ADVANTAGES AND DISADVANTAGES OF MACHINE VISION APPLICATIONS FOR AUTOMATIC SORTING OF AFLATOXIN CONTAMINATED DRIED FIGS

Eng. Gharibkhani M.*, Prof. Dr. Akdeniz, R. C.*
*Department of Agricultural Machinery, Faculty of Agriculture, Ege University, 35100, Bomova, Izmir, Turkey
Correspondent author: m.gharibkhani@gmail.com

Abstract: Nowadays in dried fruit producing factories, aflatoxin contaminated dried figs inspection and separation is of great importance, and also time and money-consuming process. In most of the factories all over the world, this process is done manually by using specialized labors in a dark room, and under the UV lights. Working under such difficult conditions reduces workers’ productivity and also may lead to some health problems in some cases. Aflatoxin contaminated figs produce bright greenish yellow fluorescence under UV light which is used for separation process. The correlation between fluorescence production and the presence of aflatoxin in fig samples is quite high. There are some machine visions systems which are used for dried fig inspection automatically but, their accuracy are still under 80% because of some unsolved technical problems. These problems are the reason for application of manual inspecting methods alone or in line with automated inspection systems. Like any other techniques, use of machine vision techniques has some advantages and also some disadvantages. The aim of this study is to review the current position of machine vision in dried fig fruit sorting systems. It is also proposed to define the problems of machine vision applications for fig fruit sorting and also give some solutions for increasing the efficiency of automatic sorting systems.

KEY WORDS: FIG FRUIT, MACHINE VISION, AFLATOXIN, AUTOMATIC SORTING

1. Introduction:
Turkey is a well-known leader country in the World market of dried figs (Sen et al., 2010) and is the World's largest dried fig exporter. Aflatoxin $B_1$ is a major problem for dried fig production and marketing. The start of this problem returns to 1985 when the laboratory of a food retail chain reported that dried figs, imported from Turkey, were partly contaminated with aflatoxins. By publishing of these results many food-control laboratories subsequently increased their activities for analyzing figs for aflatoxin contamination. They reported the detection of tens of ppb's in fig samples. On the basis of these findings, the Federal Office of Public Health in USA set the legal limit for aflatoxins on figs (Stenier et al., 1968).

Aflatoxin is capable of growing when temperature, relative humidity and product moisture conditions are favorable (Iamanaka et al., 2005). The conventional dried fig production method leads considerable quality and quantity losses caused by aflatoxin $B_1$ (Oztekin et al., 2001). Aflatoxin $B_1$ is known to be a potent hepatocarcinogen for humans (IARC, 1993). Current legislation limits 4 ppb for total aflatoxin in dried fruit for direct human consumption and 10 ppb to be subjected to sorting or other physical treatment before consumption or use as an ingredient in foodstuffs (Commision Regulation, 2003). Till now many studies are conducted to determine the aflatoxin concentration in dried fig produced in Turkey and different countries (Rieker and Battaglia, 1988; Boyacioglu and Gönül, 1990; Özay, et al., 1995; MAFF, 1997; Mac Donald et al., 1999). Aflatoxin is considered a potential risk to human and animal health (Williams et al., 2004; Iamanaka et al., 2007).

The relation between Aspergillus flavus and bright greenish yellow fluorescence (BGYF) was discovered for the first time in 1950s (Bollenbacher and Marsh, 1954) in raw cotton. It was also determined that BGYF was associated with aflatoxin contamination of cotton seed some years later (Ashworth, and McMeans, 1986). Further researches showed that there is a high relationship between appearance of BGYF and aflatoxin in other agricultural products, too. Also, it was confomed that BGYF associates to aflatoxin contamination in dried figs (Rieker and Battaglia, 1988). Till now, this result is considered as a principle of determining aflatoxin contamination manually or automated in dry fruit producing corporations. So, the aim of this study is to compare the manual and automated machine vision methods which are used by different enterprises and corporations for controlling aflatoxin contamination in dried figs.

