NON-DESTRUCTIVE METHODS FOR DETECTION OF FOOD QUALITY

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ABSTRACT

At the present stage of economic development of the Republic of Uzbekistan, the problems of increasing the efficiency of food industries come to the fore. The requirements for improving the quality and competitiveness of domestic food products are increasingly increasing.

The solution of these problems in modern conditions is possible only on the basis of the use of the latest scientific achievements in the field of engineering and technology, ensuring the stability of production processes, equipping flow-mechanized lines with modern means of continuous automatic control, regulation and management using intelligent technologies.

Conditionally, control measures can be divided into periodic and continuous. Most types of inspections can be attributed to periodic ones. Another type of classification is that non-intrusive and intrusive control methods are distinguished. The former are usually understood as methods that do not require either:

- destruction of the controlled object or its disassembly

- physical access to the controlled object

Sometimes the concept of "Intrusive control" is interpreted much more broadly. "Non-intrusive" refers to the sensitivity of the information that is recorded as a result of such control. Therefore, it is quite difficult to draw a clear line between intrusive and non-intrusive methods. It would seem that today satellite surveillance methods are a pronounced example of non-intrusive control. Nevertheless, it is curious that when the Americans launched their first photo-reconnaissance satellite into orbit in the early 1960s under the Korona program, the Soviet Union protested about this at the UN, calling this activity contrary to international law.

Keywords: *Intrusive control, non-intrusive, automatic control, satellite methods.*

Introduction. Today's steady growth of foreign trade turnover, on the one hand, the restrictive measures of the global pandemic COVID-19, on the other hand, force the search for optimal forms and mechanisms of quality control of imported products. is one of the most important stages in the process of customs clearance of foreign trade goods.

In this regard, the study of ways to remotely control the quality of imported goods without breaking their packaging remains a topical issue.

Such methods are usually called nontrusive methods of control (nnu), one of its types is the control of the quality and safety of the product with the help of an image obtained using X-rays or gamma rays. Bunda allows you to control the load of the contender or vehicle without opening or unloading. This method significantly reduces the number of unnecessary checks and reduces the time spent on it .tiradi The nontrusive method, unlike the intrusive test, provides for verification of the quality, reliability and safety of objects without destruction, that is, then it is possible to carry out the control without purposeful use of products and, in some cases, without interrupting the operation of the object.

For example, if the control of imported goods transported by motor transport can last up to 8 hours with a simple intrusive method, then with the help of the control technique using the nnu, its verification takes an average of 10 minutes. Thus, the use of non-corrosive methods of inspection allows to significantly reduce the time of Customs Control and increase the permeability of car transfer punches.

Nontrusive control methods have a number of advantages, such as:

- higher security level than traditional tools;
- less time and costs required for supervision;
- control efficiency is high;
- it is possible to carry out control on the basis of a purposeful and clearly defined plan;
- it is possible to carry out control remotely;
- reduces the possibility of damage to products

Methodology. Methods of non-destructive testing

1) Magnetopowder - particularly suitable for checking welds. Magnetic tape captures the scattering fields that appear in the weld over the defect areas when magnetization occurs, to prevent cracking. The scattering flux is displaced to the surface because the magnetic permeability is disturbed and much less than that of the metal at the crack site, and the magnetic flux, by circling the weld, helps in finding the defect. This method of inspection is not often used as a stand-alone.

2) Vortex current (electromagnetic) - sensitive to small cracks, both external and internal (subsurface) cracks method, based on the movement of eddy currents, which

appear as a result of the electromagnetic field in the metals. However, these currents have their own field, which interacts with the external one. Deviations in the homogeneity of the product weaken the internal field. The discrepancies are the basis for judging irregularities in the conductive metals. The "zest" of the method is the possibility of carrying out with the exception of the interaction between the transducer and the object, the distance gives them free movement relative to each other, so the accuracy of the results is possible even at high speed of the object.

3) Radio-wave - radio waves are received and processed, while the object is in the resonator, according to the results of changes make conclusions about the violations, reading the results from the measuring instruments. Advantageous method for the analysis of dielectrics, semiconductors, liquids, volatile substances. Its capabilities are quite broad due to the availability of 30 "sub-methods". Possibility to develop in the future as a feature of the method is holographic - ideal for volumetric images.

4) Optical - the method has the ability to be performed with measuring instruments (magnifying glass, caliper, depth gauge, ruler, stylus, tape measure). The disadvantage is that it can not help you to identify defects smaller than 0.1 mm in diameter. And the factors in which the inspection is made, directly affect the result - inaccuracies are possible.

5) Ultrasonic - requires close interaction with the object, because the result depends on the elastic vibrations. The method is mainly designed for deep defects, there may be difficulties in determining the size of the crack, but is useful for structural analysis.

