NON-DESTRUCTIVE SORTING OF POTATOES

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ABSTRACT

The internal quality of potatoes and other vegetables and fruits is an important quality factor for both consumers and food industry. There are several diseases and defects, which have no effect to the quality of potato skin. Therefore internal defects remain invisible to human and also to ordinary camera.

V-camera instrument

V at V-camera stands for "virtually peeling". In this method and technology the potato, or other skinned fruit or vegetable, is virtually peeled by measuring the NIR transmission of potatoes and simultaneously measuring the NIR reflection from the potato skin.

Keywords: NIR, potato, sorting, internal quality, defects, v-camera, NIQAT

INTRODUCTION

Problem status

It is well known that the quality of potato tubers intended to processing is determined by the quality status of the tubers flesh notwithstanding the quality of the peel which is to be removed. In case of surface defects due to diseases, pests, mechanical injuries, and soil pollution the machines so far known most frequently are sorting such tubers as defectives although their fleshy content is flawless.

The sorting machines based on the light reflected by the objects, i.e. based on their appearance only, can not detects that are hidden not only from man's sensory receptors but also from all kinds of instruments working with reflected light.

Therefore, because of this problem, the tubers having a flawless peel but with internal cavities, internal discolorations, vitreousness, and other kinds of internal defects are erroneously assessed and discarded by sorting as unfit for processing the sorting machines based on measuring the light transmitted by the objects (INAME AQS 602 et al) can defect both **external and internal defects** but without distinguishing between those type of defects. Therefore, tubers with flawless flesh but having defects on the skin due to Rhizoctonia mechanical injuries etc. are frequently assessed as defectives and discarded as unfit for processing. This leads to incomplete use of the raw material and losses to both the producers and processors.

METHOD AND MATERIALS

The new machine, here presented, has not the above mentioned drawbacks. It is based on a method patented by Prof. G. Krivoshiev in 1999 year BG Pat. 62304. In scientific community this method is known under the name "Seeing through layer" (STL). The author is declaring it as being a virtual method (V) because by means of optical and mathematical mans id predicted (measured) the internal spectrum of the fruits without they being peeled or sliced. This is equivalent to a virtual removing of the skin (peeling) and allows for defection of internal diseases and defects otherwise unseen by observation. Moreover, up to now such defects could not be detected reliably by spectral instruments as well because the disturbing effect of the skin strongly prevented from measuring of the internal spectrum.

STL - method

The STL method is created in 1996 by Prof. Krivoshiev and it is originally called "the method for a virtual peeling of the skin" (V-method). The word "skin" in this case means the skin of potato tubers, which hinders to fulfil a precise assessment of fruit flesh quality. It is a method for a nondestructive measurement of the internal (of the fruit flesh) optical density by eliminating the disturbing skin spectrum using the diffuse reflectance. In the year 2000, D. Dham gives to the new method the name "Seeing Through Layers" (STL).

The method STL has built the foundation for the more sizable studies in the framework of the research project NIQAT financed by the European Commission

The nondestructive instrumental measurement of the internal optical density of potato tubers

The studies with potatoes are carried out in the course of three selection years by using 29 cultivars of potatoes, with proven origin, supplied from Bulgaria, Germany, Holland, England and Finland.

Acquisition of NIR data

It is used spectral computer system of Bentham Instruments Ltd, UK, to which has been integrated the developed by CANRI-Plovdiv, Bulgaria, photometric camera.
The camera allows the simultaneous measurement of the transmittance and reflectance spectra in both the visible and NIR regions by using two geometry patterns - T 0/180 and R0/45. Two variants were made: Option 1 - for smaller objects with dia.up to 50 mm, and Option 2 - for objects with dia. up to 100 mm.

Statistical analyses

The software packages GRAM developed at ICFT Plovdiv, Bulgaria and The Unscrambler 6.11 version, of CAMO - Norway were used. The computation procedure essentially consists in determination of the coefficients of a MLR model with reselected architecture for each wavelength (with a gap of 5 nm). The architecture of the MLR models was built according to the STL - method.

