Dr hab. inż. Katarzyna SZWEDZIAK prof. Uczelni[1]
Dr inż. Ewa POLAŃCZYK[1]
Inż. Aleksandra CHEŁPA
Prof. Dr hab. inż. Petr DOLEŻAL[2]
[1]Department of Biosystems Engineering, Faculty of Production Engineering and Logistics, Opole University of Technology
Poland
Katedra Inżynierii Biosystemów, Wydział Inżynierii Produkcji i Logistyki
Politechnika Opolska
[2]Department of Animal Nutrition and Forage Production (FA), Mendel University in Brno, Czech Republic

MANAGEMENT OF INNOVATIVE EVALUATION TECHNIQUES SELECTED QUALITY PARAMETERS IN INDUSTRY FOOD®

Zarządzanie innowacyjnymi technikami oceny wybranych parametrów jakości w przemyśle spożywczym®

The meat industry is looking for quick evaluation methods due to the fact that meat has a relatively short shelf life and is subject to rapid technological changes, e.g. under the influence of storage conditions. The reference methods, despite the relatively short time of analysis, do not determine the accuracy of measurements. In order to ensure the repeatable quality of meat, it is necessary to search for new evaluation methods that will eliminate, among others, subjectivity resulting from the human factor and will allow for quick results. In the case of using computer-based evaluation methods, it is important to obtain a good-quality, distortion-free image of the test sample as well as proper classification and recognition of the recorded images. The article analyzes the content of fat visible in poultry meat using the traditional method – organoleptic, and using visual techniques – computer analysis image. A computer application based on the RGB model to recognize individual colors was used for the tests.

Key words: computer image analysis, innovation management, quality assessment methods, poultry production.

Przemysł mięsny poszukuje szybkich metod ocen ze względu na to, iż mięso ma stosunkowo krótki termin przydatności do spożycia oraz szybko ulega zmianom technologicznym, np. pod wpływem warunków przechowywania. Metody referencyjne, mimo stosunkowo krótkiego czasu analiz, nie odznaczają się dokładnością pomiarów. W celu zapewnienia powtarzalnej jakości mięsa niezbędne jest poszukiwanie nowych metod oceny, które wyeliminują m.in. subiektywność wynikającą z czynnika ludzkiego oraz pozwolą na szybkie uzyskanie wyników. W przypadku wykorzystania metod oceny opartych na analizie komputerowej istotne jest pozyskanie dobrej jakości, wolnego od zniekształceń obrazu badanej próbki oraz właściwej klasyfikacji i rozpoznawania rejestrowanych obrazów. W artykule dokonano analizy zawartości tłuszczu widocznego w mięsie drobiowym metodą tradycyjną – organoleptyczną oraz za pomocą technik wizyjnych – komputerowa analiza obrazu. Do badań wykorzystano aplikację komputerową opartą na modelu RGB do rozpoznawania poszczególnych barw.

Słowa kluczowe: komputerowa analiza obrazu, zarządzanie innowacjami, metody oceny jakości, produkcja drobiu.

INTRODUCTION

In recent years, food production has shown an upward trend. In order to meet the constantly growing needs of the food market, food companies must constantly develop and use raw materials and services of other entities. They stock up on individual elements necessary for final products, and therefore depend on the state of economic development.

The animal products market is one of the main sectors of the food economy. Poultry meat, considered a source of wholesome and easily digestible protein, is the most frequently chosen type of meat by consumers. It is produced from chickens, turkeys, geese and ducks [8].

The overall quality consists of a set of features that distinguish a given food product. The appropriate quality of meat determines its attractiveness and health [9]. One of the most important characteristics of meat is its color. It is the main factor that determines the choice of the product by the consumer because it suggests that the offered product is fresh and of good quality. The color of meat is influenced by many factors. Poultry meat has a gray-pink color, which is influenced by the concentration and form of myoglobin (a heme pigment found in skeletal muscles and the heart muscle). The myoglobin content depends on the age of the poultry. The value of myoglobin is not constant and depends on the activity of the muscle. Hemoglobin also affects color,