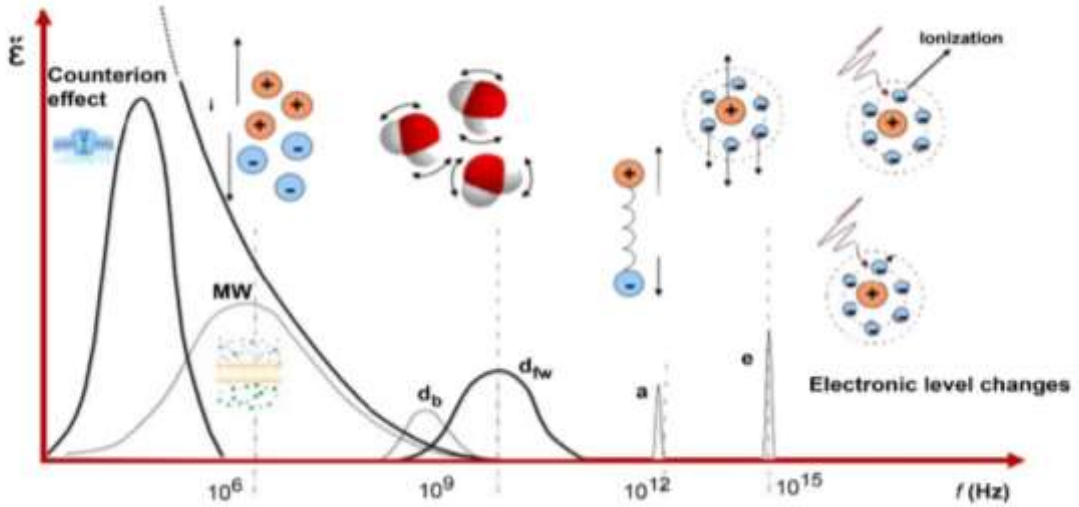
Non-destructive methods (NDMs) are a part of high-quality control functions and they support other established techniques. Non-destructive analysis refers to the surface testing of fruits and vegetables without any intrusive technique affecting the food aspect and quality.

The non-destructive assessment methods supply data on food characteristics such as structure, mechanical, physical, and chemical properties. The application of non-destructive measurement is the best approach for food processing [1]. Antioxidants are materials that can stop the oxidation of other materials and suspensions to protect against cell harm [2]. Specifically, some antioxidants such as anthocyanin, lycopene, and polyphenols extensively occur in several food products, including mulberry, tomato, sweet potato, lychee, and tea. Based on successive projections algorithms for choosing the ideal wavelengths related to anthocyanin content in lychee pericarp, the radial basis function support vector regression and radial basis function neural network models were combined into a single model that demonstrated the best performance in predicting and visualizing anthocyanin content variation in lychee during storage (R2 = 0.872)

Table1 summarizes the most common non-destructive techniques used to test the quality of agricultural products. Regular non destructive assessment techniques include machine vision, near-infrared spectroscopy, hyperspectral imaging, electronic noses, ultrasound measurement and acoustic emission measurements Regularly, the processing methods are affected by changes in chemical structure of the agricultural product. The dialectical properties of agricultural products are influenced by cell membranes, the presence of ions, electrical charges on proteins, and pH variations, while cause dielectric spectrum changes as shown in Figure 1.

Table 1. Most common non-destructive techniques used to test the quality of agricultural products.

Principals	Technique being used	Components
Optics	Image analysis	Size, shape, colour, external defects
	Reflectance, transmittance and absorbance spectroscopy	Colure, chemical constituents, internal defects
	Laser spectroscopy	Firmness, viscoelasticity, defects, shape
Dynamics	Vibrated excitation	Firmness, viscoelasticity, ripeness
	Sonic	Firmness, viscoelasticity, internal cavity density
	Ultrasonic	Internal cavity and structure, firmness, tenderness
Electro-magnetic	X-ray image and CT	Internal cavity and structure, ripeness
	Impedance	Moisture contents, density, sugar content, internal cavity
	MR/MRI	Sugar, oil, and moisture content, internal defects and structure



