APPLICATION OF COMPUTER VISION SYSTEM FOR QUALITY ASSESSMENT OF PORK MEAT

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Abstract: The present work is a review and analysis of different approaches, methods and tools for computer vision in the evaluation of quality indicators of pork meat. The authors have developed and delivered software as a tool that allows analyzing and evaluating key elements in meat - meat tissue, fat, bone and skin. In the graphic user interface, which is a part of the software instrument is built-in functions for pre-processing of visual images and histogram analysis of the used color features.

Keywords: Meat quality assessment, Graphical User Interface, PSE, Fat content in meat.

1. INTRODUCTION

Safety, quality and wholesomeness of pork meat can be ensured only through the integration of law and control of the entire food chain. Achieving these indicators on food also is a goal that requires joint efforts and skills of experts from different professional areas – agronomists, technicians, and engineers [9]. Synchronous operation between them would be possible if they are qualified for additional opportunities to identify, monitor and act on indicators of safety, quality and wholesomeness of meat. The scientists mostly rely to objectify this process on modern technologies and providing them automatic control systems.

Despite many new facilities, machinery and processing lines in the meat industry there is still a big part of the routine process stages and operations (grading, sorting, and packaging) are performed manually and / or visually by people. This situation is due to many factors, but the most important reason is that labor costs are capitalized to compete with new technological equipment.

All these facts give us grounds to launch a study on the feasibility of using computer vision systems as an alternative and fast method for determining the main quality parameters of pork meat.

The problem of the existing defects in the pork meat is of interest to researchers and manufacturers for many years. One of the important factors affecting the quality of the final product, and the economic result of the processing of pork meat is quality of raw material used. The importance of properly detecting meat of lower quality becomes significant.

An important and frequent diversion in pork meat quality defect is PSE (pale, soft, exudative). The exact identification of this defect is very difficult. Many experiments were carried out to develop methods to assess the quality of pork meat and to discovery defects in continuous measurement (for example, on conveyor belt). One of the most commonly used criteria is the value of pH. Moreover, there are known methods of using the changes in the color and electrical conductivity. They help to identify the defects in meat. Despite the high
accuracy of these methods, they are labor-intensive and difficult to apply for measurement in flow industrial environment. These methods have some drawbacks. There is no single criterion for determining meat quality based on these parameters. The color is an important indicator of the quality of pork because it is one of the most important characteristics affecting the evaluation of the user. One of the main methods for measuring and evaluation the color is CIELab color model by a colorimeter.

The benefits of computer-based methods of image analysis are confirmed by many authors. Statistical evaluations were used to determine the correlation between physico-chemical parameters of pork and changes in the components of various color models [7,8] (RGB, HSV, Lab, XYZ, etc.). The image analysis allows tracking of the color change on the surface of the pork meat, and determining the ratio of fat, bone, skin, muscle and connective tissue.

Computer vision systems have proven to be suitable for objective evaluation of food products [2,7,9]. The computer vision, including recording, processing and analysis of images is a non-destructive method to assess the visual quality performance of food [8].

The aim of this work is to analyze the achieved results in assessing the quality of pork meat and to offer programming tool that accelerates and automates the process of identification of the main elements in meat - meat tissue, fat and bones.

2. EXPOSITION

2.1. Main indicators of the quality of pork meat

The meat has some typical external signs by which we can judge about its freshness, and thus its quality. The color is determined by the amount of myoglobin in muscle fiber. It is influenced by sex, age and breed, the ratio between muscle and fat tissue. The muscle and fat tissue are better for the nutritional value of the meat because they contain essential nutrients but connective, bone and cartilage tissue are adversely.

The fat content is mainly determined by chemical analysis, but it is expensive and time-consuming method. Some measurements such as the number, size and spatial distribution of fat is impossible to perform by chemical analyzes.

The object of this study is the development of software tool that allows analyzing and evaluating key elements in meat – meat tissue, fat and bones.

2.2. Evaluation of the color characteristics of pork meat

The application of computer vision reduces the possibility of incorrect assessment of the quality of meat due to human error modification of environmental conditions, fatigue and experience of the evaluator. Computer vision systems can replace many expensive, labor-intensive and time-consuming methods and provide non-destructive obtaining of color data measured on the surface of the meat.

Data for the amount of meat tissue, fat and bones can be obtained with continuous measurement on a conveyor belt, which is difficult by conventional methods for determining the quality of the meat.

There is requirement of analysis of formed color images to obtain these data. Regression methods are used usually [2,4,5]. These methods have the necessary information to assess the quality in processing and sorting of food. Comparison with databases at all stages of quality assessment is important for accurate decision about the quality of the tested meat and it is a major part of image processing. The tools such as neural networks, fuzzy...
logic and genetic algorithms are part of the means to detect defects in pork meat [2]. Neural networks and fuzzy logic have been successfully applied in computer vision systems used in other sectors of the food industry [7,10,11,12].

