also possible to verify changes in their intensity over time in terms of quantity and quality using the modified Time-Intensity method.

2.4. Summarizing the publication cycle

Experimental studies using static and dynamic methods that were presented in publications constituting scientific achievement allowed for a detailed analysis of the impact of individual variability factors in experiments on determining changes in sensory characterisics of both model food matrices as well as food products on the example of meat products (hams).

By using a comprehensive methodological approach based on innovative dynamic methods and traditional static methods, detailed sensory characteristics of products could be determined; both quantitatively and qualitatively. Furthermore, this has led to understanding the relationship between the extent to which consumer products are liked and the emotions in terms of the expected and experienced quality together with determining the emotional responses of consumers and their visual perception in relation to evaluated food products (Hypothesis 1). Identifying the type and level of emotions induced by product flavour over time with a simultaneous analysis of consumer's individual facial expressions (emotional) has found that the extent that emotions change when measured by FaceReader may depend not only on the products's sensory properties, but in a large way by the subjective responses of consumers.

In addition, the analysis of results using Kohonen's neural networks enabled a thorough analysis of experimental results related to the determination of the emotional profiles of consumers (Hypothesis 2). Using FaceReader has allowed a more profound understanding of the dependencies involved when compared to measuring emotions by classical scaling method; this taking into account not only the type or level of emotions experienced over time, but also their influence on any final evaluation of products.

Defining the consumer focus map according to the external appearance of products through simultaneously using the innovative Eye Tracking method (based on dynamic measurement over time), and evaluating the extent that a product is visually liked (based on classical scaling point measurement methods) has enabled the role that visual impressions make on overall sensory perception to be more completely understood. Such studies are especially important for determining those factors affecting consumers' decision-making processes.

The methodical approach used was an innovative approach to research using various methods and devices to assess products in cognitive and affective categories, including

emotional reactions of consumers and their visual perception in relation to the evaluated products.

Studies using both classical ranking methods (based on static measurements) and dynamic Time-Related-Profiling method has made it possible to determine the size and direction of changes in the palatability of food products and the intensity of quality attributes evoked by flavour-shaping substances (umami substances, substances responsible for pungency sensations). It should however be noted that a factor design experiment should be adopted when planning such studies which permits elucidating the effect of increasing concentrations of those substances responsible for shaping taste, flavour and product consistency, taking into account the different types of model food matrices (Hypothesis 3). The adopted methodological approach allowed to determine intramodal and intermodal interactions in the final effect of receiving sensory impressions depending on the type of matrix. Outcomes from such research possess both cognitive and practical aspects when determining the impact of modifying the composition of raw materials on changes in the sensory qualities of various food products.

2.5. Conclusions

Summing up, the considerations regarding the sensory studies performed by myself, using various research methods, which were accompanied by the striving to determine the most reliable and optimal model of conduct in this field, the conclusions can be formulated as follows:

- Innovative methods based on mimic expression and ophthalmography are a valuable complement to the traditional static and dynamic methods used in sensory and consumer research aimed at improving the quality of food products.
- Multidimensional analysis and using Kohonen's neural networks on the experimental data are reliable tools for interpreting the type and intensity of emotions over time, including individual consumers' responses as measured by modern methods of mimic expression analysis.
- Dynamic methods used to measure different sensations over time are a key element of sensory and consumer research because of the unique nature of the information which is both cognitively and application-orientated; thereby enabling their use for developing new products with a verified consumer acceptability.

- The obtained outcomes indicate that the classical ranking method (within static methods) used for sensory studies enables the nature of changes to be determined in the palatability of food products.
- The use of the modified Time-Intensity method, as based on dynamic measurement, permits changes in the intensity of key flavor attributes to be determined for food products when subjected to substances that cause intense sensory impressions.

In the context of conducted research and obtained results, it can be concluded in general that appropriately planned experiments allow the impact of individual variables to be investigated on the sensory impressions, taking into account any interactions. This in turn allows changes to be predicted in sensory quality upon modifying existing food products and in developing new ones.

The conclusions so formulated are cognitive and application-orientated in nature and indicate, the options and legitimacy in using both modern and traditional static and dynamic methods for conducting sensory and consumer research, whose complementarity optimizes new food product development, increases product competitiveness and ensures that innovative studies undertaken in market practice are profitable to food manufacturers.

