ISSN 0002-306X. Изв. НАН РА и ГИУА. Сер. ТН. 2013. Т. LXVI, № 2.

UDC634.11 **RADIOELECTRONICS**

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THE AGRO PRODUCT SORTING SYSTEM BASED ON THE DEGREE OF MATURITY

The current material contains theoretical information associated with usage of NIR-band in social life especially in agricultural engineering. It also covers some specific details related to the new device developed by IRPhE's Applied Radiophysics Laboratory's team. The main purpose is the evaluation of fruits-vegetables' maturity and quality before/after harvesting using NIR waves' properties.

Keywords: NIR, Beer Lambert's low, portable and programmable, NIR absorbance.

Year by year the volume of productized agro material increases dramatically due to the population growth on Earth. The figure below shows the results of the survey (shown in Fig.1). A large portion of all fresh products is lost after harvest worldwide. The main causes are physiological (wilting, shriveling, chilling injury, etc), pathological (decay due to fungi and bacteria) and physical (mechanical injury), being these causes in many instances interrelated, i.e. mechanical injury can lead to postharvest decay in many cases. Losses are estimated at 20…40% in developing countries and 10…15% in developed countries, depending on the crop. Just in the EU an estimated 4 billion EUR is lost due to postharvest losses and reduced quality of fruit. Here is some evidence [1]:

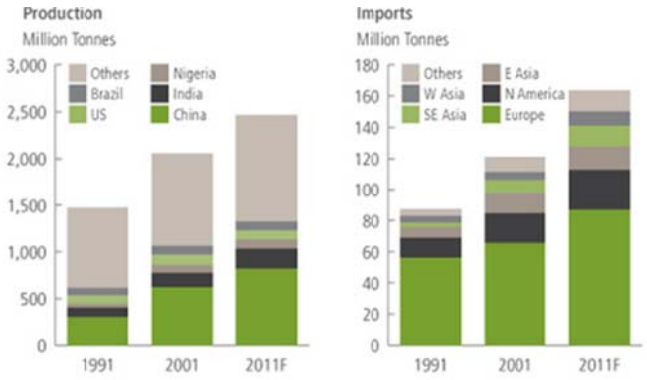


Fig. 1. Vegetable (tomato, cucumber, pepper, beans) postharvest losses in Southeast Asia range between 13…20%

A new sorting and evaluation system was introduced based on NIR technology as a simple and low cost solution to the above mentioned challenge. Near infrared technology has been extensively and effectively employed in a variety of fields both

for research and application utilities, including food, agricultural, chemical, pharmaceuticals, textiles, polymers, cosmetics and medical spheres, though it might have inherent limiting factors. Compared to the silence of the one and a half century after the discovery of NIR, an increasing number of scientists and engineers have been devoting themselves to exploiting this old but "young" technology.

Sorting system via fruit's quality indicator. The various components of quality are used to evaluate fruits and vegetables. Quality is classified into external and internal components. Appearance, flavor, texture, nutritive value, and defect factors are generally recognized as the five quality factors of fruits and vegetables. A portable device was prototyped by IRPhE's Applied Radiophysics Laboratory's team which evaluates and sorts fruits /vegetables according to their maturity level. The hardware uses a reflection mode from existing three acquisition configurations shown in Fig. 2.

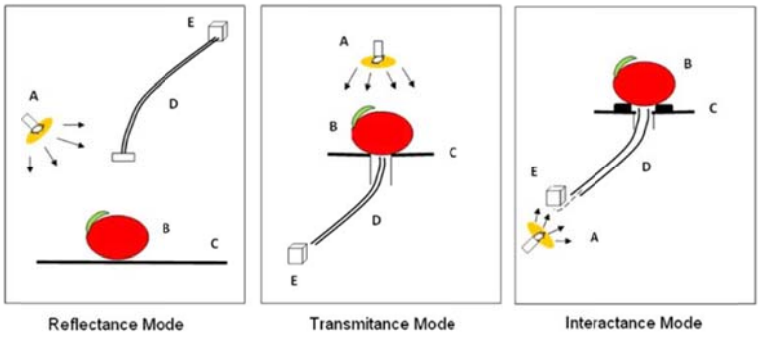


Fig. 2. Sketches: NIR source (A), Object (B), Fruit holder (C), Optic fiber (D), Detector (E)

In reflection mode the information content refers to the reflected signal's power volume. Due to the absorbance property, part of transmitted energy is absorbed by the object (agro product) the other part reflected back. The deviation of absorbance value depends on the maturity degree and transmitted waveform length as illustrated in Fig. 3 [2- 4].