2.3. Evaluation of the main elements in pork meat

There is indicated in the literature that regression methods using correlations can determine the relationship between the composition of meat and intersection, which is measured [2]. Relatively high values of $R = 0.83$ for determination of lean meat, and lower results in the determination of fatty content, and good results in determining the percentage of meat - fat. The optimal coefficients are obtained at security levels 92% to determine the amount of content veins $R = 0.78$, while the percentage of veins $R = 0.72$, and for fat $R = 0.70$. These studies show that the methods of image processing can be used as an alternative to classical methods for automated inspection in various stages of processing meat. There is developed system of machine vision operating in real time, which determines the quality of fresh meat by measuring color and fat. The meat is sorted by hand depending on the quality. Accepted quality criteria are weight, pH, defects, fat content, muscle color and homogeneity of the color. Quality criteria depends on the thickness of subcutaneous fat, muscle color, homogeneity of the color but this grading depends on subjective factors. The authors propose a method for the detection and measurement of subcutaneous fat and methods for segmenting muscles to assess the color. We discovered a correlation $R = 0.83$ between the manual measurement of subcutaneous fat and measuring system of image processing. The developed system is working well, which means that measurements of color and fat have good statistical reliability.

Methods are proposed [3] for color segmentation to detect defects in fresh meat. Healthy skin is characterized by color features in different color areas and different methods of segmentation. The right choice of color channel and segmentation method gives good results in the detection of defects. Disparate healthy skin and the defects determine the choice of method and threshold segmentation. Segmentation methods based on S and H components of the HSI model are not sensitive to shading the sides of the meat and produce good results in the detection of defects. There is studied the use of image segmentation for grading veins, fat and muscle connections and we found out relationship between these areas and the level of salting the meat. The authors developed robust segmentation algorithm for different areas of the color images of meat in two steps – computation of high contrast grayscale image by linear combination of RGB components and segmentation using $k$-means [1].

The stability of the color of vacuum pork meat pieces during cold storage cupboard is researched and the initial state of vacuum packaging, the level of oxygen permeability and ultraviolet light of packaged products is studied also [5]. The basic process of discoloration as a result of destruction of nitric oxide in the presence of oxygen depends on the degree of suction. The careful control of these factors is important for optimizing packaging and storage to preserve the color of the product. The color of the surface of the product in vacuum is measured by colorimeter. We found out that the parameters of the Hunter “a” correlated with subjective color points and it has a standard deviation 0.2. To reduce the interference of packing material and because of the product variability the parameter “a” is normalized to its initial value. The combination of light and the presence of oxygen in the package are a major cause of discoloration of the product [4, 5]. In other studies they used multifactor experiment to research the interactions between certain factors – oxygen and its distribution, changes in volume, level of reflection and nitrite levels, affecting the color stability of meat products packaged under different conditions.
Statistical analysis shows the significant effect of these main factors to reduce redness of the sausages. The selection of non-optimal values for a parameter could affect many other values that affects the color change during transporting and storage of products. Thermally processed meat products are characterized by the method of handling, their organoleptic and chemical parameters as indicators of quality [6]. The color of these products is measured using colorimeter CIE Lab color model. The technical analysis does not give good results for the determination of meat quality.

Basic technical analysis methods use wavelength reflection and absorption by the object in the visible light spectrum. These methods are suitable for the study of food also.. They give average values to small areas of the sample and should be measured many points to get the color profile of the product. The authors determined that only the summary results of technical, chemical and organoleptic analysis can provide accurate data on the quality of the product.

2.4. Description of the developed software for assessment the quality of pork

Figure 1 shows the graphical user interface (GUI) "Pork meat quality assessment" developed in the Matlab 7.11 programming environment. In the creation of software we used system functions and tools of GUIDE Templates. The interface is built on a modular basis and consists of four modules:
1. Module for recognition of fat, meat and bone tissue;
2. Module for histogram analysis of the image specified by the user color model;
3. Visualization module;
4. Module For classification.

Through the graphical interface we develop assessment the quality of pork by images using integrated criteria, rules and classifiers as the preliminary processing image meat is done by an additional built-in function. The interface allows individual assessment of meat and evaluation of a sample of meat. The instrument is set and complete testing of new types of meat and includes extracting, evaluating and ranking by informativeness of color features which are typical for the respective type of meat. Histogram analysis of color features is performed in interactive mode, which allows selecting the attribute.
Figure 2. Image processing of pork meat in order to determine the ratio of meat / fat

Figure 2 illustrates the performance of the subroutine for image processing of pork meat. The ratio of meat / fat in pork is an important parameter because of the demand of lean meat by consumers. Selection of pigs for meat increasing the amount of tissue leads to another problem – this occurs the increase of risk of occurrence of the defect PSE, which in turn requires research of methods for accurate and timely determination of this ratio.

3. CONCLUSION

The following conclusions can be drawn by authors based on the review and analysis of published results related to the application of computer vision systems for quality assessment of the main indicators of pork:

1. Computer vision systems are appropriate tools for fast and non-destructive determination of main elements of pork in laboratory and industrial conditions.
2. The results of the analysis of the literature showed more accurate determination of lean meat ($R = 0.78\div0.83$) and lower results in measuring the fat content ($R = 0.70\div0.79$).
3. There is developed software tool which facilitates for the determination of defects in pork using histogram analysis of the images and classification of meat tissue, fat and bones.

4. REFERENCES:
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