2. Use of colour and computer vision in agricultural product sorting:
Colour and appearance of fruits are considered as important sensorial properties which provide some useful information about fruit quality and fruit perception by human. Colour can provide some basic quality information about the product such as freshness, maturaty, and sometimes taste of the fruit. It is far used as basis of vision machines for inspecting and sorting of agricultural products and specially fruits. Colour is used by many researchers (e.g. Blasco et al, 2003 for fruits; Cubero et al., 2011 for fruits and vegetables; Quevedo et al., 2010 for salmon fillets; Rocha and Morais, 2003 for apple) for automatic inspection and quality determination of fruit and feeds. Different types of image acquisition and different types of illuminating systems are being used by machine vision systems. The method used for dried fig sorting systems is based on benefitting from a light source which makes an invisible property visible to human eyes. The aflatoxin contamination is not visible for human eyes but UV light makes it visible. The principle of this method is to exposing the product under ultraviolet light to observe light reflection from the surface of the product. The transmitted UV light should be in range of 360-370 nm (Mostly 365nm). If there is contamination on the surface of fruit it reflects BGYF under the UV light (Doster et al., 1998). The vision system of the sorting machine senses these reflections and compares it with data defined for the system previously. If there is any matches a comment will be sent to the rejection system of machine which rejects the contaminated products mechanically or pneumatically. The schematic of such a system is given in figure 1.
2.1 Manual sorting process of dried fig:
Most of dry fig producing corporations in Turkey use non-automated sorting line for separating aflatoxin contaminated figs. In this method after loading figs on moving elevator external materials would be removed and the figs which stuck to each other would be separated by workers. Then the figs which are not in suitable condition for packing and selling from point of appearance, size or quality are selected by workers and separated from others on the moving elevator. Then the figs move along the elevator toward a room which is called dark room. As it is obvious from the name of this room it is a darkened place where there are just some UV light (365 nm) sources right on top of the moving band. In this stage expert workers seating near by the moving band (mostly women) control figs one by one while passing though the line. Workers inspect the figs and pick up the suspect ones and try to determine the contaminated figs from the BGYF reflection from aflatoxin contamination under UV light. They do not only control outer surface of fig, but also try to open the wrinkles of the suspect ones to control more accurately all parts of the fruit. The workers sometimes open the internal cavity of the fruit partly to control the fig under the UV light more precisely when get suspicious about the existence of internal contamination. This process is done by workers seated across from each other at the opposite side of moving band. It means that each fig might be controlled by at least 5 to 20 (depending to the capacity of the factory) workers while passing through the moving band (Figure 2). Then other healthy product continues passing through the production line. This is followed by washing process to remove any dust, soil, dirt, etc. Then figs are confronted to drying process to remove the excessive water gained during washing which allows a safe product through strict control of moisture and water level after drying.

2.2 Use of laser light in fig sorting machines:
New machines designed to determine aflatoxin contamination in dried fig use optical laser technology to detect contaminated products at a normal processing flow. In this procedure, after loading figs on moving elevator and before entering machine the figs which are stuck together got separated by workers or a simple machine. Then figs move along the elevator toward the machine and enter to feed shaker part. The feed shaker spreads the product uniformly over the free-fall channel. Then figs fall down towards the inspection zone, by gravity force. In the inspection zone figs subject to laser light. Some machines are capable of controlling products in full spectrum range of RGB color space. The aflatoxin deflected figs are recognized by machine vision system from the BGYF light reflection from surface of contaminated parts. All products are scanned one by one from either one or both sides depending on the design of the machine. Passing through the scan zone of the machine, the signals from the reflected lasers form the surface of figs are evaluated. In a few milliseconds duration the defected ones get hit by timed, high-speed air guns and diverted from healthy ones. The aflatoxin contaminated ones are dropped into a reject chute. Other untouched healthy product continues untouched into the accept chute and go through the production line to continue other production processes like washing, shaping, and etc.

3. Discussion:
Nowadays by use of new techniques and methods the numbers of new technologies are dramatically increased especially in agricultural sector. Machine vision technology is one of these techniques that is improved every day and is vastly used by engineers for designing of sorting machines for agricultural products (Blasco et al., 2003; Brosnan and Sun, 2004). But still there are some problems in sorting small fruits by machine vision systems (Blasco et al., 2009). In spite of advantages in use of the dried fig sorting machines, these machines are confronted by some problems which lead to reduction in the accuracy of the sorting process. The main advantages and disadvantages
of applying machine vision technique for dried fig sorting include:

3.1. Advantages:
- The rapidness, persistence, and non-destructiveness of the method;
- Reducing the need to labor force and reduction of tiresome and subjective human visual involvement;
- The ability to conducting the process 24 hours a day and increasing the capacity of production (kg/h);
- Limitating the number of workers working under bad situation (dark and boring rooms) and providing the chance of benefiting from this labor force in other processes.

3.2. Disadvantages:
- The sensitivity of the machine is lower than 80%;
- There is still need to use expert labors after the sorting machine to control the figs again;
- The prices of these machines are relatively high which eliminates use of them in small enterprises and corporations.

The main disadvantage of dried fig sorting machines is related to low accuracy or sensitivity for detection of aflatoxin contaminated figs. There are some technical reasons for this problem.

4. Conclusion:
Different types of computer vision systems have been widely used for quality inspection of food and agricultural products. It was far tried to replace manual inspection with computer vision systems as they can provide a rapid, accurate, objective and nondestructive assessment of food ingredients. Although many successful applications have proved the accuracy and rapidity of machine vision systems for automatic external quality inspection of fruits and vegetables, but in some fields there are still some unsolved problems remaining. Dried fig is one of these examples. Despite the advances made in the production of these machines, still they cannot fully replace human labor because of the problems arise discussed before. But these machines are good enough to work in parallel with reduced number of workers, improve the efficiency and saving the time. It can be foreseen that by designing a machine which have ability of control inside of each fig during inspection process the accuracy of the machine will get much improved. Also, the design of machine in a manner that completely remove the chance of overlapping and sticking of figs while passing the control unit would be efficient in improving the accuracy of system.

5. References:


