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Consumer facial expression in relation to smoked ham with the use of face reading technology. The methodological aspects and informative value of research results

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ABSTRACT

The study determined the emotional reactions of consumers in relation to hams using face visualization method, which was recorded by FaceReader (FR). The aims of the research were to determine the effect of the ham samples on the type of emotion, to examine more deeply the individual emotional reactions of consumers and to analyse the emotional variability with regard to the temporal measurement of impressions. The research involved testing the effectiveness of measuring emotions in response to the ongoing flavour impression after consumption of smoked hams. It was found that for all of the assessed samples, neutral and negative emotions prevailed as the overall emotions recorded during the assessment of the taste/flavour impression. The range of variability of the overall emotions depended more on the consumer reactions and less on the properties of the assessed product. Consumers expressed various emotions in time and the ham samples evoked different emotional reactions as an effect of duration of the impression.

1. Introduction

Consuming a product is not limited to just satisfying hunger but also involves perceiving sensations due to its sensory properties and other features. Those sensations are internal, complex experiences; they include the assessment of the product's sensory properties and are the source of satisfaction, pleasure, happiness, etc., which are guaranteed by the definition of a food product (food) (Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January, 2002). Consumers select a food product when the quality of the product meets their expectations (Baryłko-Pikielna & Wasiak-Zys, 2004).

According to Steenkamp (1990) consumers create quality expectations based on their past experience with a product during consumption and they take into account information available at the shopping place. The expectations are related to quality cues, both intrinsic (sensory and physical characteristic) and extrinsic (e.g. brand name, price, labelling, production) attributes of the products (Verbeke et al., 2005; Deliza & Macfie, 1996; Grunert, 2002).

Sensory characteristics of food evoke emotional reactions of pleasure or disgust which play an important role in the choice and the preference of products by consumers (Eertmans, Baeyens, & Van den Bergh, 2001). Jiang, King, and Prinyawiwatkul (2014) list sensory properties (taste, odour, texture, appearance), type of food (starchy food, meat, snack, beverage, herbs and spices) and the individual's characteristics (food familiarity, gender, personal disposition, food association due to various eating habits, education, culture) as factors that can elicit emotional responses to food products. Foods of various sensory features may evoke different emotional responses from consumers. Moreover, the survey carried out by Desmet and Schifferstein (2008) showed that 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%). 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).

Emotions treated as either the basis or supplementary to sensory research are developing dynamically, especially in the case of consumer science. The use of emotions as an element of food sensory assessment is described by King, Meiselman, and Carr (2010) who indicated that it

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is necessary to distinguish emotions from moods because it is significant in the subsequent interpretation of results.

Previous research on emotions examined different issues e.g. the effect of real (tasted) and conceptual (names) food stimuli on emotional responses (Cardello et al., 2012), consumers' emotional responses to food packaging (Liao, Corsi, Chrysochou, & Lockshin, 2015); the influence of emotions expressed by external eaters on the desire to eat the foods (Barthomeuf, Rousset, & Droit-Volet, 2009); measurement of emotions evoked by fragrance (Churchill & Behan, 2010); emotional changes after eating chocolate (Macht & Dettmer, 2006); temporal dynamics of sensory and emotional attributes during chocolate tasting (Jager et al., 2014), whether consumers' willingness to eat hamburgers depends on the emotions they experience when confronted with the food (Olsen, Røssvoll, Langsrud, & Scholdere, 2014); and the effect of culture and language on reported emotions (van Zyl & Meiselman, 2015).

There are numerous methods that are being applied for measurements of emotions including traditional conscious verbal approach (subjects complete a self-report questionnaire usually scaling a number of criteria) and those involving cognitive, physiological and/or behavioural expressions (Churchill & Behan, 2010). According to Jiang, King & Prinyawiwatkul (2014) many non-verbal measurements like observation of emotion suggested by facial, vocal, and body gestures can be used complementary to verbal ones. Different systems for facial scaling have been developed such as Noldus FaceReader (http://www.noldus.com/human-behaviorresearch/products/facereader), PrEmo (http://www. premo-online.com/en/home) and Sensorylogic (http://www.sensorylogic.com/) (Jiang, King & Prinyawiwatkul, 2014; King, Meiselman & Carr, 2010). On the other hand, the psychological research determines a direct reaction to emotional response of consumers by using skin conductance, heart rate and others (Bensafi et al., 2002).

The sensory assessment of food products by means of recording emotions is still a little-known technique, but it has great potential for a better understanding of consumer preference factors. This is significant when new assortments of products are introduced to the market and is crucial in developing scientific discipline to seek new research methods which could be recognized as objective and helpful in shaping characteristics that would yield high desirability among consumers (Tuorila & Monteleone, 2009).

FaceReader is applied for conducting research in consumer behaviour as well as in education, psychology and market study (Danner, Haindl, Joechl, & Duerrschmid, 2014). The possibilities of the device are related to the direct scanning of consumer's emotional reaction during or after consumption of a product as opposed to self-reported questionnaires such as those used in EsSense Profile or rating the animations of a cartoon character in accordance with emotional reactions (PrEmo).

In the available literature little research has been undertaken with the use of FaceReader device to measure the facial expressions in relation to taste/flavour, and there is no study which takes into account emotion elicited by solid food, for example meat products. According to Font-i-Furnols and Guerrero (2014) the sensory enjoyment of meat is associated with several features like visual appearance and in-mouth perception of both texture and flavour, but preferences in this respect are not homogeneous among consumers.

One of the most popular meat products among consumers is cured ham. However, up till now, little research has been published about the intrinsic and extrinsic features of such kind of a product from the perspective of consumers, regarding the hedonic acceptance, emotional responses and also considering the profiling characteristics done by expert panel. There are various numerous references with respect to sensory aspects of the dry-cured ham ("serrano type"), including liking effect (Pham et al., 2008; Morales, Guerrero, Aguiar, Guírdia, & Gou, 2013; Ruiz, Garci'A, Muriel, Andre'S, & Ventanas, 2002).

Present study attempted to statistically interpret the results obtained after the consumption of smoked ham by means of facial expression recognition registered with a FaceReader device as a consequence of the duration of the flavour sensation in the mouth. The aims of the research project were also to determine the effect of the product (ham samples) on the type of emotion, to examine more deeply the individual emotional reactions of consumers and to analyse the emotional variability with regard to the temporal measurement of impressions. This research is based on methodological issue associated with the use of the new sensory device-aided method like FaceReader (FR) to determine the type of emotion expressed by consumers in relation to solid sample on example ham.

The available technology for facial expression interpretation is based on the developed face expression models that correspond to different types of emotions (Danner, Sidorkina, Joechl, & Duerrschmid, 2013). In the experiment consisting of face observation immediately after consumption of selected meat products, the facial expression was interpreted basing on six basic types of emotions: happiness, sadness, anger, surprise, scared and disgust. The lack of those emotions was recognized as neutrality (indifference).

The present study is a part of a larger project determining the sensory characteristics of pork products and taking into account the effect of the sensory and non-sensory factors on the acceptability of meat products by consumers.

2. Material and methods

2.1. The research material

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 × Duroc (R2), fed from 50 kg BW 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. All diets were iso-energetic and iso-protein. The average body weight of slaughtered pigs was 107 ± 5 kg (170 ± 5 days of age).

The hams were produced in the "Olewnik-BIS" Meat Factory in Poland. All of the products were made using the same technology, with the following technological assumptions: a) ready product efficiency 105–110%; b) no added phosphates; and c) limited use of additional substances (sodium citrate, sodium ascorbate, sodium nitrite). The smoking was conducted in industrial conditions, and the same parameters were applied to ham made of meat from each testing group. The technological process of meat products ensured preservation of nutrients and healthy components. It has been submitted to the Polish Patent Office (Patent: P-410127). Five hams were provided to the sensory laboratory (at the Faculty of Human Nutrition and Consumer Science, WULS-SGGW, Warsaw).

2.2. Experiment design and methods

2.2.1. The principle of sensation measurement with the use of a FaceReader device

FaceReader 4 software (Noldus Information Technology, Wageningen, The Netherlands) allows the assessment and analysis of a consumer reaction thanks to recording in time: the intensity and type of reaction, the facial expression, the indication of head orientation, as well as some other information such as: eyes—open/closed, mouth—open/closed, and eyebrows—raised/no reaction/lowered. Particular emotions are appropriately classified to enable the determination of whether the reaction to the food product consumed was positive, negative or neutral. FaceReader records a face image with a specified time definition and it interprets each recorded state with the use of six abovementioned emotions, the intensity of which is measured in a numerical scale from 0 to 1 (st. u.—standard units). It also measures in the same scale the neutrality (the seventh characteristic of emotions), e.g., the deformation of the baseline situation by emotions evoked by a

particular stimulus. For each recorded measurement, an individual result is obtained. An example of an individual record contributing to the full assessment is presented in Fig. 1.

This software reproduces the face three-dimensionally based on 491 model points allowing a reliable measurement of the aforementioned facial patterns. The device does not retrieve a result if there are circumstances or consumer behaviours which make the right assessment of all the particular emotions impossible. For this reason, in spite of the steady time of observation, the number of images varies. It must be noted once again that a result is retrieved only when it is complete. An example of a complete result of recording sensations expressed after consumption of smoked ham and an example of this assessment interpretation are presented in Fig. 2.

In the present study, to minimize artefacts due to solid sample tasting and chewing, the emotions of participants were recorded by a video camera within 30 s after consumption of a particular piece of ham. The time of the emotional reaction was established during a preliminary study with the Time-Intensity measurement of saltiness and smoked flavour impression in ham samples. During this time, approximately 100 to over 300 images (individual face shots) were recorded and interpreted with special software to evaluate the intensity of particular emotions and neutrality. This resulted in a set of data for statistical analysis consisting of 35.172 records, with each record consisting of 7 numbers describing the intensity of particular emotions in a given moment after consumption of a particular product and the state of neutrality. We found 4.541 empty retrievals among all the recorded images. These were the results that could not be interpreted as face images in a sensible way. Those empty records amount to almost 13% of all records. They are not desirable, but they make the rest of the records more reliable.

2.2.2. Subjects

2.2.2.1. Facial expression recognition (semi-consumers study). In the study the facial expression of 30 consumers were measured in relation to the smoked ham. The mean age of respondents was 23 years and 70% of them were female. They declared (88%) their consumption of meat products either every day or several times per week. The study was based on methodological issues so it was acceptable to use fewer respondents compared to a typical consumer study.

2.2.3. Sample preparation and presentation

To measure emotions with FaceReader, each consumer received one slice of ham of 3 mm (size 1.5 cm × 3.0 cm) at room temperature (21 ± 2 °C) in plastic containers coded with 3-digit random numbers. The assessment procedure for respondents was as follows: “please, taste the whole presented sample, take approximately a 10 second break after swallowing it, then give a start signal to the experimenter. A facial expression will be measured as a result of the taste/flavour impression in relation to the sample”.

2.2.4. Testing conditions

The assessment was performed in the Sensory Analysis Lab of the Laboratory of Food Assessment and Diagnosis in the Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences, which fulfils all requirements for accredited sensory laboratories specified in the ISO standard (ISO 8589, 2007). The FaceReader sessions were conducted in the morning and early afternoon hours.

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, using Media Recorder software (Noldus Information Technology, Wageningen, The Netherlands). 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 test person sat and looked frontally into camera (angle <40 °C). The particular distance of respondent from the camera was 50–60 cm. During research the strong shadow or reflection were eliminated to produce reliable results. Two USB LED lights (to either side of the monitor) to illuminate the test participants face were used. Before analysing facial expression, we selected the face model “General” (from models such as “Children”, “EastAsian” and “Eldery”). This model works well under most circumstances for most people.

2.2.5. Statistical analysis of the results

Particular facial expressions simultaneously show the intensity of all the distinguished emotions. Each may express a “full reaction”, which is indicated with the number 1, no reaction, which is indicated with the number 0, or an intermediate state represented by a fraction between 0 and 1.

