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USE OF INFORMATION TECHNOLOGY IN THE EVALUATION OF CONTAMINATION IN FLOUR

Summary

During the flour manufacturing process flour may be contaminated resulting in lower quality. Before placing a product in the commercial circulation flours are subjected to laboratory analysis, including in terms of product purity. This analysis is based on organoleptic determination (through visual inspection) of the amount of impurities in the flour and in the cereal products. This paper presents innovative techniques to assess quality in terms of pollution of flour using image analysis and artificial neural networks (ANN).
***Key words**: image analysis, artificial neural networks, quality assessment, pollution of grain mill products, image recognition*

ZASTOSOWANIE TECHNIK INFORMATYCZNYCH W OCENIE ZANIECZYSZCZEŃ W MĄCE

Streszczenie

W czasie procesu technologicznego produkcji mąki, może ona ulec zanieczyszczeniu, co powoduje obniżenie jej jakości. Przed wprowadzeniem produktu do obiegu konsumpcyjnego, mąki poddawane są analizie laboratoryjnej, między innymi pod względem czystości produktu. Analiza ta polega na organoleptycznym określeniu za pomocą zmysłu wzroku ilości zanieczyszczeń w mące i przetworach zbożowych. W artykule przedstawiono innowacyjne techniki oceny jakości pod względem zanieczyszczeń maki wykorzystujące analizę obrazu oraz sztuczne sieci neuronowe (SSN).
***Słowa kluczowe:** analiza obrazu, sztuczne sieci neuronowe, ocena jakości, zanieczyszczenia w produktach przemiału zbóż, rozpoznawanie obrazu*

1. Introduction

Quality assessment is a comprehensive process. It includes the assessment of physical-chemical, microbiological and sensory properties.

“Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skilful execution” *Will Forster* [6], those words do not only refer to the excellence of the product or its highest quality, but going deeper into their philosophy we may also say that when the product quality is considered, we should pay attention to the methods of quality assessment too so that it would be reliable and convincing for the 21st-century consumer. Doubtless it is another example of how important the method of assessment is. It is essential to look for innovative, state-of-the-art and reliable methods for those complex determinations; so far they have been known solely from the tedious work of laboratory assistants in the laboratories which applied chemical methodologies, where the adding of one more or one less drop of a reagent might distort results.

Summing up, we may say that product assessment with particular attention paid to qualitative properties which are considered in the commercial evaluation is crucial as it contributes to their quality and client satisfaction. The use of quick and effective methods is highly justified since it allows for accurate and quick observations without complicated laboratory methods. Computer image analysis and neuron modelling have a great future in the food industry and agriculture.

2. Image analysis

Agricultural and food products and raw materials are characterised by their proper colour and shape, which makes them very easy to recognise. By means of digital pictures of examined products we may objectively determine e.g. the colour, which in most cases is the leading property and proves the quality of the raw material or product [2].

The colour is one of the basic physical properties which contribute to the attractiveness of raw materials and products. It applies to both the external and internal appearance. As regards senses every person discerns colours in a bit different way. It is related to the fact that visual memory is very poor, as compared to auditory memory, and it imposes restrictions on memorising colours. Another obstacle in the description of colours is the fact that the incident light influences colour perception.

The expression of “image recognition” is a sort of widely used brachylogy. It should be formulated more precisely as “automatic determination of the affiliation of physical objects to set classes of abstraction based on their images” [5].

According to Tadeusiewicz [5] it is possible to perform a number of many useful transformations, which are applied to improve the quality of information in the image. In their studies, Koszela and Werses [2] applied a number of morphological transformations enabling them to emphasise the features of the shape of vegetable chips. We distinguish four groups of transformations, including: geometric transformations (shifts, reflections), point transformations (modification by means of logical and arithmetic operations), morphological transformations and filters [3].

Colours are divided into achromatic and chromatic colours. Achromatic colours have one attribute only – brightness or luminance – and it changes from white through shades of grey to black. On the other hand, chromatic colours have three different attributes: brightness, hue and chroma.

A very important factor is the type of lighting, because the perceived colour is not the property of the object but of the incident light. Depending on whether artificial or natural light falls on the examined sample, the colour will be perceived in different ways.

An important element in image analysis is the correct definition of the colour and hue, which is significant for determining how to obtain images for analysis. Colour is a psychophysical feature of visual perception, which requires appropriate: emission of light, stimulation of receptors of the retina, processing of stimuli transferred by the ophthalmic nerve in the cerebral cortex. The study by Mantiuk [4] uses a very simple experiment which determines how the surroundings influence colour perception. Colours of red rectangles were compared. On the basis of the experiment it was concluded that the colour perception by a human being depends on the colour of the surroundings, colour of lighting and chromatic adaptation. Colour perception may be defined regardless of the surroundings expressing the colour in the perception space and calculating brightness and chroma factors.

The impression that the colour of the given object exists results from the reflection or transmission of certain parts of spectrum and absorption of others e.g. an object seems to be green, because it reflects this range while absorbing other lights in the spectrum of the white light. White objects transmit almost the full range of spectrum while black objects absorb almost the entire spectrum.

The human eye receives colour due to the stimulation of three visual pigments in the cones of the retina. One of them receives the wavelength of approx. 630 nm (red colour), the second one - the wavelength of approx. 530 nm (green colour) and the third one receives the wavelength of approx. 450 nm (blue colour). Through the comparison of the power of the light source for particular colour components, the human brain interprets the colour of light. Such an approach to the issue of colour vision has become a basis for the construction of devices to generate colourful images and colour models [1].

Over hundreds of years various mathematical models of colour description, often abstract, have been developed for the purposes of product description.

3. Purpose and scope of the paper

The purpose of the paper was to determine the level of impurities in flour by means of an innovative method based on the computer analysis of images. Preparatory work consisted in the preparation of a test stand to enable the taking of samples for examinations in the form of digital pictures and a computer application was developed to assess impurities in the examined food material. Tests were conducted in a laboratory comparing the traditional (gravimetry and sieve) method and the computer image analysis.

4. Test methodology

10 series of quality assessment tests were conducted for flour of different contamination levels; each series had 4 repetitions performed (Table 1). For every variant a sieve analysis was performed, which allowed for the determination of the percentage of undesirable substances. A picture of the same sample was taken to obtain a digital image. The picture was analysed in a computer application called APR and also the percentage of undesirable substances in the examined flour sample was obtained.

Table 1. Percentage of impurities in the sample of flour
Tab. 1. Procentowy udział zanieczyszczeń w próbce mąki

Sample no.	Weight of flour [g]	Weight of impurities [g]	Percentage of impurities in the sample [%]
1	50	2	3.84
2	50	3	5.66
3	50	4	7.40
4	50	5	9.09
5	50	6	10.7
6	50	7	12.2
7	50	8	13.7
8	50	10	16.56
9	50	12	17.98
10	50	14	20.47

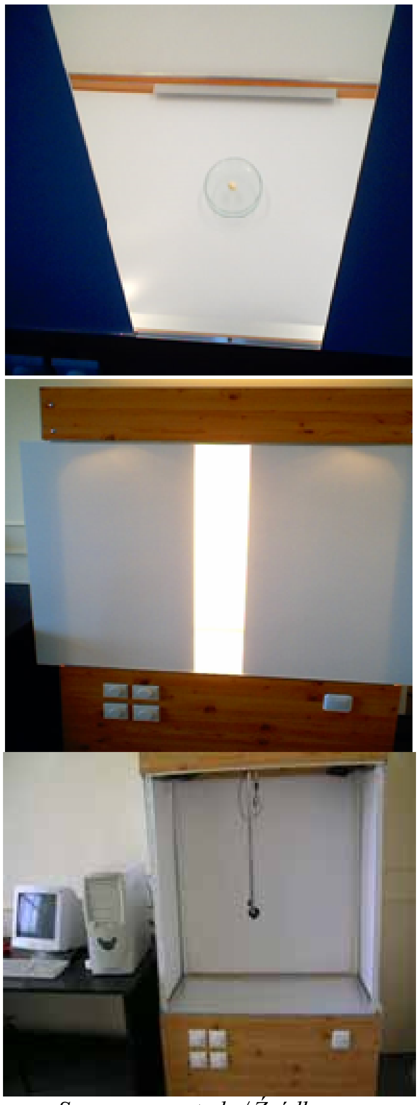
Source: own study / Źródło:opracowanie własne

The sieve analysis consisted in the sifting of flour and separating impurities present in flour and then weighing them on an analytical balance. (Figure 1).

Source: own study / Źródło: opracowanie własne

Fig. 1. Position for sieve analysis
Rys. 1. Stanowisko do analizy sitowej

Then by means of the computer image analysis stand (Figure 2) pictures were taken with a digital camera and the examined samples were analysed in the Leaf computer application (Figure 4).