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3. Presentation of other scientific and research achievements

My scientific career began in 1996 at the Warsaw Institute of Food and Nutrition in the Department of Food Technology under the directorship of Professor Nina Baryłko-Pikielna DSc. My professional experience in later years was mainly focused on sensory research in which I was closely involved in during 1998-2003 at Meat and Fat Research Institute in Warsaw. At that time, I undertook my doctoral thesis on „Interactions of flavouring additives with food ingredients and their sensory effects (using liquid smoke preparation as an example)", with Professor Nina Baryłko-Pikielna DSc being my tutor. I received my PhD thesis with honours from the Faculty of Food Sciences of the Warsaw University of Life Sciences - SGGW in Warsaw. Since 2003 I have been employed at the Faculty of Human Nutrition and Consumption Sciences at Warsaw University of Life Sciences - SGGW in Warsaw, working in the Department of Functional Food, Ecological Food and Commodities. In 2004, the Faculty established a Laboratory of Food Assessment and Health Diagnostics under which, amongst others, a Sensory Analysis Laboratory was also created. I am the head of this Laboratory and bear responsibility for conducting research studies and sensory training for industry. I have collaborated long-term with Professor Nina Baryłko-Pikielna DSc where I have gained much experience and achieved a large measure of independence in undertaking scientific research and all its associated challenges, including taking part in national and international projects. I have also co-jointly taken part with Professor Nina Baryłko-Pikielna DSc in meetings and workshops organized by the European Sensory Network (an International Scientific Society), whose members include staff from the leading European (and some non-European) academic and research centers in the field of sensory and consumer research. This has now become one of the most important elements of my scientific development that I intend continuing as a career path.

My scientific work is focused on various aspects of sensory and consumer research for determining, *inter alia*, the impact of technological process and food recipe changes on the sensory quality of various products; this including the addition of substances responsible for food flavouring, taste and texture additives. A significant part of my professional interests relate to using various new research methods, including Rapid Sensory Methods and in comparing outcomes obtained from sensory and consumer testing of various food products; which include both analytical instrumentation and psychophysiological studies. I have also undertaken projects in developing methodological approaches used for conducting sensory and consumer research and in seeking practical solutions thereof, as well as collaborating with

industry. One important topic in my current interests is investigating sensory perception in children and adolescents. My scientific studies are additionally focused on elucidating sensory and non-sensory factors that govern consumer choice of products, which including those suffering a dysfunction of the senses. In the these aforementioned fields, I have authored or co-authored many scientific publications, numerous case reports and have presented abstracts at international conferences as well as managing and performing numerous national and international projects.

Referring to international projects and the thematic area related to the use of new methods and the development of research methodology, I was involved in grants of the European Sensory Network under the so-called research pillars regarding the use of advanced methods in product evaluation (*Advances in Sensory Methods*), consumer perception of products in connection with physiological aspects (*Product Perception and Physiology),* and determining the psychological aspects and behavior of consumers (*Consumer Psychology and Behaviour*). I was the head or contractor of the following ESN grants: Proficiency Testing in Sensory Analysis: Development of reference samples for Proficiency Testing; Palatability, satisfaction and satiation of beverages; Measuring Temporality of Sensations and of Liking in Consumers and Wellbeing project: Foods and Beverages, Beauty, Home Care (Projects I-1.1, I-1.4., I-1.5., I-1.6.).

Several thematic groups to my scientific and research interests can be distinguished as follows:

- Determinants of sensory quality of various food products;
- Sensory education and its role in the perception and acceptance of products by children, adolescents and adults;
- Sensory and non-sensory factors affecting consumer choice and consumption of food products;
- Implementing sensory, analytical instrumentation and psychophysiological research for determining the quality of selected food products regarding those substances responsible for flavour.

3.1. Determinants of sensory quality of various food products

Sensory quality plays a key role in consumer choice and the acceptability of food products as well as in their consumption. The most important factors determining consumer choice include the product's sensory properties; particularly taste/flavour. With this in mind, sensory research can be applied on the one hand for determining the impact that both technological factors and modifications to raw material composition have (e.g. for developing new products by reducing fat content) on the sensory properties of products and their acceptability, but can also be widely used for monitoring quality control of the product.

The literature emphasizes that the perception of flavors changes significantly as a result of lowering the fat content in food products. Fats are responsible for the sensory properties of many products (e.g. dairy products, cheese, meat, fat spreads) and affect food texture, aroma and taste, and thus significantly contribute to to eating pleasure. In our own research with model mayonnaise-type O/W emulsions differing in the level of fat (80 and 50%) and the addition of a flavoring substance (liquid smoke preparation), changes in the intensity of leading attributes (odour and smoked flavour and salty taste) were determined. It was found that flavour and taste perception by the same smoke flavourings concentration in mayonnaise type emulsion of reduced fat content (50%) and 0.8% of guar gum for viscosity compensation was much less intensive as compared with those in full fat emulsions (with no guar gum added). The above data were cross-checked by applying three different methods (intensity scaling, profiling, Time-Intensity) for repeated evaluation samples of the same composition. It was noted that in the present study the causative factor of intensity differences in smoke-curing flavour and salty taste in the emulsion containing 50% of fat and 0.8% of guar gum as compared with full-fat one (80% of fat, 0% guar gum) could be rather guar gum than lower level of fat (Publication II.A.2).

Research related to determining the influence of fat level on sensory quality and the palatability of selected attributes was continued by assessing soft fat spreads. Two samples of fat mixes of 55% and 75% fat content and four samples of low fat products of 20 and 25% fat content have constituted research material. It was shown that products with a fat content of 55 and 75% represented a higher overall sensory quality, which was positively correlated with butter aroma and flavour and the impression of meltiness, and negatively related to the intensity of hydrogenated flavour and taste as well as fatness impression (profiling results). The distance in sensory quality between samples with a higher and lower level of fat was confirmed in semi-consumer tests (scaling method, 9-point hedonic scale). The changes in the

sensory profile and palatability of examined fat spreads probably depended not only on the level of fat, but also on emulsifiers, stabilizers and the quality of butter flavour used for low-fat products (Publication II.D.13). The effect of the level of substitution on sensory quality of "Bologna" - type sausage (measured by Quantitative Descriptive Analysis), with a traditional recipe which has been modified by added polysaccharide-protein fat substitute in quantities 50, 75 and 100% of fat content was investigated in another work. It was shown that 50% replacement of recipe fat with the polysaccharide-protein substitute did not cause any lowering quality of sensory quality "Bologna" - type sausage, with the distinct lowering of fat content in the product (Publication II.D.3).

An important element of my research activity is also the verification of sensory quality of various types of market food products. In relation to this aspect, the microbiological and sensory quality of 30 assortments of market milk was determined. Sensory characteristics of all the milk samples was performed by scaling method (5-points scale). Selected samples of milk were additionally assessed by means of profile method. Regardless of the preservation method, all the evaluated milk samples were characterised by a high sensory quality. There were no changes in smell and taste, resulting from the development of undesirable microflora. The tested samples of milk differing in the preservation method (sterilisation, pasteurization at high temperature and subjected to microfiltration and low pasteurisation) varied in the sensory profile. Milk pasteurised at high temperature represented the most harmonised overall quality (Publication II.A.5). In the next work, sensory quality of selected market milk replacers and assessment of their nutritional value in relation to cow's milk were carried out. It was found that sensory characteristic of vegan beverages was remarkably different from milk. Vegan drinks distinctively varied in intensity of leading attributes such as cereal, soy, oat, milk, sesame, nutty or coconut flavor and aroma, which originated from main ingredients used in manufacturing (based on profiling results). High intensity of cereal and soy notes as well as bitter aftertaste deteriorated the overall sensory quality of milk substitutes. The most acceptable flavour and aroma was found in beverages based on almonds, walnuts, coconuts and soybean (palatability assessment, scaling method). Nutritional value of vegan milk substitutes was significantly different from caws milk, especially in protein content and fatty acids profile. Vegan beverages were additionally source of unique bioactive compounds coming from plant constituents (e.g. flavonoids) (Publication II.D.22).

In reference to the scientific and research activity related to the methodological aspects in sensory and consumer tests, the changes in the perception of leading sensory attributes of products over time were determined using the Temporal Dominance of Sensation method

(TDS). In addition, the acceptance of products over time using the scaling method (9-point hedonic scale) was performed. The research was also focused on the assessment of changes in the perception of sensory impressions during repeated testing of products. In the present study, a variation of the data acquisition protocol was done, aiming to record TDS and liking simultaneously on the same screen in a single session during multiple product intakes. This method, called Simultaneous Temporal Drivers of Liking (S-TDL), was used to describe samples of Gouda cheese in an international experiment. To test this idea, consumers from six European countries (n=667) assessed 4 Gouda cheeses with different ages and fat contents during one sensory evaluation session. The significant differences in preference of cheese products were observed among countries, but there were global preferences for a longer dominance of melting, fatty and tender textures. The cheese flavour attribute was the best positive TDL, whereas bitter was a strong negative TDL. A cluster analysis of the 667 consumers identified three significant liking clusters, each with different most and least preferred samples. These results showed the importance of overall liking segmentation before TDL analysis to determine which attributes should have a longer dominance duration in order to please specific consumer targets. The impact of multiple cheese consumption on changes in the perception of dominant attributes and the level of their liking was not reported in the studies (Publication II.A.7, Project II.I-1.5).

3.2. Sensory education and its role in the perception and acceptance of products by children, adolescents and adults

Expectations of food products quality and dietary preferences are largely based on family models shaped from childhood. Sensory experiences include multimodal perception, memory, expectation and actual consumption, which determines eating habits, product choice and its consumption. Food preferences can be modified through various educational programs targeted at children and adolescents of different ages; for example, one aim being to increase their readiness and openness to eating fruit and vegetables. Important parts of sensory education are: 1) presentation and being aware of the role played by the senses in assessing food quality, making food choices, consumption and in the acceptability of food products; 2) an interest in identifying those sensory properties of products when using the senses; 3) engaging participants in various tasks related to sensory perception, including food preparation for eating. Such issues can be an important part to shaping positive eating habits and limit nutritional neophobia. To achieve this goal, an original program of sensory

workshops and research were developed and targeted to children and young consumers (including adolescents).

Referring to the thematic area, the aim of the research was to determine the perception and acceptance of odours in preschool children and to examine the memory for odours in the context of single lesson (episode). Three research stages have been completed: 1) odour identification and assessment of their acceptance; 2) odour education by integrating different senses; 3) and odour identification after education. The research was carried out in the kindergarten on a sample of preschool children (n=94-121). Eight natural odours representing three categories (fruits, vegetables, spices) were used as stimuli. The measurement was based on intermodal sensory matching test (recognition of odour) and 5-point mimic scale (acceptance of odour). In the sensory matching test the children's task was to match the odour of a sample to corresponding pictures of fruit, vegetables and spices presented on the board. The board with pictures (15 product of photographs representing fruits, vegetables, spices and one field - empty, denoting the answer „I do not know") was used. While odour learning via multisensory integration, products were presented in the whole, on the cross-section, odour samples and their name. Each child was able to learn about different attributes of the sample (shape, size, colour, surface, cross-section colour and smell) in their integration. The results have shown that the recognition and acceptance of odours among children (n=121) depended on the product type. Children most easily recognized the odour of paprika (from the group of vegetable and spice odours) and fruit odours, such as lemon and banana. In general, children were able to classify samples into appropriate fragrance groups (fruit, vegetable/spice). The efficiency of the recognition and memory for odours enhanced with age. The acceptance results indicated that children liked the fruit odours more than other type of odours, which were generally assessed negatively.A single learning session improved children's performance in the identification task but this effect depended on the type of odour and age range of the children (n=94). For example, it was observed that the youngest children could more easily recognize the odour of paprika, mushroom, strawberry and pineapple than pepper or banana. The children willingly participated in the tests and were absorbed in such form of learning (especially to know new fruits and vegetables) (Conference materials III.B-1.6).

To gain insights into factors determining perception of food products by adolescents using quantitative approach combined with practical task during sensory workshop. 765 adolescents aged 11-13 years from Poland took part in the sensory workshops. The questionnaire covered aspects such as: 1) perception of food packaging including practical task with 15 s exposure; 2) identification the odour of various herbs/fruits and

sensory properties of product (yoghurt); 3) consumption of the canapés which were prepared from various fruits and vegetables (integration of different senses through the reception of visual, taste, flavour, texture, auditory impressions). Additionally, it was determined such aspects like preparing meals with parents/grandparents, preferences and familiarities of fruits/vegetables and the importance of senses in fruits/vegetables choice and consumption and eating habits as consumers (now and in the future). Adolescents declared that the most important information for them on the product packaging was the expiry date and then ingredients, nutritional value, storage conditions. The least important were: brand and appearance. During olfactory task, it was revealed that the ability of identification and acceptance of odour by participants depended on the type of stimulus. Adolescents showed great creativity when describing their impressions related to the sensory quality of strawberry yoghurt. While preparing canapés, adolescents willingly included in their composition less known fruits and vegetables. They created visually attractive, tasty and acoustic products and enjoyed their consumption. About 80% of all adolescent declared that they are interested in getting to know new tastes/flavours by consuming products and they stated participate in preparing meals at home. Nevertheless many adolescents had a problem with giving examples of spices used in the process of seasoning. Among the listed, most popular spices were salt and pepper. A high share of participants claimed to be familiar with domestic and exotic fruits and they declared the desire to consume some unknown fruit (carambola, figs, avocado) but were far more reluctant to try unknown vegetables (e.g. chicory, asparagus, patison). A large group of children declared willingness to change their eating habits (e.g. reduce consumption of sweets and fast food products) (Conference materials III.B-2.1, III.B-2.2, Projects I-2.5, I-2.6).

An important research issue related to the identification of tools for sensory and nutritional education of young consumers (18-30 years) was to develop an innovative approach to determining the reactions of young consumers to interactive messages on the principles of healthy and sustainable diet, including messages related to the perception of sensory attributes of food products and meals. For this purpose, experimental studies were carried out that enabled the determination of the impact of messages sent using the mobile application „FoodUP", designed exclusively for the research project, on the attitudes of young consumers and their behavioral intentions. The messages contained graphic materials, animated photos and videos referring among others to health issues and sensory aspects of various food products and meals preparation and consumption. Personalized, according to the cluster membership, messages were sent to the participants every 2-3 days for the period of

four weeks, in which the frequency and time devoted to familiarize with the message during the implementation of the intervention study was recorded. It has been found that information transmitted via mobile applications can effectively motivate young consumers to change their food related behaviors. In addition, the opportunities related to the transmission of personalized information, increased the efficiency of reaching young consumers with adequate messages matching their expectations (Publication II.A.4, Project I-2.3).

3.3. Sensory and non-sensory factors affecting consumer choice and consumption of food products

Another research topic was related to the determination of sensory and non-sensory factors for consumers' decision-making processes as well as for consumers' expectations of quality, taking into account the effect of external appearance features, sensory memory and in generating expectations regarding taste/flavour of food products in the context of their acceptability, consumption and the shaping of experienced quality. Human senses play a significant role in these issues. Taking such considerations into account, I undertook research for determining the significance of the aforementioned factors in a study on food choice and acceptability using in-house developed approaches to the methodologies employed.

In one of the works, research on drinking strawberry yoghurts (in the traditional and light version) was carried out. The aim of the study was to determine: 1) the visual and taste/flavor factors (sensory and non-sensory) determining the consumers' impression and acceptance of products by Check-All-That-Apply method; 2) the relationship between the expected and experienced liking and associated emotions before and after consumption of the products with 9-point hedonic scale; 3) sensory characteristics of products using Napping® and Ultra-Flash Profiling; 4) motives and frequency of consumption of yoghurts by consumers and their preferences regarding the selection and purchase of such products. The consumer test were performed in sensory laboratory by 110 respondents at the age of 22-23 years. It was found that the yoghurts differed in sensations related to visual sensory and non-sensory characteristics. In the visual perception of consumers, the shape of the packaging, its graphics and information provided by the manufacturer played a significant role, which determined the level of liking and the type of emotions in relation to the product. Yoghurts evoked different feelings related to sensory and non-sensory attributes after their consumption. Light version of products were characterized by a low degree of acceptance and were perceived as bitter, very sweet and artificial in taste/flavour, as well as cheap and

unhealthy. The relations between expected and experienced quality in terms of liking and emotions caused before and after consumption of products depended on their sensory characteristics. In general, the expected quality was significantly higher than the experienced quality, regardless of the version of yoghurt (traditional versus light). The results were correlated with the taste/flavour of the evaluated products. At the same time, consumers have declared that the taste is the basic factor influencing their decisions to buy and consume yogurts, then the nutritional value, consistency of the product, price and habits were important to them. The motivations associated with the consumption of yoghurt are related to positive sensations of taste/flavour and health benefits (mainly regulation of digestive system, influence on bone structure and increasing the body's resistance) (Conference materials III.B-1.20, III.B-1.21).

In another work, research was carried out among people with vision dysfunction. The aim of the study was: 1) to investigate the factors determining the choices of food products in people with impaired vision; 2) to identify the obstacles visually impaired people face while purchasing food, preparing meals and eating out; 3) to determine what would be helpful for them in the domains of food shopping and meal preparation. A novelty of this research is to determine the importance of sensory attributes in the selection of different group products by visually impaired people. Data were collected from 250 blind and visually impaired people. Participants were recruited mainly through the National Association of the Blind. The study revealed that majority of visually impaired make food purchases at a supermarket or local grocery and they tend to favour shopping for food via the Internet. Direct sale channels like farmers markets are rarely used by visually impaired. The most important factors that facilitated their food shopping decisions were the assistance of salespersons, product labelling in Braille, scanners that enable the reading of labels and a permanent place for products on the shop shelves. The results showed that visually impaired people considered price and brand to be the main factors determining the purchase of food, while sensory aspects, such as taste/flavours, were mentioned by them less frequently. Respondents also declared that they usually buy products of the same brand for many years and do not use a wide range of food products. This may be due to many obstacles they face when it comes to evaluation of external quality cues and feelings of discomfort associated with asking others for assistance. Another issue is the poor access to information provision on new and innovative food products and brands. Almost all respondents (regardless of the degree of vision dysfunction) indicated that they are interested in having information in the Braille about product name (98.4%), price (91.2%) and expiry date (89.2%). In addition, 76.0% of

respondents said that information on storage conditions would also be helpful and helpful in this regard. Participants with visual impairment indicated that features such as freshness, taste/flavour and consistency influence their purchasing decisions, but the importance of these attributes was product related. For instance in case of meat and meat products, the impaired vision consumers mentioned freshness, fat content and odour as primary sensory cues. The most frequently mentioned attributes determining the choice of fruit and vegetables by people with visual dysfunction were their freshness, an appropriate firmness, taste/flavour and a lack of defects/blemishes. Considering the issues related to the meal preparation, it was found that particularly peeling, slicing and frying pose many challenges to visually impaired. More than half of the respondents eat the meals outside the home but mainly with family or friends. Helpfulness of the staff and menu in Braille were crucial for them to create positive dining out experience. The results of the study provide valuable insights into the food choices and eating experiences of visually impaired people, and also suggest some practical implications to improve their independence and quality of life. It was found that retailers and restaurateurs can improve access to products and services to meet the expectations of consumers with sight dysfunction through a better understanding of their needs in terms of shopping, culinary experience and customer service and product labeling in Braille (Publication II.A.6).

3.4. Implementing sensory, analytical instrumentation and psychophysiological research for determining the quality of selected food products regarding those substances responsible for flavour

A vital issue in these scientific studies is linking together the results/outcomes obtained by sensory, instrumental and/or psychophysiological research. This approach enables a deeper analysis of the results in terms of, amongst others, the impact of various technological processes on sensory quality and the acceptability of food products by consumers. Nevertheless, an interesting issue concerns the characteristics of volatile compounds responsible for giving many food products their typical aroma and flavour. This aspect is particularly important in the process of flavouring food as well as for non-food products.

The studies compared the composition of volatile compounds and sensory properties of smoke preparations and their seven smoke fractions (obtained at various mean boiling points at the top of the rectification column measured) produced from the same raw material (ash wood), but obtained by two different methods. The objective of the study was to

determine which compounds or groups of them are responsible for the characteristic, desirable smoke-cured flavour. It was found that preparations obtained by distillation and reconstituted preparation (mixture of all fractions in appropriate proportions) showed very similar composition of volatile compounds. In contrast, the preparation obtained by extraction/distillation method did not contain carbonyl compounds. In sensory profiles there was a great difference between smoke flavourings. In sensory profiles there was a great difference between smoke flavourings: preparations obtained by distillation (SF-DP) had „smoke-meat" leading note accompanied by „caramel" and „bulion-type" ones, whereas the profile of the preparation obtained by extraction was profile was dominated by „died bonfire" and „medicinal" notes (negative attributes) and represented less intense „smoked odour". Among analysed fractions, only F2 (120°C) demonstrated the profile similar to SF-DP; other fractions had not (or very weak) „smoke meat" attribute. In chemical composition among all fraction, F2 had the highest share of carbonyls (cycloten, 3 methylocyclopenten), phenols (phenol, o-cresol, p-cresol) and guaiacols (guaiacol, 4-methyloguaiacol) and only traces of syringol ones. Probably these compounds were responsible for the characteristic smoked aroma (Publication II.A.1).

In other studies, the sensory profile and psychophysiological reactions of consumers were determined in relation to various flavoring substances, including lemon, cinnamon, chocolate, Cheddar cheese and coconut aromas. In addition, the respondents` opinions about the mentioned odours have been taken to find out if there was a correlation between the degree of liking the odours and the emotional reaction of responders. Three stages of the research were performed using different methods: 1) qualitative and quantitative characteristics of flavouring substances (QDA method); 2) emotional reaction of consumers (galvanic skin response, muscle tension and the pulse measurements); 3) memory responses and liking of odours by consumers (the survey). The sensory characteristics of odour flavourings were evaluated twice by an expert panel. Twelve consumers participated in the psychophysiological research and sixteen respondents took part in the survey. The changes in the odour characteristics depended on the type of flavouring substances and their concentrations. Larger differences in the intensity of some odours with the concentrations of flavourings were observed for lemon, cinnamon, Cheddar cheese than for chocolate and coconut ones. It was found that the results of psychophysiological reactions were related to the variety of the flavouring substances and individual responses of consumers. The odour of cheese evoked the most negative emotion whereas lemon and chocolate induced reduction of muscle tension and caused calmer reaction of consumers. The outcome of the study showed a

relationship between the sensory image of flavourings and emotional reaction of consumers; the degree of liking various odours and memory recalling of odours (Conference materials III.B-1.15).

The purpose of other research was to examine the impact of drying methods (vacuum, convection and sublimation) and their parameters on the properties of strawberries (their structure, mechanical parameters and sensory profiles). It was found that the applied drying methods and their parameters influenced the diversification of the internal structure of strawberries, their mechanical and sensory properties. The largest deformation of the structure was noted in the strawberries from dried convection, which at the same time represented the highest impression of adhesiveness, chewiness, hardness and were difficult to fragment into small pieces. The evaluated sample of strawberries differed in the sensory profile (appearance, texture and taste/flavour). The highest correlation between sensory and mechanical properties was found in the case of vacuum dried VD fruit (55°C, 4kPa). Differences in the intensity of attributes determined the overall quality of samples and the applicability of the drying method in practice. The results of the presented research are included in the publication: Piotrowski D., Kostyra E., Grzegory P., Janiszewska-Turak E., 2018: Influence of drying methods on structure, mechanical and sensory properties of strawberries fruits, Journal of the Science of Food and Agriculture, in review, 35 pts MSaHE). The publication is in the process of evaluation.

4. Summary of scientific publications

Publication record including number of points according to MSaHE journal rank and *Impact Factor* values was included in Table 1.

Tabela 1 Summary of scientific publications with regard to Polish Ministry of Science and Higher Education scoring and *Impact Factor*

No	Publications	Number of publications		Polish Ministry scoring by year	IF (by year)	IF (5-year)	Sum of scoring based on Ministry scoring
		Before PhD	After PhD				
1	2	3	4	5	6	7	8
A. Publications published in scientific journals with the Impact Factor (IF), and indexed in the Journal Citation Reports (JCR)							
1.	Food Research International	0	1	40	3,086	3,856	40
2.	Appetite	0	1	35	3,403	3,843	35
3.	Meat Science	0	1	35	3,126	3,313	35
4.	LWT – Food Science and Technology	0	1	35	2,329	2,929	35
5.	British Medical Journal Public Health (BMC Public Health)	0	1	35	2,265	2,814	35
6.	Food Quality and Preference	0	1	32	3,013	3,098	32
7.	Food Quality and Preference	0	2	24	3,592	4,23	48
8.	Food Quality and Preference	0	1	24	1,365	brak	24
9.	Polish Journal of Food and Nutrition Sciences	0	1	15	0,679	brak	15
10.	Journal of the Science of Food and Agriculture	0	1	24	1,386	1,674	24
Total		**0**	**11**	**-**	**24,244**	**25,757**	**323**
B. Publications in scientific journal without Impact Factor, included in the list B of MSaHE journal rank							
1.	Żywienie Człowieka i Metabolizm	1	0	1	0	0	1
2.	Gospodarka Mięsna	1	0	0	0	0	0
3.	Roczniki Instytutu Przemysłu Mięsnego i Tłuszczowego	1	0	2	0	0	2
4.	Żywność Nauka Technologia Jakość	1	0	3	0	0	3

1	2	3	4	5	6	7	8
5.	Roczniki Instytutu Przemysłu Mięsnego i Tłuszczowego	2	0	2	0	0	4
6.	Przemysł Spożywczy	1	1	3	0	0	6
7.	Polish Journal of Food and Nutrition Sciences	2	0	4	0	0	8
8.	Żywność Nauka Technologia Jakość	0	1	4	0	0	4
9.	Postępy Techniki Przetwórstwa Spożywczego	0	4	4	0	0	16
10.	Polish Journal of Natural Sciences	0	1	2	0	0	2
11.	Zeszyty Problemowe Postępów Nauk Rolniczych	0	1	3	0	0	3
12.	Handel Wewnętrzny	0	1	6	0	0	6
13.	Postępy Techniki Przetwórstwa Spożywczego	0	2	5	0	0	10
14.	Żywność Nauka Technologia Jakość	0	1	13	0	0	13
15.	Postępy Techniki Przetwórstwa Spożywczego	0	2	6	0	0	12
Total		**9**	**14**	-	-	-	**90**
C. Chapters in scientific monographs							
1.	Research works published in English as chapters in a monograph	0	1	5	0	0	5
2.	Research works published in English as chapters in a monograph	0	1	4	0	0	4
3.	Research works published in Polish as chapters in a monograph	0	3	3	0	0	9
Total		**0**	**5**	-	-	**0**	**18**
D. Chapters published in Polish in academic course books							
1.	Chapter	0	2	3	0	0	0
Total		**0**	**2**	-	-	-	**0**
E. Publications in conference materials indexed in Web of Science							
1.	In the form of abstracts, in English	0	2	0	0	0	0
Total		**0**	**2**	-	-	-	**0**

1	2	3	4	5	6	7	8
F. Publications in conference materials not indexed in Web of Science							
1.	In the form of abstracts, in English	2	29	0	0	0	0
2.	In the form of proceedings, in English	1	3	0	0	0	0
3.	In the form of abstracts, in Polish	4	10	0	0	0	0
Total		**7**	**42**	-	-	-	**0**
SUMMARY							
Publications in total		**92**		**Total points**	**IF (by year) 24,244**	**IF (5-year) 25,757**	**Total points 431**

My scientific achievements cover in total **92** works, including **11** research manuscripts published in journals indexed in the *Journal Citation Report* (JCR) in the years 2006-2017 (number of points **323**). The remaining achievements include:

- 23 manuscripts published in domestic journals without the IF and included in the B List of MSaHE journal rank;
- 5 chapters published in English and in Polish in scientific monographs;
- 2 chapters in an academic course book;
- 49 publications in the form of abstracts and proceedings in the conference materials.

The total number of points for publications acc. to MSaHE journal rank (acc. to the year of publishing) is **431 points,** including **126 points and IF 10.264** for works constituting the Main Scientific Achievement for Habilitation procedure. The number of points of my scientific papers published after achieving my Ph.D. degree is **392** points (according to the MSaHE list, appropriate for the year of publication).

Total Impact Factor of my publications (according to the JRC list, appropriate for the year of publication) is **24.244** while the 5-year Impact Factor for them is **25.757**.

According to the ICI Web of Science database the number of cites accounts for **83** (without self-cites for **81**). The Hirsch Index acc. to the ICI Web of Science database is **5**.

According to the Google Scholar database the number of cites accounts for **240**. The Hirsch Index is **8**.

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