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NON-INVASIVE INVESTIGATION METHOD OF NATURAL FIBER SEEDS QUALITY

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Abstract: *The paper tries to analyze the possibilities of classification of hemp fiber plant seeds in order to provide a sorting system to select the high quality seeds destined for human consumption. The existing automatic classification systems for seeds take in consideration the size, shape, color and texture in order to assess the quality of nutritional seeds. This work investigates the classification possibilities of image systems using photo images acquired by an RGB camera.*

Key words: *ripeness of seeds, pixel intensity level, white balance, color histogram.*

1. Introduction

Fiber plants such as hemp and flax are considered valuable crops for both fibers and food supplements for human and animal nutrition.

New food products developed from fiber plants seeds, in countries such as France and Austria, demand selection solution of the high quality of seeds destined to be used in foods and drinks, such as: hemp oil, hemp butter, hemp chocolate, hemp sauce, hemp pasta, hemp bars and patisserie that use hemp seeds and oils.

In agriculture the new image recognition technologies are gaining more ground in the sorting systems. The automated devices try to eliminate the human inspectors that are prone to fatigue errors and are limited to a certain operation limit. Having these limitations the industry has focused on development of machine vision devices that are able to sort and detect products based on external and internal characteristics.

The imaging systems use for the detection of the external characteristics the investigation of the color in order to generate the shape, size or type of defects. The work of [2], [3] involves the use of a image sensor that was used to build a database containing images of various weed species. The histograms of the pixel intensity level were developed and used in order to highlight the difference between the seeds.

Image processing has started to gain a very big interest due to development of computer technology and optical sensors that are able to easily convert images to digital information. Based on mathematical algorithms detection through digital imaging is today a common task to recognize, differentiate, and quantify objects in order to make various differentiations between classes of objects.

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Earlier works made in the direction of identification of seeds by machine vision, were focused on technical crops and their varietal differences. The differences between varietal seeds were of geometrical nature that appear in the structure of the seed, and which could provide the identification parameters that could build the discrimination algorithm for the seeds variety [1], [10].

Other discrimination parameters, such as color intensity levels, were used in experimental works that aimed at separation of lentil seeds [7], from non-seed impurities such as twigs, dirt and stones. Classification of the grade of wheat was conducted by [5], [9], and special grading classes, etc.

Color as a discrimination parameter in the classification algorithms, was used for the separation of wheat with different color shades, with good repeated results.

Color as a discriminating parameter has certain advantages and could be used in separation of seeds in grading classes. Several studies used color images determine seed quality for legumes seeds, immature soybean seeds [9], damaged kernels [4], etc.

2. Natural fiber seeds as food source

Hemp seeds can be used in traditional bakery and in culinary products with great added value in the human health. The hemp seeds can be collected as part of the fiber crop or can be produced in crops destined especially for the seeds production. The main use of hemp seeds in the eco-tourism can be divided in two main directions: for human nourishment and for animal feeding.

Hemp seeds presented as whole grains or hulled hemp seeds are a great source of oil and protein rich food supplement. Many of the healthy food consumers appreciate greatly natural sources of proteins and can be used to supplement the low animal protein diets.

Hemp oil is regarded as being one of the main quality vegetable oil that provides an ideal proportion of omega 6 to omega 3 fats. In figure 1 can be seen a comparison of the different fats content on oils that are rich in omega 3 fats and omega 6 fats. It can be seen that hemp oil offers a valuable balanced vegetable oil that can supplement the human nourishment and provides a healthy diet.

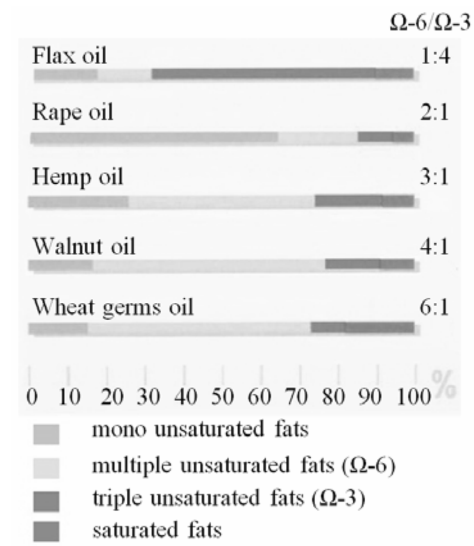

Fig.1. *Fats content comparison of various vegetal oils* [3].

The healthy food market represents an ever growing sector were hemp seeds can have a greater role.

Today the largest amounts of hemp seeds are sold for animal feed, as bird seed or as bait for fishers.

2. Materials and method used in reaserch of the seeds quality

The experimental work presented in this paper, was focused on evaluation of seeds quality based on surface color and pattern in order to make an estimation concerning the grading of the seeds, depending on the percentage of the ripe seeds versus immature seeds. The paper begins with the presentation of the experimental stand and the equipment used in research with the conditions used during the capturing of the images. The algorithm and the software developed for the quality analysis of the seeds are presented with the procedure followed in order to establish a repeatable experiment. Finally, in the last section the results are discussed and conclusions are presented.

The image analysis digital measurement process usually takes several steps and operations in order to provide a proper output.

The image measurement method is based on three major operations: setting up of the working parameters of the camera, image processing and interpretation of the classifying algorithm applied to the images. The result will be displayed as graphs, marks, classes of quality, etc.

The sequence of these operations is shown in Fig. 2.

Fig. 2. *Flow chart of the digital image processing.*

Machine vision is currently used in agriculture in grading of different sorts of seeds and impurities. The fiber hemp seeds are not seen as an important crop. Only recently, due to the rich and valuable oil content of the hemp seeds, this crop has started to be seen as the new wonder nutritional source for human beings.

Harvested fiber hemp seeds are mostly free of weeds seeds since this crop is a natural weed suppression [6]. The development of the fiber hemp seeds is not uniform, such that, on the same female stalk, seeds with all growing stages will be found. The seeds maturity is achieved in average in three to five weeks. The mature fiber hemp seeds have dark markings that look like white mosaic lines [11]. Immature seeds have a shell color that range from a green to white color.

There are numerous reasons for identification of the unripe seeds. The quality of the seed and final product are influenced from storage to processing, since unripe seeds present a higher moisture that will affect the proper storage and drying. The immature hemp seeds are also a major defect source in the final processed food products that have as raw material fiber hemp seeds.

As a reference comparison for the sorting system seeds were selected in order to best represent the unripe and quality ripe seeds. In Fig. 3 it is presented the image with the ripe hemp seeds (on right side) and the unripe seeds (on left side) that was used as a reference in the software developed for the recognition of the quality identification system.

a) b)

Fig. 3. *Samples for representation of the quality of fiber hemp seeds. a – unripe seeds; b – ripe seeds.*

The economic aspects regarding the cultivation of the fiber hemp crops bring new challenge to the farmers that try to provide high valuable fiber hemp seeds for human consumption. The additional revenue form the commercialization of the fiber hemp seeds is possible only by providing high quality seeds free of unripe seeds.

High amounts of chlorophyll are found in the unripe seeds and therefore these must be largely removed so that the final product will be more stable requiring less light protection and better tasting [4].

In Fig. 4 it is presented the experimental stand used for acquisition of the images that will be analyzed and evaluated in order to determine the percentage of the ripe seeds versus the underdeveloped seeds. The fiber hemp seeds (1) are placed on the background surface (2) that has a dark color and is made out of lusterless material that has as purpose the elimination of the shadows of the seeds.