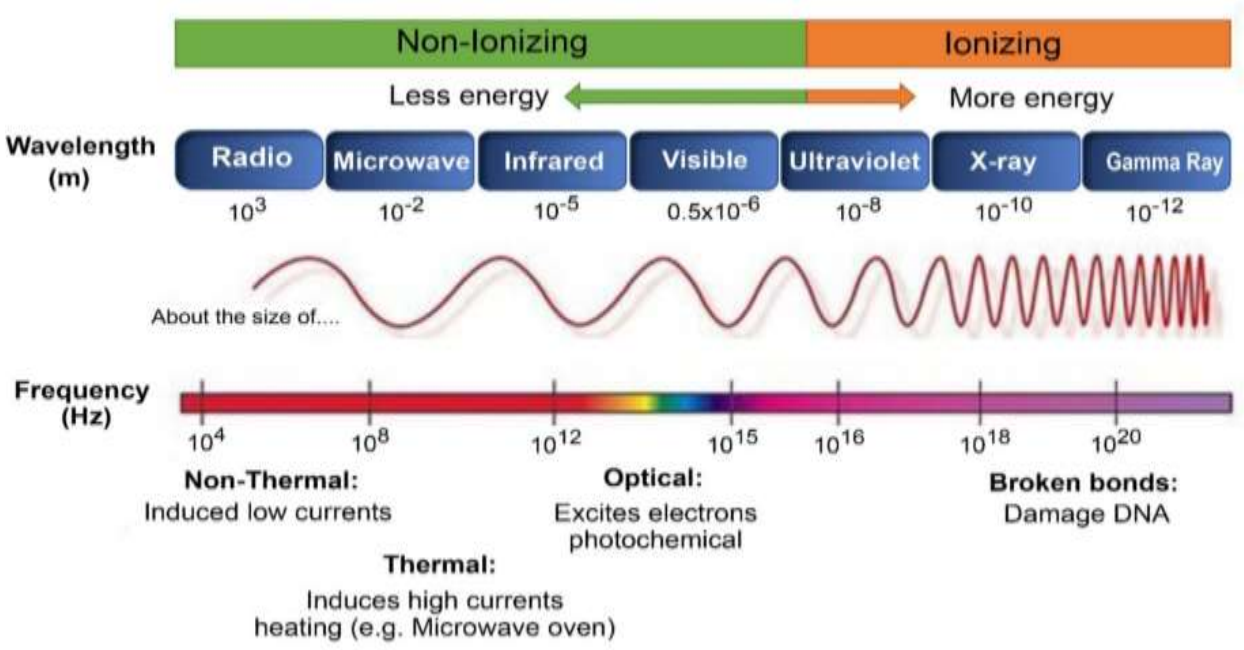


Figure 1. Schematic representation of the electromagnetic spectrum of the different effects that contribute to effective loss factor

Machine Vision System

The use of machine vision in food processing has been improved significantly in recent years. Machine vision techniques are automatic, non-destructive, and perfectly suitable for food quality assessment. There are a number of fields in which computers are an intricate part, including terrestrial and aerial mapping of natural resources, crop monitoring, non-destructive evaluation of material quality, etc. In machine vision systems, digital cameras with image analysis systems are used for the automation of visual reviews.[3] The machine vision system usually consists of five basic components: a light, an imaging unit, an image capture board, and the appropriate computer hardware and software. The working principle of machine vision as shown in Figure 2.

Machine vision can streamline dreary visual observing processes that take quite a while or require complex mechanisms to be completed. Martynenko confirmed that computer vision techniques showed changes in the density and porosity of ginseng roots during the drying process, consequently providing a strategic alternative to the requirement for checking complex electron optical microscope imaging. However, due to their biological nature the automatic examination of agricultural products has precision issues and problems that are not present in other fields. Although industrial products often have similar colours, shapes and sizes, the same agricultural products may display very different appearances from one item to another. The texture and colour of agricultural products are highly important after harvesting. Besides, the colour of the fruit surface of one piece of fruit may match the colour of an imperfection

on the surface of another sample of the same variety. The machine vision technique has been used to examine and estimate foodstuff quality in the food industry. It is affordable, quick, economical, hygienic, and consistent.. Currently, applications of the machine vision technology are commonly used for shape classification, defect detection, and quality assessment.. The results showed that the geometric parameters such as length, width, height and the projected area of the three studied varieties decreased while the sphericity increased significantly after removing the outer and the brownish layers. It was found that the values of micrometer data were lower for all the geometric factors.

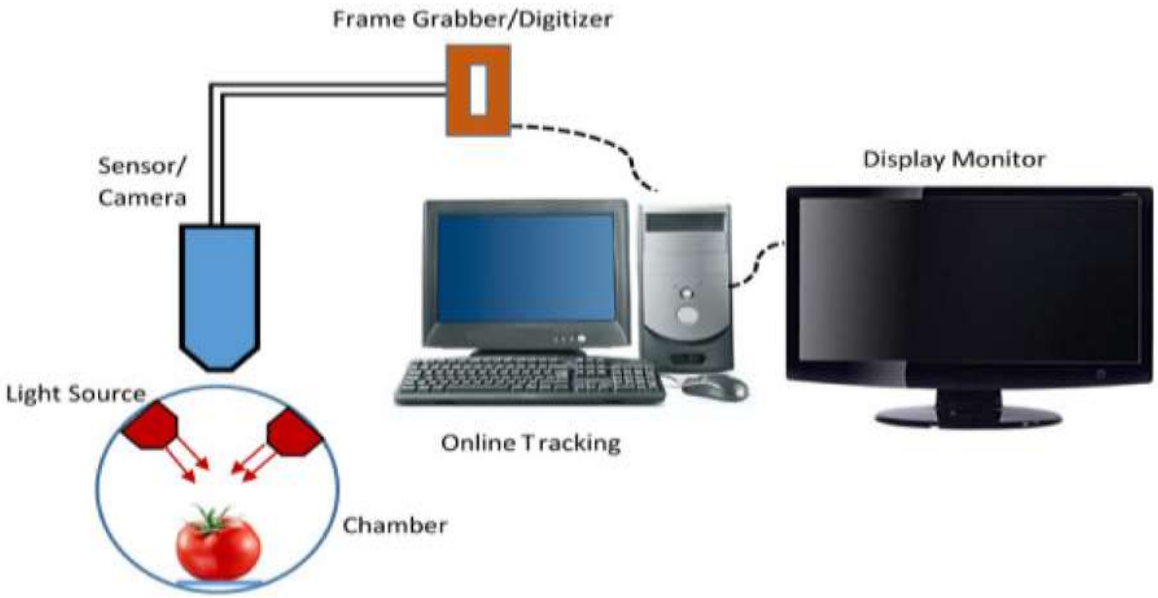


Figure 2. The basic concept and components of a typical machine vision system

Machine vision techniques were also applied for quality assessment of cumin and fennel seeds. The method based on discovery minor axis length and zone of the seeds. The classification of good and bad quality was completed on discovery the amount of seeds with basis and foreign elements available in bulk of seeds. The results showed that the quality was inversely proportional to the number of seeds with pedestals (x1) and number of foreign elements (x2) present in the samples. Machine vision systems have been widely used for detection of external pest damages in agricultural products, but because of the challenges involved in the penetration of visible light inside the fruits, it is not effective to detect the internal defects. Application of algorithm showed that the RGB image convert into L × a × b colour space and then active counter model algorithm was used to extract the fruit shape. Finally, the image was segmented to find the defects. The defective pixels were achieved 96% with strong pixels of 91%.

Conclusion. Non-intrusive inspection technologies, such as X-ray or gamma-ray imaging, can quickly verify the contents of a container or vehicle without the need to

open it or unload the cargo and thus confirm or refute the results of a risk assessment. In combination with the coordination of the activities of all authorities, this method will help to significantly reduce the number of unnecessary inspections and reduce time costs. Pillar One Standard 3 of the WCO Security Framework of Standards recognizes the usefulness of non-intrusive inspection technologies for trade facilitation and recommends that Customs authorities have and use non-intrusive inspection equipment where possible in accordance with the results of a risk assessment. Large non-intrusive inspection equipment is installed in buildings and has a high scanning depth, allowing a vehicle to simply drive through the installation. This speeds up the process and reduces the overall cargo inspection time. To ensure the correct installation and use of non-intrusive inspection equipment, the WCO has developed Non-Intrusive Inspection Guidance to help Customs authorities optimize the use of such technology for the benefit of control activities and trade facilitation.

ICC Customs Recommendation #17 also talks about the benefits of using non-intrusive inspection technologies.

The International Chamber of Commerce, also known as the World Business Organization, prepared in 2003 a set of 54 https://iccwbo.org/publication/icc-customs-guidelines-revised-version-june-2012/ concerning the most important issues in the activities of customs as an institution and as a border agency. These recommendations were revised jointly with the World Customs Organization (WCO) and published again in 2012. The 2012 edition contains 57 recommendations, representing a comprehensive list of practices that, according to the ICC, should be applied by all modern customs authorities.

WCO Guide to Non-Intrusive Search Equipment

Purpose: The WCO has published Guidance on the Procurement and Operation of Inspection and Inspection Facilities, which is part of the Framework of Standards for the Security and Facilitation of Global Trade, to provide guidance to Customs administrations on the procurement and use of such equipment to optimize the use of non-intrusive inspection technology.

Brief description: This manual contains a list of points that customs authorities should pay attention to when purchasing and using non-intrusive inspection systems. This process begins with identifying needs, including why non-intrusive inspection equipment is needed and for what inspection purposes it is needed. The procurement process must then be considered, including a summary of the technical specifications of the non-intrusive inspection equipment, and in terms of commissioning, it must be ensured that the systems and equipment are properly integrated into Customs procedures. The WCO regularly updates the Guidelines for the Acquisition and Commissioning of Inspection and Inspection Facilities.

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