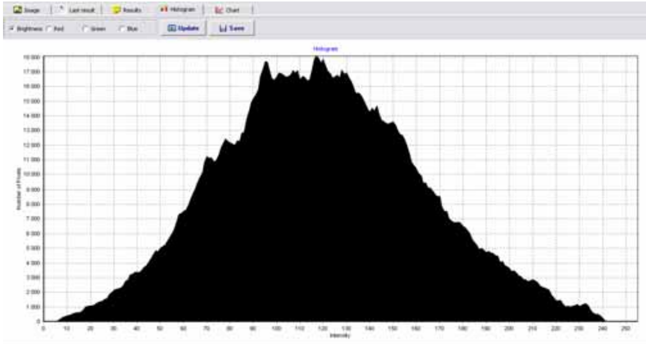
Source: own study / Źródło: opracowanie własne

Fig. 2. A general view of the base module of the computer image analysis stand

Rys. 2. Ogólny widok modułu podstawowego stanowiska do komputerowej analizy obrazu

A crucial element of the image acquisition process was the choice of appropriate lighting and positioning of the acquisition equipment. The stand ensures smooth supply of incident light (as regards the intensity), both from the direction of the camera and from the direction opposite to the camera, in relation to the examined material. The backlit table was an important element, which allowed for obtaining a high contrast of the image and its background. Strong, multidirectional lighting from the direction of the camera makes it possible to eliminate any shadows. It is essential to choose the lighting intensity taking into account the range of sensitivity of sensors in relation to picture acquisition. In particular it was necessary to examine a histogram of pixel brightness levels as regards the maximum use of the range (Figure 3).

For the purposes of repeatability of measurements the side walls were made of a material which diffuses light. The main source of lighting was provided by internal lamps. It is essential that external lighting is not too intensive and did not fall on the side walls pointwise.



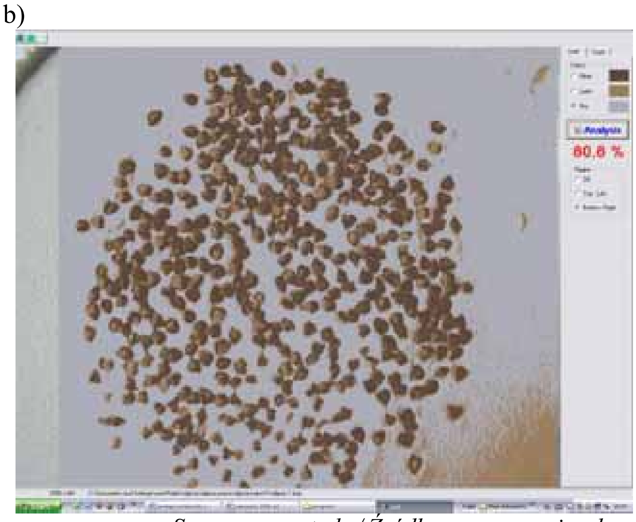
Source: own study / Źródło: opracowanie własne

Fig. 3. An example of a histogram of pixel brightness levels obtained from a digital image analyzed by the application "APR"

Rys. 3. Przykładowy histogram poziomów jasności pikseli uzyskany na podstawie zdjęcia cyfrowego analizowanego przez aplikację „APR"

a)

b)



Source: own study / Źródło: opracowanie własne

Fig. 4. Sample images of impurities by weight of flour in the dialogue box of the *APR* application: a – imported image as *bmp*, b – analysis of the imported picture

Rys. 4. Przykładowe zdjęcia zanieczyszczeń w masie mąki w oknie dialogowym aplikacji APR: a – zaimportowane zdjęcie w postaci bmp, b – analiza zaimportowanego zdjęcia

The APR program (Analyses Processing Recognition) is an application for analysing, processing and recognising images. Its basic feature is to build scripts for image processing. For this aim a scripting language was embedded to enable a number of graphic operations. Moreover it is possible to enter commands directly in the command line. Some operations are available from the panel with an appropriate user communication interface. The basic elements of the user interface are composed of three basic windows: main, video and script windows.