Corresponding author – Adres do korespondencji: Katarzyna Szwedziak, Politechnika Opolska, Wydział Inżynierii Produkcji i Logistyki, Katedra Inżynierii Biosystemów, ul. Mikołajczyka 5, 45-271 Opole, email: k.szwedziak@po.opole.pl

but to a lesser extent compared to myoglobin. Texture is another differentiator in judging the quality of poultry meat. It is expressed through the feeling of hardness, elasticity and elasticity of the meat. It depends on the structure of muscle tissue and the amount of collagen, the value of which changes with the activity of the muscles. Age plays a key role here - the muscles of young chickens have thinner muscle fibers, which increases the tenderness of the meat obtained from them [3]. Juicy is a parameter related to the water absorption of meat, i.e. the ability to retain meat juice in the muscle. The meat is characterized by better juiciness during slight losses of muscle mass. The presence of intramuscular fat enhances the feeling of juiciness. Transport and post-slaughter processing of chickens has a significant impact on the palatability – broiler stress reduces the water absorption capacity, which makes the meat less juicy [7].

One of the traditional methods of quality assessment is organoleptic assessment, which consists in verifying organoleptic characteristics with the help of the senses. It allows for an analysis of the quality of the product, e.g. its fat content, color, smell, consistency or clarity. It takes place through the sense of sight, smell, taste and touch, it is unique and unplayable. It is an immeasurable method due to the inability to maintain the objectivity of the assessment. The results are influenced, inter alia, by the health condition of the assessor and environmental conditions. This is a very important assessment, especially for a finished product, because the consumer, when making a purchase decision, determines the visual features of this product [10]. The organoleptic evaluation is used for the sensory analysis of the product.

Innovation in quality management is understood as activities consisting in improving the existing ones or introducing new solutions that will contribute to the improvement of the quality of products. It is particularly important that the new activities contribute to the optimization of the time of obtaining results and condition their credibility and value. Meeting these conditions enables the use of innovative techniques as an effective tool for food technologists and producers. It is important to methodically prepare people working with new tools so as to obtain value from the obtained results [4].

Innovations in the field of quality management have been a frequent development path chosen by representatives of food companies in recent years, which confirms the need to use innovative solutions in this area. Enterprises decided not only to implement new methods of quality assessment, but also to reorganize the tools used so far [6]. Due to the dynamic development of the sciences in the field of automation, it is also used for new methods of food evaluation. Reference methods are not preferred in in-house research centers mainly due to the time-consuming nature of analyzes. The use of vision systems turned out to be effective [2].

Computer image analysis is a research technique that allows for an unambiguous assessment of the sensory quality of food products, such as size, shape or color. The aforementioned discriminants are the key aspect that prevails in the choice of a product by the consumer [1]. This method automatically processes and analyzes the image, extracting the desired information and comparing it with the specified standards [5]. The undoubted advantages of computer image analysis are the speed, non-invasiveness and repeatability of the assessment [1].

The aim of the article was to present the application of innovative methods to assess the quality of poultry meat using computer image analysis and to compare them to traditional evaluation methods.

RESEARCH METHODOLOGY

The research material consisted of selected elements of poultry meat – thigh meat of broilers fed with standard mixtures. The weight of a single sample was about 200 g. The research material was obtained from a nearby slaughterhouse. Slaughter was carried out automatically on the slaughter lines with the sanitary requirements in force in the meat industry. After slaughter, the chicken carcasses were cooled by the air-spray method to the temperature not exceeding 3°C. Muscles were obtained from a chicken carcass automatically

Table 1. Card of the innovation process
Tabela 1. Karta procesu innowacji

Process name	The use of an innovative technique of poultry meat quality assessment in a food enterprise
process owner	Quality Management System Specialist
Process type	Management process
Purpose of the process	Searching for new methods of product quality assessment to ensure the highest sensory quality of products
Imput data	Technologists' initiative An initiative of the employees of the Quality Management Department Production Director's initiative
Ouput	An innovative method of assessing the quality of poultry meat, and in the future – also of processed meat products, e.g. sausages
Meters	The possibility of using new technologies in the product evaluation process
Process related proce-dures	Specification of the products Poultry meat evaluation sheet

Source: Own study
Źródło: Opracowanie własne

using a dividing line. The average pH of the meat oscillated between 5.8–6.0. The results are similar to the data given in the technological specification. The determination was carried out 24 hours after slaughter. Until the examination, the meat was stored under the conditions declared by the producer, ie at a temperature of a maximum of 4°C.