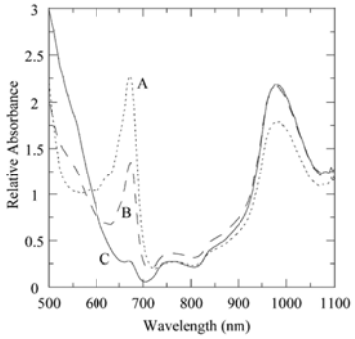


Fig. 3. Typical absorbance spectra for (A), mid-harvest (B) and late harvest (C)

NIR sorting equipment works as follows. A NIR source is focused to illuminate a piece of fruit as it passes under the NIR system. Some of the light penetrates through the fruit and is retransmitted. (This effect can be observed by holding the fruit to a bright lamp in a dark room. The fruit will grow at a distance from where the light is shining on it). The amplitude of the transmitted/reflected light is affected by the internal properties of the fruit and contains information about the internal properties of the fruit. A high maturity fruit will absorb more light at a certain wavelength than a low maturity fruit. Initially, when the fruit or vegetable is raw the distance among the cells in flash is relatively close in contrast to the mature one. Gradually with maturity, the distance starts increasing. Accordingly, the absorbance starts increasing too. Chlorophyll also plays a vital role as its absorbance value is around 680 *nm*.

Beer's law states that the absorbance is directly proportional to concentration.

$$\mathrm{A} = \mathrm{e} \times \mathrm{b} \times \mathrm{c}, \tag{1}$$

where A - is absorbance (no units, since $A = \log_{10} Po/P$), e - is the molar absorptivity with units of L *mol-1 cm-1*, b - is the path length of the sample. We will express this measurement in centimeters, c -is the concentration, expressed in *mol L-1*.

The amount of radiation absorbed may be measured in the following ways:

Transmittance:

$$\mathrm{T} = \frac{\mathrm{P}}{\mathrm{Po}}. \tag{2}$$

%Transmittance:

$$\%\mathrm{T} = 100 \times \mathrm{T}. \tag{3}$$

Absorbance:

$$A = \log_{10} \frac{Po}{P}, \tag{4}$$

$$A = \log_{10} \frac{1}{10}, \tag{5}$$

$$A = \log_{10} \frac{100}{\%T}, \tag{6}$$

$$A = 2 - \log_{10} 10 \times \%T, \tag{7}$$

where P - radiated power, P_0 is the transmittance power.

So, if all the light passes through an object without any absorption, then absorbance is zero, and the transmittance is 100%. If all the light is absorbed, then transmittance is zero, and absorption is infinite.

The new developed device uses values of P, P0 to calculate the absorbance percent and makes a decision of the maturity degree. It consists of the following components, NIR source (for generating modulated signal), analyzing part (detection,

displaying), optical fiber bundle (reflected portion redirection) (Fig. 4). The device uses this advantage to calculate the absorbance value and makes a decision on maturity degree.

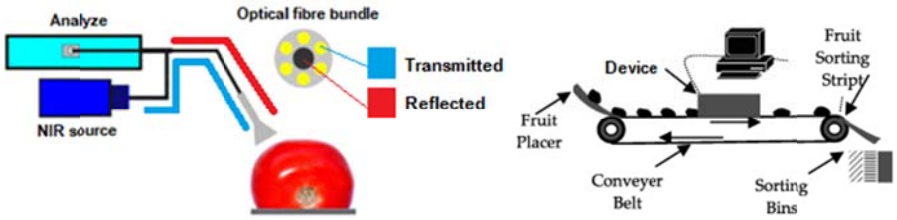
It consists of the NIR source components (for generating modulated signal), analyzing part (detection, displaying) and optical fiber bundle (reflected portion redirection) (Fig. 4).