Increasing or decreasing of particular emotions during the assessment changed the state of neutrality as appropriate. By principle and intuition, a high state of neutrality should be expected when there are no emotions expressed. It is typical that particular emotions during consumption change dynamically, namely, their intensity; they often appear as short or individual impulses, which is typical, especially for high levels of emotions (Fig. 2). Such situation is a challenge for the analysis, which, due to merging numerous emotions in one facial expression, should be a multidimensional analysis. A proper statistic from a multidimensional analysis sample is the centroid, which is a vector of the average values from a sample for k examined variables (Aczel, 2000). The centroid can be written as:

$$\overline{X} = \begin{bmatrix} \overline{X_1} \\ \overline{X_2} \\ \vdots \\ \overline{X_k} \end{bmatrix}.$$

Even a preliminary assessment of a record from an individual experiment (occurrence) shows the appropriateness of searching for certain repeating patterns (profiles in case of model states, many centroids). It is also challenging to interpret the intensity of particular emotions

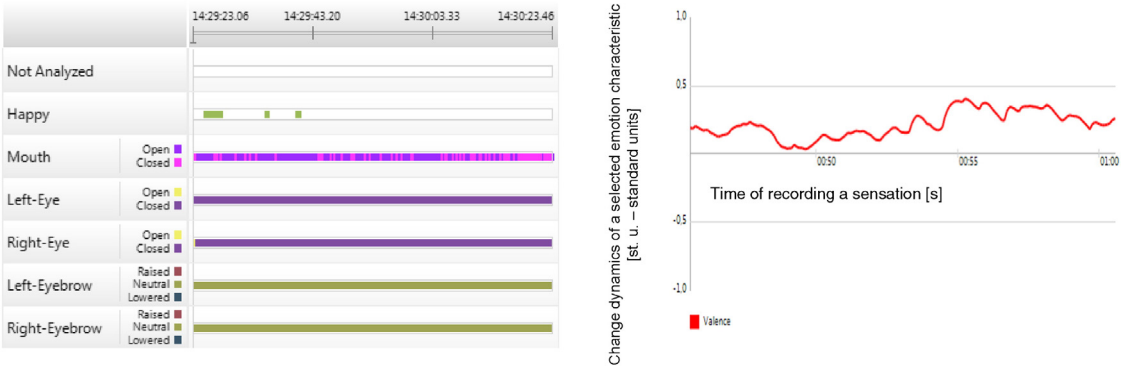


Fig. 1. An example of data obtained during an individual measurement of facial expression recognition recorded by a FaceReader device (an individual image).

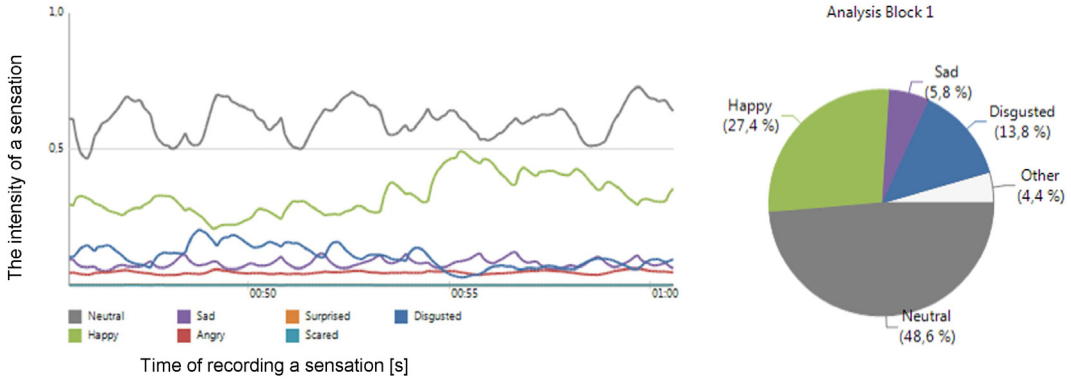


Fig. 2. An example of a result and an interpretation of a single experiment—a person's facial expression recognition immediately after consumption of the ham sample.

in the context of sensory features and other properties of a food product, which are the subject of the assessment.

This study also analyses results based on Kohonen's neural networks for the classification of occurrences, i.e., emotional states in subsequent moments from the start of the taste/flavour impression of the sample after consumption by means of the software Statistica (StatSoft, Inc. 2011, version 10). The self-organizing Kohonen's neural networks were used in order to look for similarities and differences among multi-dimensional vectors of emotions (six emotional types and neutrality). This type of network is capable of "mapping" variability of emerging clusters of cases (vectors) similar to each other. The networks of various sizes were used to classify, from 4 to 11 neurons in the output layer, by training them on a set of available data. Each network was taught in 300 passes (periods), and a learning coefficient was changed in the range from 0.7 to 0.01.

The classification with five clusters is presented in this article as it's satisfactory in terms of clarifying variation of consumer's emotion, it is characterized by more than half the total explanation of the measures of variability (calculated correlation value for each type of emotion ranged from 0.2 to 0.9, with an average of 0.6). The emerged and presented clusters represent the emotional profiles, which were called by taking into account the predominant type of emotion.

3. Results

3.1. The general description of the output data obtained from a FaceReader device

The preliminary and general analysis of the obtained results revealed that the ranges of variability (fluctuation) of particular types of emotions were different. In the experiment involving 30 respondents and the five ham samples, *neutrality* was the most expressed among other emotions at the average level of 0.58 ± 0.35. Subsequently *sadness* appeared to be the prevalent emotion with the high average level of a little over 0.22 and the large variability—the standard deviation was 0.29 which covers almost 1/3 of the nominal variability range. The subsequent emotions in regards to agitation are *scared* and *happiness*; the averages were at the levels of 0.13 ± 0.25 and 0.09 ± 0.19. The other emotions, e.g., *anger*, *disgust*, and *surprise*, did not appear; they were only at the margins of the overall emotional reactions. Consequently, the average neutrality was 0.58 ± 0.35 (Fig. 3).

However, looking at the structure of emotions with regards to their intensity (volume), we can see that the largest share belongs to small emotions that do not exceed the level of 0.2. The other emotions, i.e., *happiness*, *sadness* and *scared*, with regards to their intensity are divided evenly across all the other ranges, although *happiness* has a smaller share than *sadness* and *scared* in each range. Thus, despite a modest "pool" of emotions, they show a differentiated character in relation to the power of expression and intensity. This result justifies further analyses to explain this diversity and shows the circumstances in which emotions of a particular type and intensity appear (Fig. 4).

Certainly, the principle presented above does not cover neutrality. Neutrality is a baseline state, and the appearance of any emotion replaces this state. Thus, it has the largest share in the highest possible level of sensations.