The computer application "APR" and the organoleptic evaluation sheet were chosen as the main methods for conducting effective research. The enrichment method was the innovation process chart, created for the proper conduct of the innovation management process. The design of the card is presented in Table 1.

The analytical part of the research included the organoleptic analysis of selected product quality indicators, carried out by 5 specialists:

- – 2 technologists,
- – 2 food quality specialists,
- – 1 lab technician.

The evaluation team had experience and qualifications confirmed by training in sensory evaluations for meat and meat products.

The test was carried out under artificial, uniform lighting. The stand is equipped with a scale, a Petri dish to be used when it is necessary to collect samples for further tests, gloves and a place for cutting and visual assessment of the test sample.

The study was carried out on 20 samples of meat from broiler thighs. The meat used was free from defects and fit for consumption by consumers.

Meat evaluation sheet prepared. The team assessed the meat on a 5-point scale (1 – unacceptable quality, 5 – the highest quality rating). The external appearance of the meat was assessed: the intensity of the color and its uniformity, and whether the general appearance is as specified.

Then, samples (digital photos) of the meat were obtained with the use of lighting ensuring even light dispersion: halogen lighting (two halogen lamps, 35W each) and fluorescent lighting (one fluorescent lamp with a power of 6W). The shots were taken with a digital camera NIKON Coolpix B500 camera on a black background which has the slightest effect on the natural color of the meat. The obtained photos show the percentage of bright fields that were fat. The "APR" computer application was used in the research. The principle of operation of the "APR" computer application is based on the RGB (red – red, green – green, blue – blue) model. Photographs are presented as a collection of points - pixels that can be saved in the form of a 1-bit, 8-bit or 24-bit scale. This model uses the receiving properties of the human eye. It allows for the reproduction of about 16 million colors. The "APR" program analyzed the meat image, on the basis of which the percentage of fat content of poultry meat was obtained, which corresponds to the sensory parameter in the tested material. The saturation and brightness of the selected color in the meat were determined to obtain results.

ANALYSIS AND DISCUSSION OF THE RESULTS

The first stage of the research was to conduct an organoleptic evaluation. Based on the organoleptic evaluation it was found that the color and shape of the samples were as specified. The assessed meat did not contain any defects in appearance or texture, and the cross-sectional appearance and compactness were highly rated. In the 5-point evaluation, the tested meat obtained values from 4–5 for each parameter, which indicates its good quality. The mean values of the fat content are presented in Table 2.

The second stage included research with the use of computer image analysis. On the basis of the photographs taken, the program performed a quantitative analysis of light fields representing fat tissue on the muscle and red fields – muscles, and then calculated their percentage in relation to the total meat surface. The unidentified area has not been identified. People who performed the organoleptic evaluation of the samples, i.e. employees of the plant from which the meat for testing was obtained, participated in the research.

Table 2. **Percentage of fat and meat in the tested samples**
Tabela 2. Procentowa ilość tłuszczu oraz mięsa w badanych próbkach

Sample no	Fatness rating [%]					
	Technologist	Technologist	Lab technician	Food Quality Specialist	Food Quality Specialist	Sample mean value
1	15	14	12	14	13	**13,6**
2	15	13	11	13	14	**13,2**
3	18	14	15	14	15	**15,2**
4	17	15	12	15	14	**14,6**
5	12	12	13	12	13	**12,4**
6	13	14	15	13	15	**14**
7	14	15	17	13	16	**15**
8	12	11	11	13	12	**11,8**
9	15	13	12	14	14	**13,6**
10	16	15	13	13	15	**14,4**

Source: Own study
Źródło: Opracowanie własne

Fig. 1.   Sample photo of the analyzed sample analysis.
Rys.1.   Przykładowe zdjęcie analizy badanej próbki.
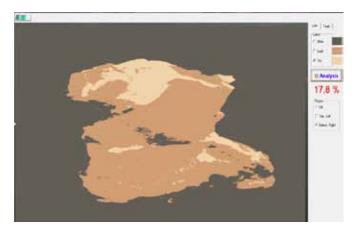**Source:** Own study
Źródło: Opracowanie własne

Fig. 2.   Digital image analysis for sample no. 1.
Rys.2.   Analiza obrazu cyfrowego dla próby nr 1.
Source: Own study
Źródło: Opracowanie własne

Table shows the percentage of fat and meat obtained after the computer image analysis.