Contribution will be done both in programming and hardware design. Here are expected results listed below:

- fast measurement,
- compatibility,
- possibility of two mode functions (production and laboratory).

This function allows a user to choose whether he/she is going to take a measurement in the field condition as a laboratory device or put it in the production mode (connect to PC run Software) for line sorting system:

- portability,
- energy saver,
- provides solutions for all varieties of fruits,
- doese not damage the product.



a) *b)*

Fig. 4. a - laboratory mode, b - production mode

Here are some technical characteristics of the device:

Table

Technical characteristics of the device:

Wave length	980 *nm*
Power consumption	0.3 *mW*
Frequency	80 *Hz*
Modulation index	100 *%*

The main advantage of the introduced machine is that it facilitates automatic grading and sorting in a non-destructive method. The whole machine is cheap compared to other existing solutions. It will also increase export of agro products as it

can process a large volume in a short time and does the quality assessment as per the requirement of export. In our country, the entire producte of fruits and vegetables cannot be taken to the storage place because of the lack of processing. But using this machine, this can be achieved. It also facilitates the machine sorting where human error is not introduced.

Conclusions. This research will develop practical sensors and technologies for quality measurement and grading of fruits and vegetables before, at and after harvest. It also aims at generating new knowledge and understanding the optical and mechanical properties of fruits and vegetables and their relationship with the physiological factors and quality attributes. A systems approach of integrating sensors development, properties characterization, and models/algorithms development will be applied to attain the following specific objectives:

Objective 1. Developing cost effective sensors and sensing systems to measure and monitor the quality/maturity of separate products.

Objective 2. Developing a commercially viable technology to presort and grade fruits and vegetables so as to decrease postharvest handling and storage costs for fruit growers.

Objective 3. Develop a technology to accurately and rapidly assess, sort, and grade harvested agro products for multiple internal quality attributes (firmness, flavor, ripeness) and defects.

Fruit maturity measurement will be achieved through integration of NIR technology with the nondestructive firmness measurement method developed in our lab. Algorithms will be developed and integrated into the sensor for real-time measurement of fruit firmness, soluble solids content and other maturity parameters. Laboratory and field tests will be performed to assess the sensor's performance and portability. A commercially viable infield mobile sorting technology will be developped for sorting and grading harvested products into two or three quality grades (fresh market, processing, and cull).

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ԳՅՈՒՂՄԹԵՐՔՆԵՐԻ ԴԱՍԱԿԱՐԳՄԱՆ ՀԱՄԱԿԱՐԳ՝ ԸՍՏ ՀԱՍՈՒՆԱՑՄԱՆ ԱՍՏԻՃԱՆԻ

Հետազոտված են ԻԿ դիապազոնի՝ հասարակական կյանքում, մասնավորապես՝ գյուղատնտեսության ոլորտում կիրառության հարցերը: Բերված են որոշ տվյալներ՝ կապված IRPhE-ի լաբորատորիայում կիրառական ռադիոֆիզիկայի խմբի կողմից ստեղծված նոր սարքավորման հետ: Աշխատանքի նպատակը NIR ալիքների հատկությունների միջոցով մրգերի և բանջարեղենի հասունության ու որակական հատկանիշների գնահատումն է՝ մինչև բերքահավաքը կամ դրանից հետո:

Առանցքային բառեր. ԻԿ, Բիռ Լամբերտի օրենք, դյուրակիր, ծրագրավորվող, ԻԿ կլանում:

Р.А. СИМОНЯН, Д.Г. ЗАРГАРЯН, А.Г. ГУЛЯН, Г.А. ПИРУМЯН

СИСТЕМА СОРТИРОВКИ АГРОПРОДУКТОВ ПО СТЕПЕНИ ЗРЕЛОСТИ

Исследуются вопросы использования ИК-диапазона в социальной жизни, особенно в сельскохозяйственном машиностроении. Описываются некоторые вопросы, связанные с новым устройством, разработанным в лаборатории прикладной радиофизики IRPhE. Дается оценка зрелости и качества фруктов - овощей до или после сбора урожая с использованием свойств NIR волн.

Ключевые слова*:* инфракрасный, закон Бера Ламберта, мобильный, программируемый, ИК поглощение.