3.2. Product type versus emotional state

Following the principles of the research projects, we examined the influence of product type on the distinguished emotions. It was expected that a product type would significantly explain both the expressed emotion type and intensity, but it was found that it allowed only a moderate explanation. 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*. The correlation measurement showing the accuracy of the product composition impacts on these emotions were 0.14 and 0.11, respectively. These are low correlations that are connected with small but significant differences in the average values of particular emotions in the ham samples (Fig. 5).

Averaged in a multidimensional system, facial expressions for particular products are indeed placed close to each other. The distances between particular centroids in relation to the span of nominal variability ranges were small, sometimes even minimal. However, it is worth mentioning that those differences allowed us to distinguish two groups of products: the first group is product 1 (RK—control sample) and product

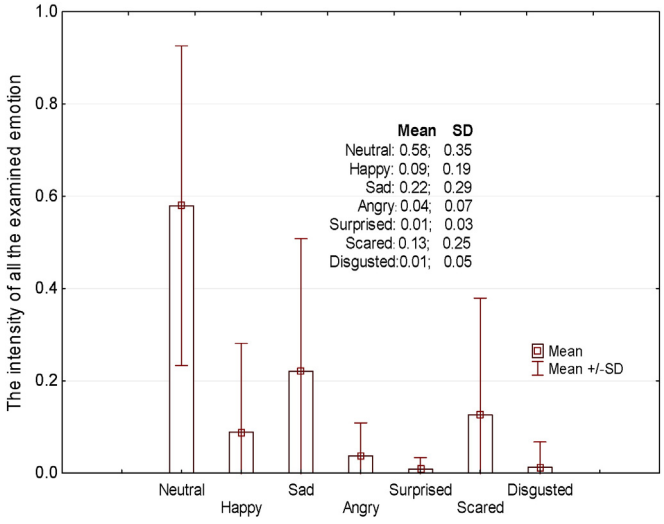


Fig. 3. The general performance graph of the experimental results related to the emotional response of respondents after consumption of smoked hams.

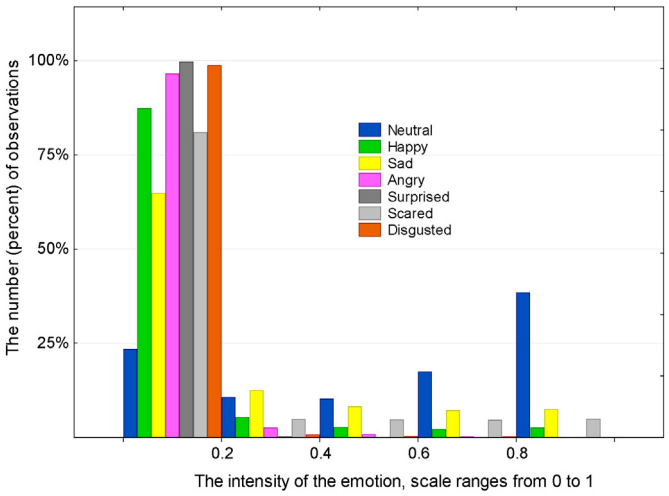


Fig. 4. The distinguished levels of particular emotions.

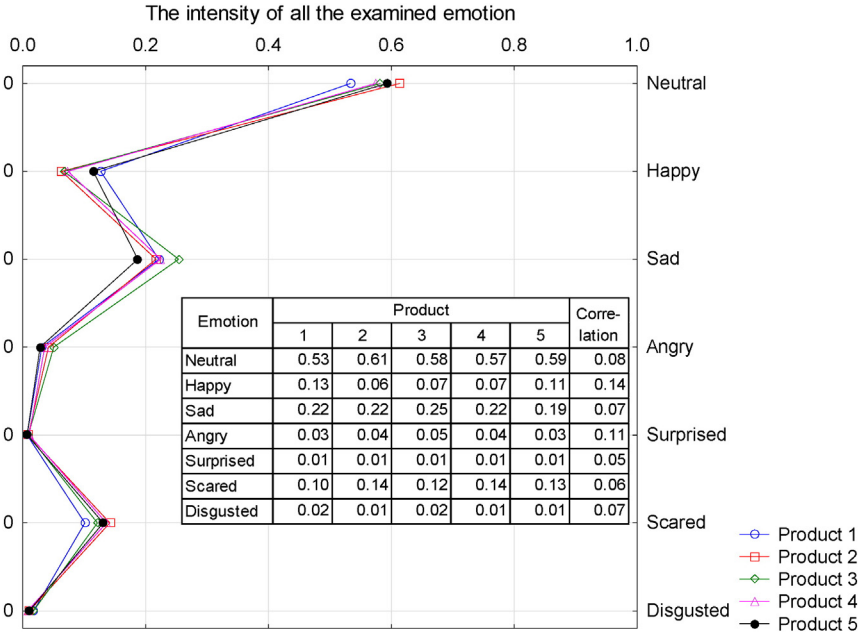
5 (R2D2—the product made of meat of animals of a mixed breed PBZ × Duroc with an increased level of vitamin E), which have slightly higher realization averages of *happiness* at 0.13 and 0.11, respectively; the second group consists of all of the other products, which have the realization average of the same emotion at the level of 0.06–0.07.

Using appropriate statistical tests, the differences between those groups in regards to this emotion are significant ($p \leq 0.05$), although because of the low correlation, these differences should be interpreted with great caution and circumspection. The averages of *sadness* appear to be interesting. In contrast to *happiness*, *sadness* is a negative emotion. Product 5 (R2D2) was the most preferably in regards to this emotion, suggesting that it obtained the lowest average level of realization against the other products, that is, 0.19 in comparison to the 0.22 of product 1 (RK). The highest level of this emotion was observed in case of product 3 (R1D2), with as much as 0.25; thus, this product was identified as one which evokes the most relative *sadness* and the least *happy* reactions. It is worth adding that this product obtained the relative highest level of another negative feature, *anger*. Although the products varied from each other slightly, they differed significantly in regards to higher correlation. This result may serve as a guideline for determining the extent and means of building a consumer's acceptance (or non-acceptance). The distribution of averages in the next negative emotion, *scared*, can also enrich this statement. In this case, the highest level was observed for product 2 (R1D1) and 4 (R2D1), it was slightly lower for product 5, and had the lowest value (i.e., the best) for product 1 (RK—control samples).