Table 3.   The percentage of fat and meat in the tested samples

Tabela 3. Procentowa ilość tłuszczu oraz mięsa w badanych próbkach

No	The amount of fat [%]	The amount of meat [%]
1	17,8	82,2
2	8,2	91,8
3	8,5	91,5
4	10,3	89,7
5	8,1	91,9
6	7,5	92,5
7	7,4	92,6

No	The amount of fat [%]	The amount of meat [%]
8	7,9	92,1
9	7,8	92,2

Source: Own study
Źródło: Opracowanie własne

Based on the photos taken and the computer image analysis, the mean value of body fat was 9.2%.

The share of light semi-light varieties was varied, as the tested meat differed in terms of the presence of fat, which influenced the technological properties of the meat. The degree of fatness is important for the palatability parameter – fat is the carrier of flavor. Nevertheless, the fat value should not be too high, as the meat will lose its appeal aspect, which for many customers is a key factor in determining the purchase. When the consumer sees excessive fatness of meat, it is associated with a product unhealthy for the body.

Based on the results obtained from the computer image analysis, a graph of the amount of fat was plotted and compared with the empirical method. The obtained results are shown in Figure 3.
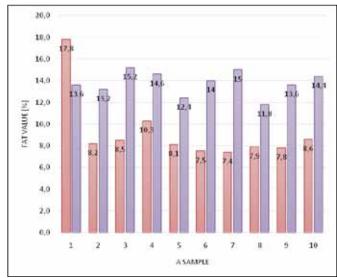

Fig. 3.   Comparison of the obtained results by means of computer image analysis.
Rys. 3.   Porównanie uzyskanych wyników za pomocą komputerowej analizy obrazu.
Source: Own study
Źródło: Opracowanie własne

Based on the chart, it can be concluded that the fatness value obtained by computer image analysis is generally lower than the result determined during the traditional evaluation of the tested samples. Only for the first sample is the result of the evaluation made by specialists lower. The differences result from the elimination of the subjectivity factor in computer vision techniques. The analysis of specialists may be marked with an error resulting from the personal preferences of the researcher, where he selects a more desirable sample from among the tested products. For this reason, the sensory test requires conducting it on a group of specialists in order

to consider it objective. Analyzes by one employee are not acceptable. With computer techniques, only one specialist is required to take pictures and then interpret the data received.

of the organization and should become an integral part of the company's quality culture. Therefore, the issue of food control is still an open field of research for the food industry.

SUMMARY

On the basis of the performed tests and the analysis of the obtained results, the answer to the formulated main problem and specific problems was obtained. The possibility of using computer image analysis as a tool for the evaluation of fat content in poultry has been demonstrated. The combination of innovative evaluation methods along with the knowledge and competences of employees in food plants guarantees the improvement of the quality of manufactured products, which directly affects their safety. Moreover, this method seems to be promising for the evaluation of other food quality parameters, e.g. color. However, remember to maintain adequate lighting and light intensity in order to obtain the desired photos used for the analysis. A barrier to the introduction of new assessment methods may be insufficient knowledge of employees about innovative quality assessment techniques. After the research with the plant employees from the meat industry, it can be concluded that their knowledge about innovations in the field of quality assessment is small. However, after familiarizing themselves with the method, they clearly confirmed the need to use newer and newer methods of quality assessment that will eliminate the subjectivity resulting from standard measurements.

In order to meet the expectations of consumers, meat products require constant improvement in the context of quality assessment. Together with a properly developed strategy, innovative methods of food analysis enable the development