The task of the computer application "APR" based on the *RGB* colour description model and using a model for colour recognition learning was to isolate the measured objects from the background and to average *RGB* components within the object outlines:

$$R,G,B = \frac{\sum R_{0-255} \cdot K}{\sum K} \qquad (1)$$

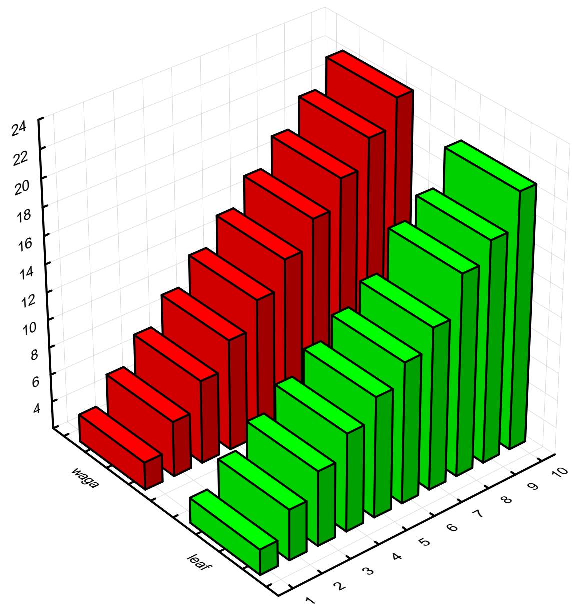
Where:
R – resolution of record (0-255),
K – number of pixels with this resolution.

Having averaged R,G and B components we may calculate the average brightness of the image according to the following formula:

$$I= (R+G+B)/3 \qquad (2)$$

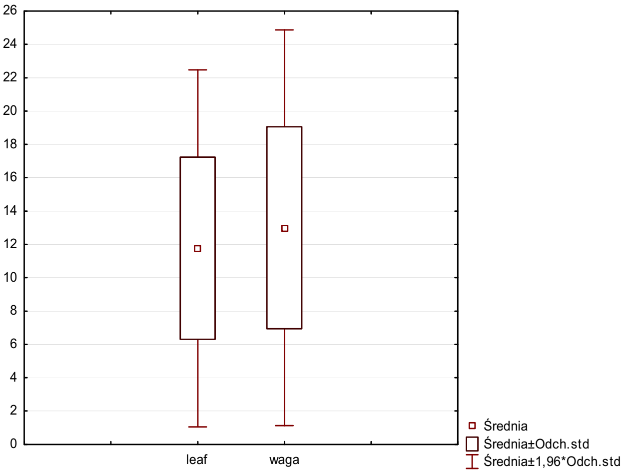
5. Result analysis and discussion

The performed laboratory tests constituted a basis for charts illustrating the comparison of two methods for evaluating the percentage of impurities in flour. The comparison concerned the sieve analysis of loose materials and the computer image analysis (Figure 5). In addition a chart of values of descriptive statistics was prepared (Figure 6). On the basis of those charts we may say that the use of the computer image analysis and the Leaf computer application is reasonable because the results obtained by means of the two methods do not diverge from each other.



Source: own study / Źródło: opracowanie własne

Fig. 5. Percentage of impurities in flour obtained by the sieve method and the computer image analysis
Rys. 5. Procentowy udział zanieczyszczeń w mące uzyskany za pomocą metody sitowej i komputerowej analizy obrazu



Source: own study / Źródło: opracowanie własne

Fig. 6. Graphical interpretation of analysis of variance to assess the contamination of flour by means of computer analysis and gravimetric analysis
Explanation: waga – weight; średnia – mean; odch. std – standard deviation
Rys. 6. Interpretacja graficzna analizy wariancji dla oceny zanieczyszczeń mąki za pomocą analizy komputerowej oraz analizy wagowej

6. Conclusions

The computer image analysis makes analysing much faster and allows for quick and easy determination of the level of flour contamination.

1. The use of the *APR* computer application enables us to determine the percentage of impurities in the weight of flour.
2. The results which are obtained through the computer image analysis do not differ from those obtained with the sieve analysis, which is time- and labour-consuming.
3. The image computer acquisition stand allows for taking pictures in a precise manner eliminating shadows, which is extremely important in the examinations.
4. The use of computer image analysis in combination with applications for the evaluation of agricultural and food products enables one to conduct quick analyses because it allows for the determination of the percentage of impurities. The method was verified and compared to traditional analyses (sieve and gravimetry method). Comparing the percentages of impurities in flour the computer image analysis did not differ much from the sieve and gravimetry analysis. The only difference was in the time for performing calculations as compared to traditional methods.
5. Due to the assessment of agricultural and food products by means of IT techniques analysing the materials in question as regards their external appearance much faster. Computer image analysis and specific computer applications - „APR" is an easy-to-use, accurate and innovative application, which may become useful for the agricultural and food industry.

Universal possibilities of the used test tools combining image analysis and artificial neural networks make it possible to apply them under the conditions of industrial practice. A picture of a material batch selected at random will be sufficient to analyse the contamination of grain received at a collection centre. The analysis time may be shortened significantly and sampling may be simplified. The described methods and techniques are highly applicable so they may be extremely useful in the processes of the food industry.

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