RESULTS AND DISCUSSION

The STL method is illustrated by fig. 1 wherein for one potato tuber, are shown: a spectrum of the whole intact tuber that of the physically peeled one, and the spectrum computed by means of the STL model. It is evident the nearness between the measured spectrum and computed one within the region from 600 to 940 nm.

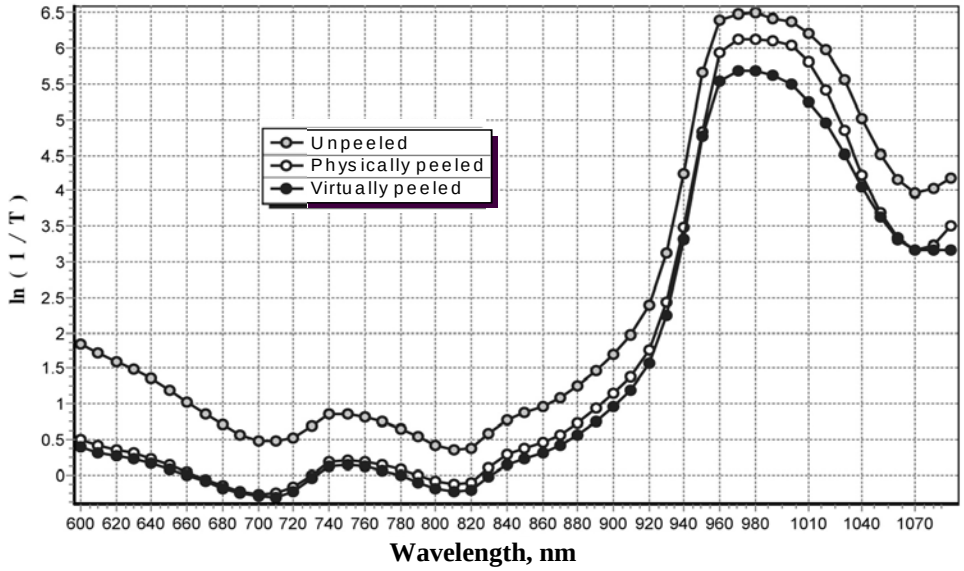


fig. 1 - Transmittance spectra of unpeeled, physically and virtually peeled potato tuber (variety BINTJE) with a skin injured by scab (Sample 257)

If only the optical density of the unpeeled tubers is used, i.e. if the STL- technology is not applied, is received quite inaccurate information for the internal optical density and from here for the internal quality of the tubers too.

If the difference between the two graphics of unpeeled and virtually tuber is bigger the quality and/or thickness of the peel (skin) is worse.

The bad quality of the peel stands (masks) the discovery of defects, especially of smaller internal defects.

The figure fig. 2 - Potato146 shows tuber with imperfect peel, caused by scabies but with flawless internal flesh. In the middle the tuber is physically peeled. Exactly on this place the graphics of the unpeeled and virtually peeled tuber coincide. This shows that the virtual peeling of the tuber with STL-technology is perfect and completely corresponds on the physical peeling in the middle of the tuber.

