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Review

Rapid and/or nondestructive quality evaluation methods for potatoes: A review

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ABSTRACT

Potato, with its several processed products, has a major rank on the human diet in many countries. Among electronic-based methods that have been used for tracking and rapidly measuring the quality attributes of raw and processed potatoes (more specifically: French fry and chip), and which are reviewed herein, vision and spectroscopic systems have shown the most promising applicability, robustness, and stable performance. Detection of external and internal defects associated with potatoes during harvesting and handling operations has been made possible using nondestructive techniques. Commercial electronic systems used for sorting potato tubers and products are being incorporated into the potato industry and are included and discussed in detail related to operation theories and performance. The need for healthy food requires more attention for detecting harmful chemicals in fried products such as acrylamide which itself demands continuous tracking of sugar during storage and in French fries or chips which encourages the need for constitute-based sorting for potatoes. Hyperspectral imaging is one of the most recently emerging tools and provides advantages of vision and spectroscopic systems and can be used, after speeding up image acquisition time, in prediction of processing-related constituents as well as defects detection. Moreover other noninvasive techniques, such as NMR and X-ray CT, have shown the potential for successful application in quality monitoring of fruits and vegetables with expected possibility for application in potatoes.

Contents

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1. Introduction

Potatoes (*Solanum tuberosum*) rank as the fifth highest produced commodity used for human consumption with 324.2 mega metric ton world production (FAOSTAT, 2012). In North America, Europe, and Australia, the majority of potatoes are processed as chips (crisps), French fries, dehydrated, canned, mashed, diced, etc. In USA, which produces 18.3 mega metric ton, only one-third is consumed as fresh product; approximately, 60% is consumed as processed products, and 6% is used as seeds (FAOSTAT, 2012).

International potato trade has doubled from 1986 (<10 mega metric ton) to 2006 with a quadrupled value in the same time range reaching $9,600 million in 2007 with majority of which being processed (Cromme et al., 2010). Moreover, in 2013, the total revenue of potato chips in USA was $9,000 million with a total consumption of 1,170 metric ton (MarketLine, 2014). Additionally, the value of US exports of chips and frozen French fries increased from $610 million in 2006 to more than $810 million in 2010 (Bohl and Johnson, 2010). Several developed countries such as: Japan, Canada, and Australia showed a considerable increase in imports of French fries in the same time span of 22%, 435%, and 558%, respectively. A similar trend was noticed for some of the developing countries such as Brazil (229%), Mexico (177%), and China (241%) (Faulkner, 2012).

Given these statistics and trends, coupled with modern lifestyle expectations of high quality foodstuff products in either home-prepared or fast food, demonstrates the need for efficient, accurate, rapid, reproducible, cost effective and easy-to-use devices and systems to assure that final product meets the required quality. The more importance given to preserving the high quality of potatoes before processing, the higher the marketability of products, and consequently more benefit for growers, processors, and consumers.

Some chemical constituents and physical properties in potato tubers determine their end use for either the processed industry or as fresh, or prevent the use of tubers if the levels of these parameters are beyond the suggested thresholds. These constituents are, but not limited to, specific gravity, carbohydrate, protein, vitamins, glycoalkaloids, minerals, flesh and skin color, carotenoids, and anthocyanins. Other aspects which determine quality and potential use are the external or internal defects such as greening, bruises, enzymatic browning, non-enzymatic browning, and other physiological disorders (Storey, 2007). Additionally, the accurate estimation of optimal harvest time is critical for potato tubers as it strongly affects quality of the harvested tubers.

There are many rapid techniques which have been used in attempts to evaluate the physiological status of potato tubers as well as to test the quality attributes of finished potato products. These systems range in basic operation theory and they include: traditional imaging systems (CCD cameras, multispectral imaging, X-ray, and magnetic resonance imaging (MRI)), spectroscopic systems (ultraviolet, visual, near, and mid-infra-red systems), hyperspectral imaging systems, and ultrasonic systems. The applications of such systems for raw tubers include predicting of chemical constituents and physical characteristics (dry matter, specific gravity, carbohydrate, and water content), detecting of defects and diseases, and electronic-based sorting. Other applications address quality evaluation of processed potato products (chips and French fries) using one and/or more of the above systems. While there have been a significant number of studies regarding the application of rapid estimation of quality attributes of raw potato tubers and processed products, no study has been conducted to technically summarize such different approaches, present the causality of some techniques to yield more robust and accurate performance than others, and the limitations of some techniques from assessing various quality attributes in raw and processed potato products. In addition to discussing the above systems overall, this review aims to present some of the state-of-the-art commercial systems that exist for online sorting of raw potato tubers and processed products. Finally, this study presents detailed discussion about the future possibility of adopting/applying several nondestructive techniques, which have shown significant success for quality evaluation of other perishable produce, in postharvest practices of potato tubers as well as in quality assessment of potato processed products. Fig. 1 depicts the applications of nondestructive methods for postharvest potatoes and potato products presented in this manuscript.

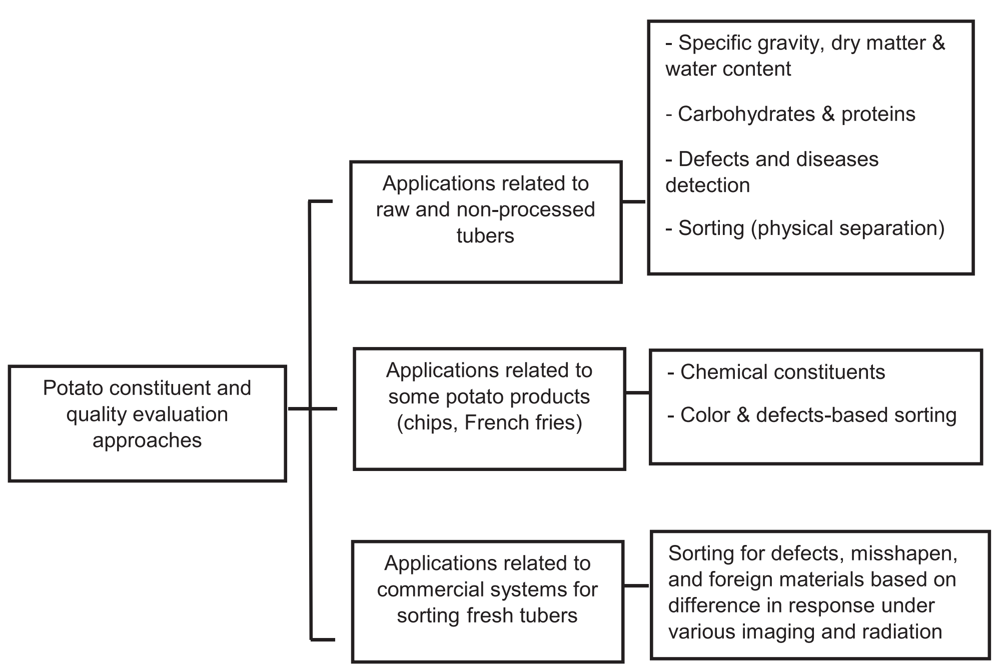

Fig. 1. Breakdown of reviewed technology used in potato postharvest and quality assurance of some potato products.