In summary, there are distinct profiles of facial expressions evoked by particular products. Although they differ from each other slightly and do not explain a considerable part of the general variability of facial expressions, it can be concluded that *happiness* is the main characteristic that positively differentiates product 1 (RK—control samples); a relatively high pleasure is accompanied by comparatively low levels of negative emotions concerning this product. A similar profile is represented by product 5 (R2D2—the product made of meat of animals of a mixed breed PBZ × Duroc with an increased level of vitamin E); however, it has a slightly lower level of *happiness*, *sadness*, and a slightly higher level of *scared*. From a marketing point of view, the profile of product 3 (R1D2—product made of meat of animals of PBZ breed with an increased level of vitamin E) was the worst, as it brought a low level of *happiness* and evoked many negative emotions.

Based on the outcomes, it may be claimed that the meat from animals of a mixed breed PBZ × Duroc contributed to hams with a better general acceptance than meat from the PBZ breed animals. The above results indicate that the larger dose of vitamin E added to the pigs' feed contributed to obtaining products with better sensory values, as reflected in the observed emotions. It should be noted that the distinctiveness of the results was low, which obligates us to draw conclusions with caution.

It was concluded that the emotional variability of persons consuming the same product should be examined. It is obvious that each person at least potentially represents their own preference, has individual likings and can accept different ideas in their life, such as current events and personal experiences. It is thus of interest to better understand to what extent the human factor explains the variability of emotions observed in the group.



Emotion	Product					Correlation
	1	2	3	4	5	
Neutral	0.53	0.61	0.58	0.57	0.59	0.08
Happy	0.13	0.06	0.07	0.07	0.11	0.14
Sad	0.22	0.22	0.25	0.22	0.19	0.07
Angry	0.03	0.04	0.05	0.04	0.03	0.11
Surprised	0.01	0.01	0.01	0.01	0.01	0.05
Scared	0.10	0.14	0.12	0.14	0.13	0.06
Disgusted	0.02	0.01	0.02	0.01	0.01	0.07

Fig. 5. Average levels of particular emotions by product type. Product 1—RK (PBZ, standard feed), Product 2—R1D1 (PBZ, standard feed + vit. E, lower level); Product 3—R1D2 (PBZ, standard feed + vit. E, higher level); Product 4—R2D1 (PBZ × Duroc, standard feed + vit. E, lower level); Product 5—R2D2 (PBZ × Duroc, standard feed + vit. E, higher level).

3.3. The variability of emotions in the group of consumers

The comparison of centroids from respondents' emotional states after consumption of ham samples reveals a great variability, especially in regards to *sadness* and *scared*. It is clear that a certain minority, but not insignificant group of consumers showed a high intensity toward those types of emotions (Fig. 6).

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). Certain differences consist mainly of a differentiated share of profiles representing a higher intensity of particular

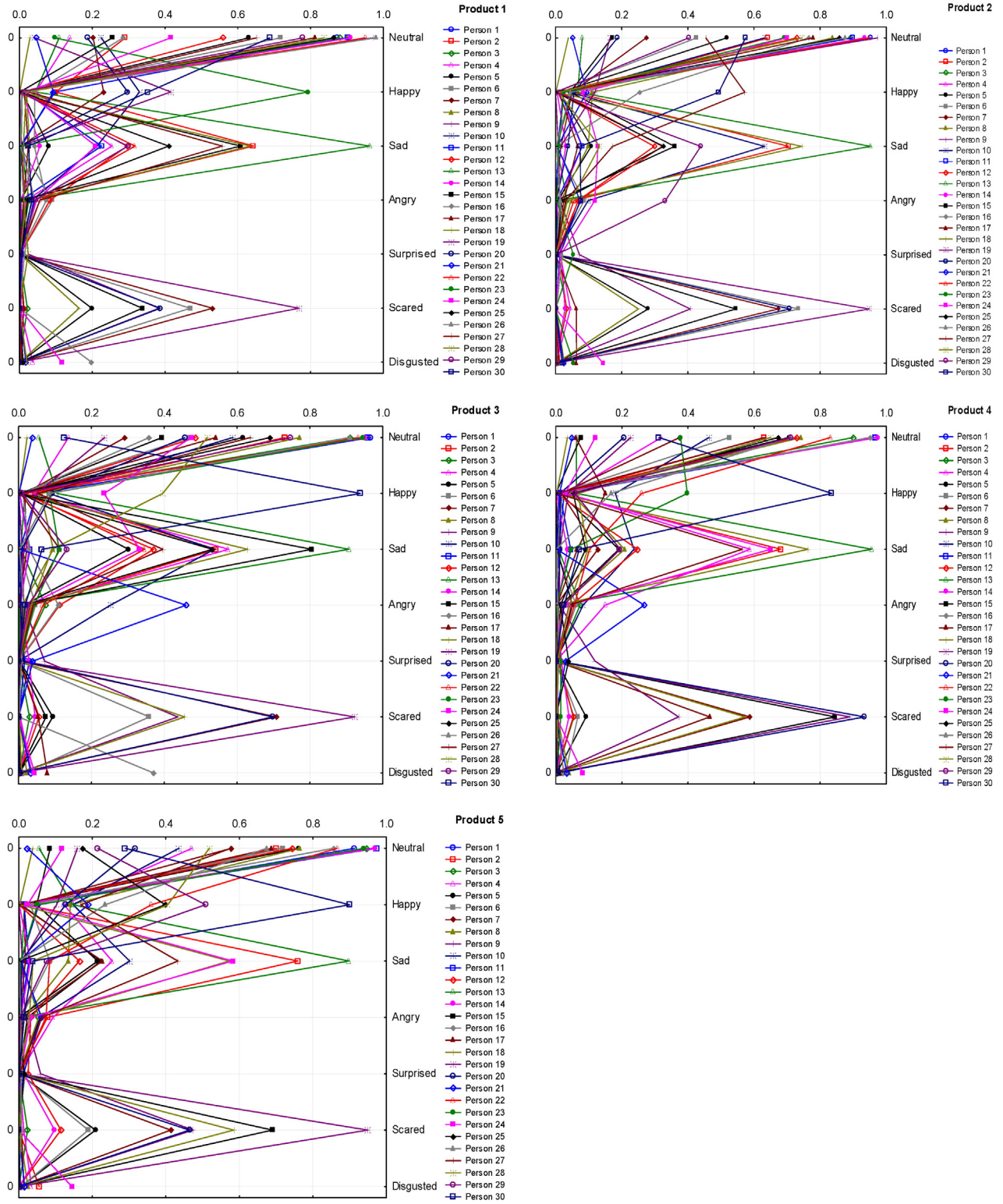


Fig. 6. Individual levels of particular emotions of consumers taking part in the research with the consideration of product type (axis x: The intensity of all examined emotions, individual results). Product 1—RK (PBZ, standard feed), Product 2—R1D1 (PBZ, standard feed + vit. E, lower level); Product 3—R1D2 (PBZ, standard feed + vit. E, higher level); Product 4—R2D1 (PBZ x Duroc, standard feed + vit. E, lower level); Product 5—R2D2 (PBZ × Duroc, standard feed + vit. E, higher level).