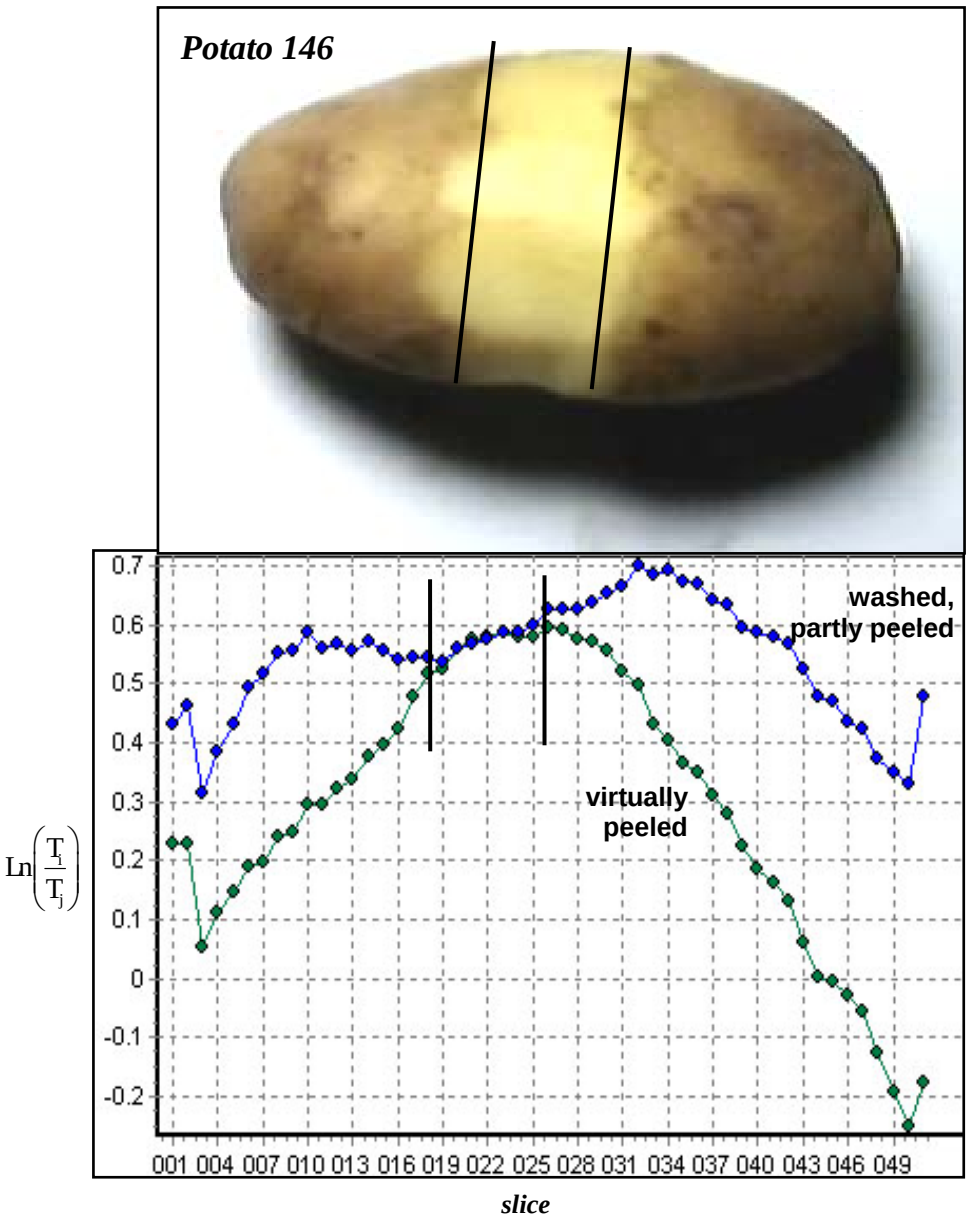
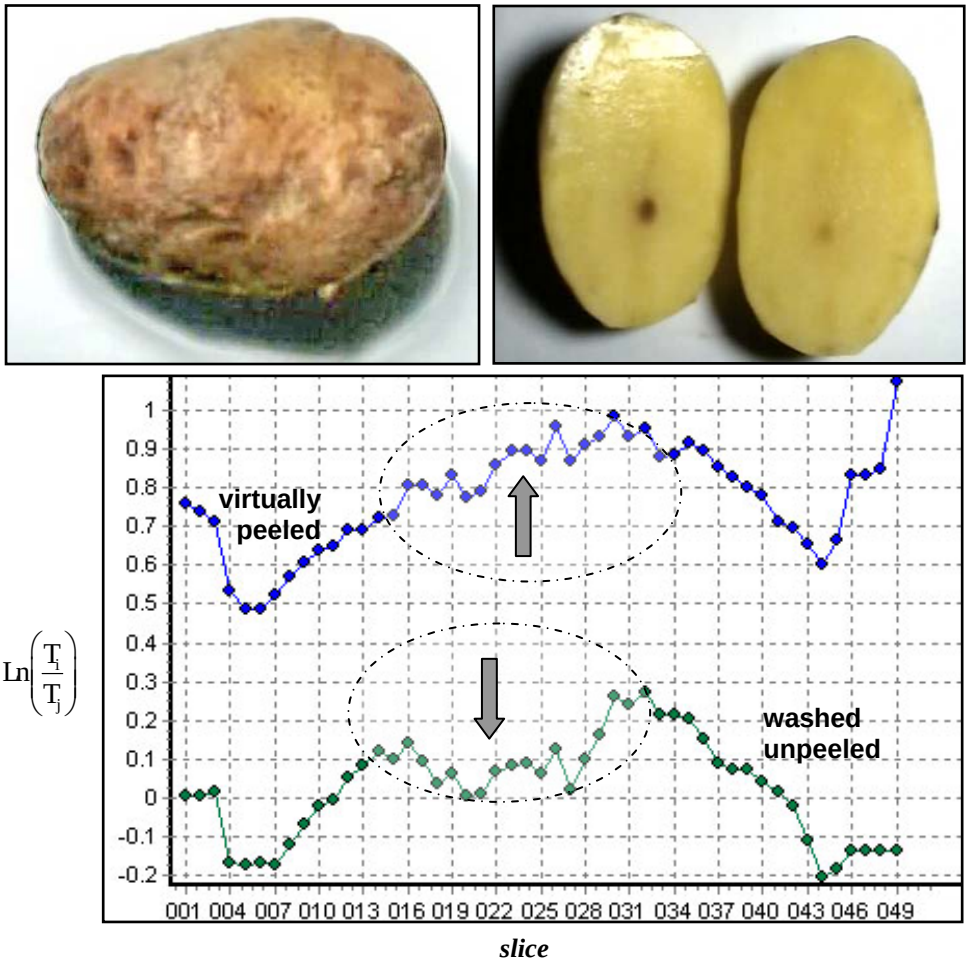