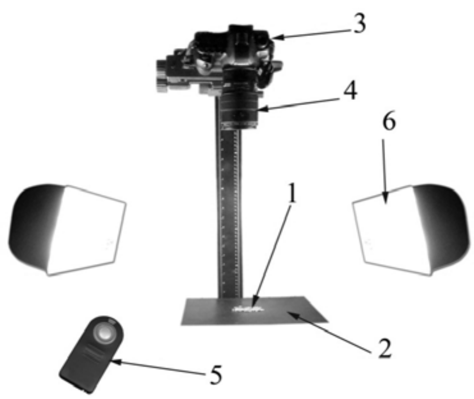

Fig. 4. *Experimental stand used for the image acquisition of the seed probes:* 1 – *seed probe,* 2 – *lusterless black background for the attenuation of shadows,* 3 – *DSLR camera,* 4 – *lens system,* 5 – *infrared camera trigger,* 6 – *fluorescent light lamp.*

The DSLR camera (3) is positioned above the probe (1) and the image is acquired through a lens system (4) that is manually adjusted in a fixed position. The remote control trigger (5) is connected over the infrared with the camera and triggers the acquisition of the image without the need of touching the camera. This device is used so that the camera will be unaffected by vibrations due to human operator manipulation of the image systems.

The equipment used in the experimental stand was composed of the following main devices:

• Photo camera: Canon 5D Mark II with a 21.1 Megapixel Full-Frame Sensor, dust and weather-resistant, self cleaning sensor, broad ISO range (50-25600) and 3.9 fps burst mode;

• Photo camera lenses: Canon EF 100mm F2.8 L IS USM Macro, maximum format size: 35mm full frame, focal length: 100mm, maximum aperture: F2.8 and minimum aperture: F32

• Lighting system: Kaiser RB 5004 HF, Reflector (500 x 210 mm), Lamps 4 x 36 watts, Color temperature 5400 K CRI 98, Operating frequency approx. 40 kHz.

The tasks that are realized to reach the required results are part of three main operations that are needed to process the image digitally.

- The setting of the working parameters involve the camera positioning above the seed probe, setting the camera parameters such as the focus point, camera aperture, etc.
- The image acquisition and processing represents the repetitive part of the experiment. In this stage the tasks that are repetitive from one probe to the next are: probe positioning in the photographing area, triggering the camera to shoot the picture, processing the image in order to compute the result that will give a quality mark for the probe.
- The data interpretation operation will provide the results of each probe that will be saved in a file for further processing. By containing all the results of the probes in a file the results

are compared as a whole and conclusions could be made regarding classifications of the quality of the seeds as a total.

The task of software analysis of the image represents the algorithm that will provide the solution for the identification of the seeds quality.

The image analysis involves the use of some set up parameters so that the software will be able to differentiate between the good pixels acquired from the quality seeds and the bad pixels acquired from the underdeveloped seeds.

The calibration must be made one time only for the all probes analyzed as long as the lighting conditions will not alter or the camera position will not be changed. The etalon image is loaded into the program and the operator will then set up the parameters that will correctly identify the background of the sample.

In order to have a successful evaluation, it is important to choose the proper calibration parameters. The upper level and lower level of the major 3 colors (Red Green Blue) are defined by adjusting the desired position of the six sliders found on the graphic user interface of the developed software for this experiment. The filter for the background selection is setting the color of the background pixels as full red so that the software will be able to properly eliminate them from the analysis.

The next step in the calibration of experimental parameters was to establish the level of the good pixels that will represent and define the ripe seeds. This procedure is made with the similar color setting sliders that were used for the filtering of the background pixels. This procedure will highlight the seeds that were considered as ripe. This filter will not change the color of the pixels chosen for the ripe seeds by leaving their natural color. The rest of the pixels from the image will be the ones associated with the unripe seeds and they will be highlighted by assigning gray level.

The optimum level of these filters will give the program the possibility to analyze each photo and establish the right ratio of representative pixels for the ripe seeds versus the pixels of the unripe seeds.

Once the experimental parameters were set up, seed probes were analyzed with 3 repetitions for each batch of seeds. Each image taken was processed by the software in order to determine the pixels for the background, the pixels for the matured seeds and the counting of the number of good pixels versus the bad pixels which gave the ratio between the good seeds versus the bad seeds. Once these values were established the software calculated the ratio and showed the value on the graphic user interface.

3. Results and discussions

The image analysis method provided surprising good results as well as weak points. The method offered during the tests good repeatability of the three probes executed for each seeds sample.

The results were compared with the quality analysis of the seeds made based on operator identification (Fig.5). The seed probes were harvested the experimental fields during the harvesting period between 30th August and 30th October in the years 20011 and 2012. The experimental harvests aimed at identifying the optimum harvest time for fiber hemp crops of the French type Santhica 27.

The histogram analysis revealed that all the three channels for the RGB offered a possibility to strongly differentiate the good seeds from the bad seed by choosing the proper interval of values from the graph that presents the pixel intensity level according with the maximum number of pixels found having this pixel intensity level value.

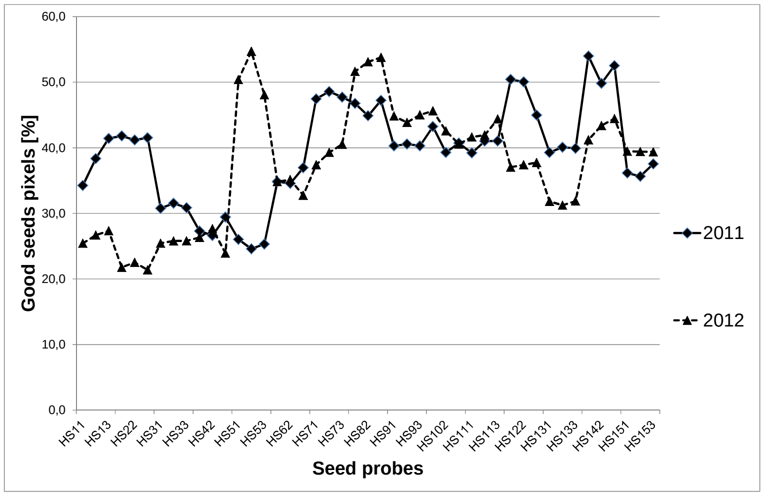

Fig.5. *Graphic presentation of the results obtained from the analyzed images of the fiber hemp Santhica 27 seeds harvested in two consecutive years 2011 - 2012.*

By evaluation of the Red channel histogram (Fig.6) it was determined that the ripe seeds were more better identified when the color level filter would be in the interval of 50 and 108, while the unripe seeds presented more pixels in the interval between 190 and 220 on the color level number chart.

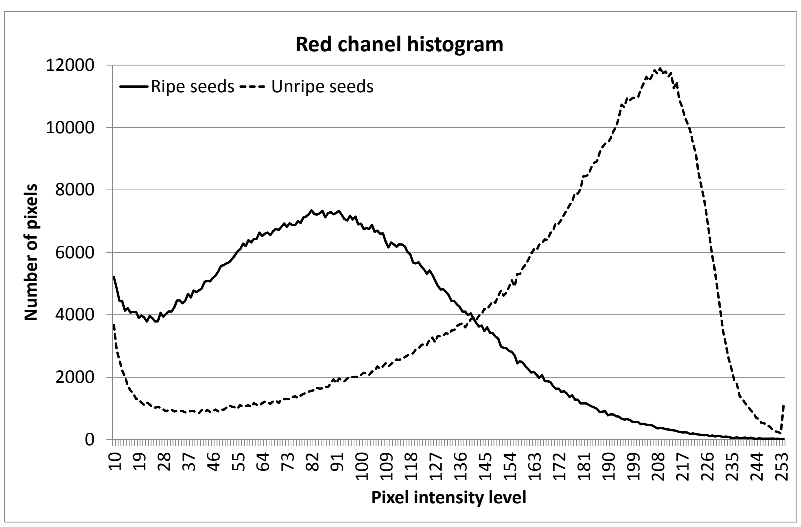

Fig.6. *Histogram of the red channel for the ripe seeds and unripe seeds images used in calibration of the classification software.*

Similar analysis made using the green channel of the RGB colors acquired by the image sensor revealed that the ripe seeds present a darker color than the unripe seeds and so most of the pixels are found in the lower values interval of the color level intensities, while the unripe seeds were mostly found in the upper values interval of the color level.

The green color level of pixels presents that a high number of pixels for the ripe seeds are found in the first part of the color level range (20 to 95) with a darker color intensity, while the unripe seeds had most of the pixels in the area with the lighter color intensities found between 160 and 210.

The blue channel histogram of the seeds was not a good filter for the ripe seeds as this color level revealed that most of the pixels for the ripe seeds were found in the interval between 15 to 45 that is a very dark intensity that will overlap with the background selection. On the other hand the unripe seeds were mostly to be found between 75 to 140 a color intensity that was more suitable for the classification filter of the unripe seeds. The biggest source of errors in the software comes from the fact that the classifying method of the good seeds does not distinguish between entities and cannot determine the geometric boundaries of each seed in the image. Further algorithms must be developed in order to identify each seed in the picture and extrapolate the classifying algorithm to the level of each seed. This is necessary as the texture of the seeds is not uniform and pixels of similar color can be found on mature seeds as well on unripe seeds.

4. Conclusions

The method provided good repeatable results with good comparison to the human operator analysis (Fig.7).

Further improvements are to be implemented in order to achieve results with higher precision. The following improvements were identified are foreseen as future work:

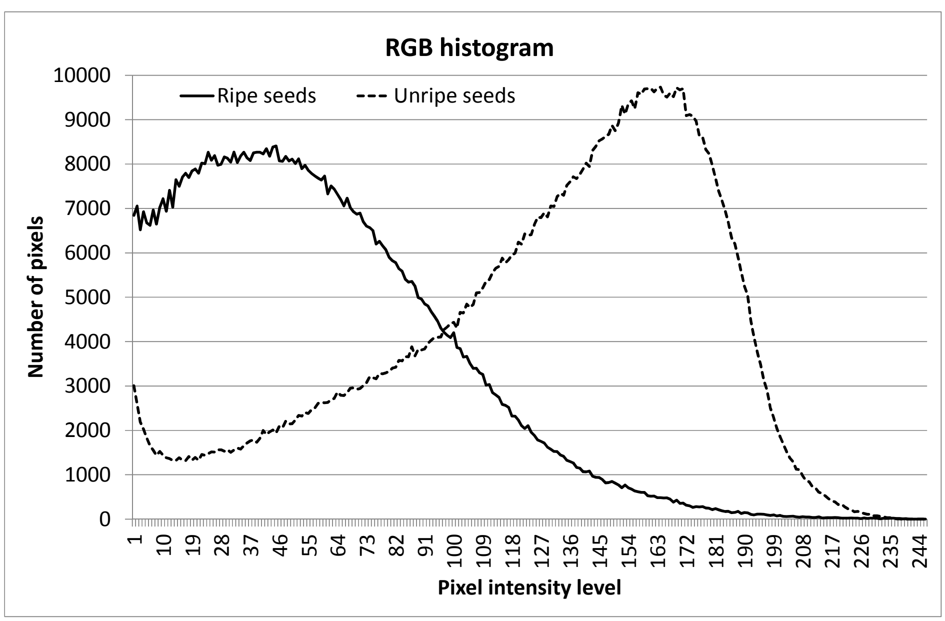

Fig.7. *The RGB histogram analysis of seed quality based on pixel intensity level value.*

The background material needs to be a better lusterless material while some reflections were identified as a source of errors;

The light source for the fiber hemp seeds probes should be adjusted so that the lighting parameters will not change during the experiments. A closed chamber with controlled artificial light should be used for the exposure of the seed probes for the image acquisition eliminating the natural light influences;

The light source will be adjusted with a color that will give a higher contrast between the seed categories.

The setup of polarization filters will diminish the influence of the light reflections from the seeds surface. Since seeds have a glossy surface they reflect light quite strong and this generates in the software errors for unripe seeds pixels.

Industrial application of machine vision in quality identification of fiber hemp seeds is possible and with the growing demand for nutritional products, the financial conditions will make this possible.

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