emotions, e.g., *happiness* appears more often at the intermediate or higher level while consuming products 1 (RK—control samples) and 5 (R2D2—the product made of meat of animals of a mixed breed PBZ × Duroc with an increased level of vitamin E). Generally, it should be noted that the above emotion averages result from sensations in a smaller group of people, in other words, as it was recorded, a considerable number of consumers showed restraint (a "poker face") when expressing emotions, but there were also spontaneous reactions.

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, i.e., 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.

Now it can be claimed with greater certainty that a person is the carrier of assessment determinants. A clearly smaller potential belongs to product features, at least in the case of that meat product experiment (Table 1).

3.4. Emotional variability versus the observation time

This study examined the time spent during the observation phase on emotional states. The nominal observation time was 30 s. If there were disrupting random incidents, the number of the distinguished states during this time exceeded 300. It is a relatively long sequence and can include a non-random distribution of emotions.

Consumers participating in the experiment received a product portion of an identical specified size. In turn, after the individualized process (act) of eating a different distribution of emotions is possible. In addition, one may become exhausted of impulses, which may lead to revealing random emotional states. Thus, 3 subperiods were distinguished in the complete time of observation: the first 100 non-empty measurements, the subsequent 100, and the rest of the recorded states (Fig. 7).

Indeed, there is a certain rule that states that while time passes from the start of the impression (after consumption), *happiness* declines and *sadness* increases. However, this rule is not absolute. It is accompanied by a correlation of 0.03 to 0.18, with the latter number concerning *happiness*.

3.5. Emotional variability—an exploratory analysis

In the next analysis, Kohonen's neural networks were applied for the classification of occurrences, i.e., emotional states in subsequent moments of impressions after the consumption of smoked ham. Kohonen's network, available in the Statistica software, is a self-organizing tool for mapping cases with a simultaneous consideration of numerous features. In the analysis process, all emotional characteristics and neutrality were included (7 characteristics).

After numerous trials of mapping different numbers of clusters, it was concluded that the classification of 5 clusters reflects the diversity of those states and simultaneously explains a significant part of the emotional variability (Table 2).

Product 1—RK (PBZ, standard feed), Product 2—R1D1 (PBZ, standard feed + vit. E, lower level); Product 3—R1D2 (PBZ, standard feed + vit. E, higher level); Product 4—R2D1 (PBZ × Duroc, standard feed + vit. E, lower level); Product 5—R2D2 (PBZ × Duroc, standard feed + vit. E, higher level).

The distinguished clusters were numbered from 1 to 5, where 1 is the cluster covering the most significant part of occurrences and 5 covering the least part, the rest were given intermediate numbers according to the principle that a lower number corresponds to a larger cluster. Cluster 1 was the most significant and covered 44% of the recorded emotional states (images). It was characterized by the domination of *neutrality*, i.e., the strongest restraint in showing emotions. Cluster 2 was characterized by a relatively high intensity of *sadness*; cluster 3 by a very high intensity of *scared*; cluster 4 by a moderately high intensity of *scared*; and cluster 5 by a very high intensity of *happiness* (Fig. 8).

An analysis by product type and by emotional occurrence to a cluster seems to be interesting. It is clear that more *happiness* appeared after consuming product 1 (RK—control samples) and product 5 (R2D2—the product made of meat of animals of a mixed breed PBZ × Duroc with an increased level of vitamin E). Product 4 (R2D1—a product made of meat of animals of a mixed breed PBZ × Duroc with a lower level of vitamin E), apart from frequently evoking *happiness*, caused relatively more of the situation represented by the profile of cluster 4, i.e., a moderate level of *scared*. It seems that product 3 (R1D2—product made of meat of animals of PBZ breed with an increased level of vitamin E) obtained the worst results; it evoked the most emotions but they were rather negative. The above results confirm the statements articulated earlier on the products (ham samples) that were better perceived, i.e., those that were made of meat from breed 2 with an increased level of vitamin E.

Table 1
Correlations: a grouping variable—Person, and Person and type of product.

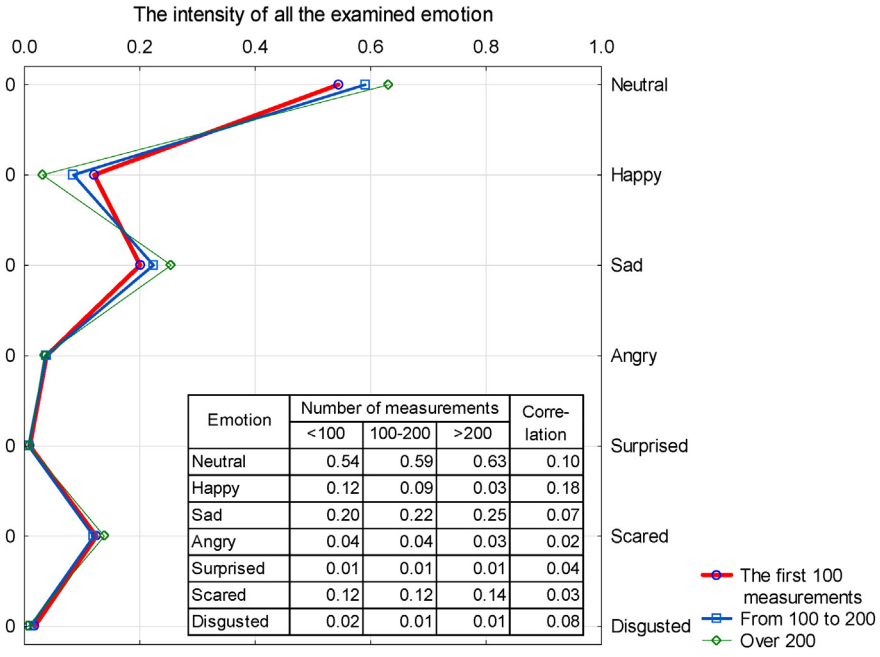
Type of emotion	Correlation	
	Person	Person & product
Neutral	0.80	0.89
Happy	0.59	0.80
Sad	0.86	0.93
Angry	0.56	0.82
Surprised	0.57	0.67
Scared	0.87	0.92
Disgusted	0.50	0.70