PODSUMOWANIE

Na podstawie wykonanych badań oraz analizy otrzymanych wyników uzyskano odpowiedź na sformułowany problem główny oraz problemy szczegółowe. Wykazano możliwość wykorzystania komputerowej analizy obrazu jako narzędzia oceny otłuszczenia w mięsie drobiowym. Połączenie innowacyjnych metod oceny wraz z wiedzą i kompetencjami pracowników w zakładach spożywczych gwarantuje poprawę jakości produkowanych wyrobów, co bezpośrednio wpływa na ich bezpieczeństwo. Ponadto metoda ta wydaje się być obiecująca do oceny innych parametrów jakości żywności, np. barwy. Należy jednak pamiętać o zachowaniu odpowiedniego oświetlenia i natężenia światła, tak aby uzyskać pożądane zdjęcia wykorzystywane do analizy. Barierą do wprowadzenia nowych metod oceny może być niedostateczna wiedza pracowników o innowacyjnych technikach oceny jakości. Po przeprowadzonych badaniach z pracownikami zakładu z branży mięsnej można stwierdzić, że ich wiedza dotycząca innowacji z zakresu oceny jakości jest niewielka. Po zapoznaniu się z metodą wyraźnie potwierdzili oni konieczność stosowania coraz nowszych sposobów oceny jakości, które wyeliminują subiektywność wynikającą ze standardowych pomiarów. W celu spełnienia oczekiwań konsumentów produkty mięsne wymagają ciągłego doskonalenia w kontekście oceny jakości. Wraz z właściwie opracowaną strategią innowacyjne metody analizy żywności umożliwiają rozwój organizacji i powinny stać się nierozerwalną częścią kultury jakości przedsiębiorstwa. Dlatego też problematyka kontroli żywności jest nadal otwartym polem badawczym dla przemysłu spożywczego.

REFERENCES

[1] **DASIEWICZ K. 2010.** „Badania nad wpływem rodzaju oświetlenia na dokładność szacowania zawartości tłuszczu metodą komputerowej analizy obrazu w modelowych mieszaninach mięsa". Nauka Przyroda Technologie Tom 4, Zeszyt 5, Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu.

[2] **DASIEWICZ K., P. SZYMAŃSKI. 2005.** „Optymalizacja warunków szacowania (metodą komputerowej analizy obrazu) tłuszczu w drobnym mięsie wieprzowym klasy II". Postępy Techniki Przetwórstwa Spożywczego 2: 44–58.

[3] **KOŁCZAK T. 2007.** „Barwa mięsa". Gospodarka Mięsna 9.

[4] **KOSTYRA E. 2012.** „Innowacyjne metody pomiaru wrażeń sensorycznych w czasie, w percepcji i akceptacji żywności". Postępy Techniki Przetwórstwa Spożywczego 1:104–108.

REFERENCES

[1] **DASIEWICZ K. 2010.** „Badania nad wplywem rodzaju oswietlenia na dokladnosc szacowania zawartosci tluszczu metoda komputerowej analizy obrazu w modelowych mieszaninach miesa". Nauka Przyroda Technologie Tom 4, Zeszyt 5, Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu.

[2] **DASIEWICZ K., P. SZYMANSKI. 2005.** „Optymalizacja warunkow szacowania (metoda komputerowej analizy obrazu) tluszczu w drobnym miesie wieprzowym klasy II". Postepy Techniki Przetworstwa Spozywczego 2: 44–58.

[3] **KOLCZAK T. 2007.** „Barwa miesa". Gospodarka Miesna 9.

[4] **KOSTYRA E. 2012.** „Innowacyjne metody pomiaru wrazen sensorycznych w czasie, w percepcji i akceptacji zywnosci". Postepy Techniki Przetworstwa Spozywczego 1:104–108.

[5] **KRZYWDZIŃSKA-BARTKOWIAK M. 2019.** Wykorzystanie komputerowej analizy obrazu do oceny struktury i różnicowania jakości wybranych produktów mięsnych. Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu: 13–16.

[6] **MAKARSKA A., K. FIRLEJ. 2012.** „Działania innowacyjne firm przemysłu spożywczego jako element ich strategii". Folia Pomer. Univ. Technol. Stetin. Oeconomica 297 (68): 37–46.

[7] **ORMIAN M., A. AUGUSTYŃSKA-PREJSNAR, Z. SOKOŁOWICZ. 2018.** „Cechy kształtujące jakość mięsa drobiowego". Postępy Techniki Przetwórstwa Spożywczego 2:90–96.

[8] **SZWEDZIAK K. 2019.** „The use of vision techniques for the evaluation of selected quality parameters of maize grain during storage". E3S Web of Conferences 132, 01026 (2019) https://doi.org/10.1051/e3sconf/201913201026.

[9] **SZWEDZIAK K. 2019.** „Artificial neural networks and computer image analysis in the evaluation of selected quality parameters of pea seeds". E3S Web of Conferences 132, 01027 (2019) https://doi.org/10.1051/e3sconf/201913201027.

[10] **TROY D, J. KERRY. 2010.** "Consumer perception and the role of science in meat industry". Meat Science Vol. 86: 214–226.