fig. 2 - Partly peeled potato tuber

Potato 134

Virtually peeled & Washed unpeeled



The figure 134 shows that the strongly defective peel masks the small internal defect. Without STL-method its discovery is practically impossible with the well known Optical Sorters, working on the principal of reflectance and on the principal of transmittance. The great difference between the graphics of the virtually peeled tuber and of unpeeled tuber shows the possibility by STL-technology to be recognized the quality and the thickness of the peel: as the graphics are more near to each other so the peel is of high quality and thin; as the graphics are more far (remote) so the peel is more damaged (presence of scabies, rezoctonium, wrinkled and etc.) and more thick.

CONCLUSION

For the first time the STL-method has been experimentally verified in on-line system for sorting of agricultural produce – potatoes.

Feasibility for on-line sorting of potato tubers

The spatial scanning is effected in DEMO-machine NIQAT01LAB in the process of tubers free falling with an initial speed 1.2 m/s and a slope of 15° toward horizontal line. This is a simple and efficient way to be secured the minimum admissible distance (≈10 mm) between the tubers at a velocity ≈ 2 m/s in the inspection zone. This operation mode ensures maximum rate of **sorting up to 40 tubers per second** or average capacity of **3.6 t/h**. Those parameters are fully corresponding to industrial practice.

NIQAT01 makes classification into 6 classes - 3 by defectiveness + 1 waste and 2 – by the extent of greening. The software allows for combination between the separate classes, so that the number of sorted fraction should be from 2 to 6. Thus, the system NIQAT can easily be adapted to modern technologies for on-line sorting of potatoes intended to storage, retail trade, processing and sowing.

Perspectives

The experience from the created industrial prototype of the new machine and its commercialization would create possibility for the development of this machine for more precise sorting and of other agricultural products. These are products for which the peel does not allow important parameters of their internal quality to be reliably determined (the quality of the flesh), as example: the degree of maturity, internal color, chemical composition, internal structure and etc.

Potential objects for STL method application and the new technology are: mature onion, kiwi , avocado, citrus fruits, mellows, some apple varieties, peaches, pears and others.

Sorting of fruits and vegetables by using the new STL sorting system will bring to clear classifying by quality and a full correspondence between the price and the quality of the product. With these and other priorities the system NIQAT is competitive on the world market.

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