4. Discussion

The problem of recognizing emotions in relation to food products is a relatively new scientific issue, which is why algorithms to solve this problem – to record and interpret them – have not been developed yet. The expression of emotions by a human under the influence of a food stimulus may be applied to sensory quality assessment. In particular, when it is necessary to better understand the reactions of different consumer groups to a given product. By determining the emotions expressed by a consumer during or immediately after sampling, it is possible to determine the emotional reaction to the food product in an objective way.

The results obtained in this study have shown that ham samples elicited different emotional impressions among consumers taking into account the ranges of variability of all samples. *Neutral* and *sad* emotions were found dominant, with the former prevailing significantly. *Neutrality* was a baseline state and the appearance of any emotion (*happy*, *sad*, *anger*, *surprise*, *scared and disgust*) replaced this state. Emotional *neutrality* impression was a transition point between negative and positive emotions. Considering the emotional reactions to the taste/flavour of the ham samples such as *happiness* and *scared* it has been found that they were less evoked than *sadness*.

It is surprising that neutral and negative feelings prevailed among in the overall emotions. An unequivocally positive emotion, such as *happiness*, emerged during the the experiment at a rather neutral level. Generally, the portion of a product given to the consumers evoked a relatively moderate emotional effect, although it lowered the share of emotional *neutrality* to an average level of slightly below 0.6. This might be connected to the clear indication of negative emotions as either the expression of disappointment or the expectation of a sensation. Such a situation may result from a consumers' hedonic expectation, i.e., their assumption that they would experience clear or even



Emotion	Number of measurements			Correlation
	<100	100-200	>200	
Neutral	0.54	0.59	0.63	0.10
Happy	0.12	0.09	0.03	0.18
Sad	0.20	0.22	0.25	0.07
Angry	0.04	0.04	0.03	0.02
Surprised	0.01	0.01	0.01	0.04
Scared	0.12	0.12	0.14	0.03
Disgusted	0.02	0.01	0.01	0.08

Fig. 7. Average levels of the distinguished emotions in the subsequent subperiods of impressions.

outstanding pleasure, as Danner et al. (2013) and Danner et al. (2014) explained referring to other outcomes of similar research.

The present study revealed that the product type explained to a moderate extent the dependence associated with the kind of emotions and their intensity. Nevertheless, it has been found that some of the ham samples elicit substantially higher level of *happiness* (samples RK and R2D2) compared to other sample. Moreover, the product R1D2 presented relatively the *saddest emotions* and R1D1 relatively high level of *neutral*, negative (*sad*, *angry*, *scared*) and low impression of positive emotions. In the current study, emotions elicited by ham samples were not correlated with the liking of the attributes (odour and taste/flavour) (Kostyra, Wasiak-Zys, Rambuszek, & Waszkiewicz-Robak, 2016). A negative correlation tendency with respect to *surprised* facial expression and liking score (measured on 9-point hedonic scale) has been found. Cardello et al. (2012) reported a positive correlation between the emotion and liking ratings and a negative relationships between negative valence with liking scores in study regarding to foods (milk and dark chocolate, regular and barbeque flavoured potato chips) and food names using questionnaire. It is in line with the study performed by Danner et al. (2014) investigating consumers' facial reaction evoked by flavour of orange juice product using FaceReader software. On the other hand, it has been shown that emotions and liking ratings do not always agree (King et al., 2010; Porcherot et al., 2010).

The expected and experienced liking and emotions before and after consumption of the products (ham samples) were found to be relatively similar with some exceptions. The differences in this respects could be related to a lower level of experienced odour and taste/flavour liking, disappointment and the higher expectations of some consumers concerning the intrinsic descriptors of the ham samples. For the emotion evaluated before and after tasting, a slight tendency toward increase scores after tasting RK and R1D2 ham samples was observed (Kostyra, Wasiak-Zys, Rambuszek, & Waszkiewicz-Robak, 2016). As it has been emphasised, expectations play an essential role in numerous emotions such as curiosity, disappointment, surprise which are the effect of mismatch between expected and actually experienced (Spinelli, Masi, Zoboli, Prescott, & Monteleone, 2015). Further study taking into account the link between emotions, liking and expectation in relation to meat products are needed to better understand these issues.

Product samples evoked a great variability of emotions in the group of consumers, mainly with respect to *sadness* and *scared*. The results showed that consumer perception of a product is depended on the individual variability. On the other hand, a considerable number of consumers showed restraint (a "poker face") when expressing emotions, but there were also spontaneous reactions. This observation is in line with Danner et al. (2014) who divided the participants into two groups: one with visible facial expression when tasting product and another with "poker face". The reason for it could be partially related to the sensory laboratory setup (the unfamiliar environment). Danner et al. (2014) recommended to carry out such research in more real-life situations. Desmet (2008) concluded that the consumer may experience various emotions to a product at different points in time and the products often elicit "mixed" emotion (rather than a single one) and multiple emotions simultaneously. Our study revealed that consumers expressed various emotions in time and the ham samples evoked different

Table 2
The share of cluster emotions in the stream of impressions concerning particular products (Cramer's V = 0.12).

Product kind	Profiles of the distinguished clusters and their main characteristics (% share)					Total (%)
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	
	Neutral	Sad	Scared++	Scared+	Happy	
Product 1—RK	42.40	34.50	7.50	4.30	11.30	100.0
Product 2—R1D1	53.60	23.30	13.90	4.80	4.50	100.0
Product 3—R1D2	37.70	40.00	11.30	5.60	5.40	100.0
Product 4—R2D1	41.70	31.30	13.70	6.50	6.90	100.0
Product 5—R2D2	44.40	22.70	8.00	11.60	13.40	100.0
Total	44.00	30.40	10.90	6.50	8.30	100.0

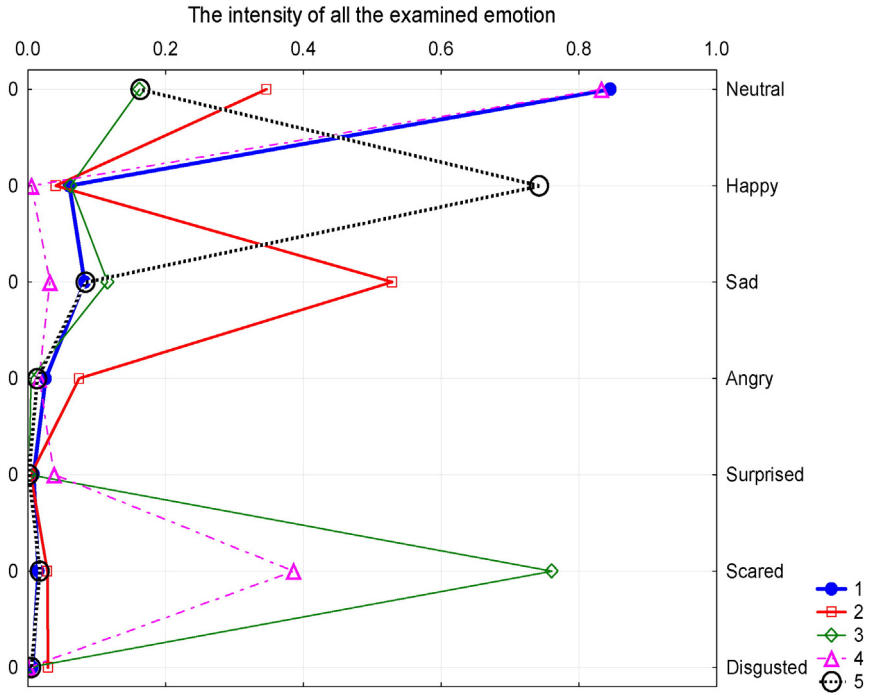


Fig. 8. Profiles of the five clusters (centroids of the distinguished clusters) of emotional states of consumers.

emotional reaction as an effect of duration of the impression. This could be due to the individual reception of sensations in the mouth and the amount of saliva.

As mentioned in the introduction, sensory properties (especially taste and flavour) is one factor affecting emotional responses to different kind of food products. Regarding food taste, the sweet solution is responsible for feelings of happiness, the bitter solution evokes such emotional reactions like *anger* and *disgust*, while salty and sour solution may cause different emotion e.g. *surprise*, *sadness* and *fear* (Rousmans, Robin, Dittmar, & Vernet-Maury, 2000). It has been found that food temperature and spiciness is highly related to food-elicited emotion (e.g. spicy food may evoke excited reactions in consumers). An interesting trend in research is an attempt to combine sensory characteristics of the product with emotional profiles. Such a kind of research on dark chocolate was done by Thomson, Crocker, and Marketo (2010). In the current study the smoked ham samples differed in colour, texture attributes (ease of chewing, juiciness, fibrousness, tenderness, softness) and some taste/flavour descriptors (smoked odour/flavour, meat odour/flavour). The intensity of the key attributes (odour, taste/flavour, texture) in ham samples might affect liking and also emotional impressions of consumers in relation to tasting products. It has been found that a slightly lower intensity of fatty odour/flavour in R1D1 and lower intensity of smoked odour/flavour and salty taste in R2D1 has given lower odour/flavour liking scores (Kostyra, Wasiak-Zys, Rambuszek, & Waszkiewicz-Robak, 2016). These findings suggest that the intensity of these attributes could potentially affect the emotions of consumers measured after the consumption of ham samples.

A lot of research has been done on the relation between sensory characteristics and acceptance of the dry-cured ham ("serrano type") (Pham et al., 2008; Morales et al., 2013; Ruiz et al., 2002). For instance, it has been found that higher consumer acceptability scores were determined by more intense attributes such as "sweet", "savoury", "caramelized", "molassses" "smoky" flavour and aroma cues, while lower acceptability of product depended on more intense e.g. "rancid", "cured", "earthy", "bitter", "salt burn" and "aftertaste" flavour and odour descriptors (Pham et al., 2008). In such meat products not only taste/flavour but also texture plays an important role in consumer acceptability (Ruiz et al., 2002). To authors' knowledge, no studies regarding the systematic impact of liking, emotion (in questionnaires study and non-verbal measurements) and sensory characteristics with regards to meat products (including hams) have been done. It would be very useful to understand more deeply consumers expectation in relation to the products e.g. with reduced fat and salt. According to Cardello et al. (2012) some foods are more emotional than other food products.

The change in the perception of emotion use, e.g., through their application as an element in designing new food products, might become a good alternative method for understanding the attributes that characterize foods that fulfil the expectations of particular consumer groups.

5. Conclusions

1. The facial expression recognition recorded by a FaceReader device enables an objective analysis of sensations which are the emotional reaction of consumers to the ongoing flavour impression after consumption of smoked hams.
2. The *neutral* facial expression on the flavour impression of the products is a baseline state and the appearance of any emotion replaces this reaction.
3. The assessment of meat products by means of facial expression recognition allows the articulation of the following statements:
   - *Happiness* is the main characteristic which positively differentiates product 1 (RK—control samples). It was observed that relatively high pleasure is accompanied by comparatively low levels of negative emotions concerning this product.
   - The meat of animals of a mixed breed PBZ × Duroc contributes to obtaining a ham which evokes a better general emotional reaction than the meat of PBZ breed animals.
   - The larger dose of vitamin E added to the pigs' feed contributes to obtaining meat and meat products which give a better flavour impression compared to the lower dose of vitamin E.
   - However, one should bear in mind that the emotional expressiveness of consumers was rather small. Conclusions should be drawn with caution and further studies should be performed.

4. For all the assessed samples, neutral and negative emotions prevailed in the overall emotions recorded during the assessment of the impression. As it was observed, a considerable part of the assessing persons show restraint, and even a "poker face" in expressing emotions, but there are also spontaneous reactions.
5. The range of variability of the overall emotions recorded by a FaceReader in reaction to taste/flavour of ham samples depends more on the human factor and less on the properties of an assessed product.
6. Consumers expressed various emotions in time and the ham samples evoked different emotional reaction as an effect of duration of the impression.

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