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Design of a Sensor to Detect Fruit Freshness

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Abstract
Fruits and vegetables constitute a significant part of human diet habit for decades. In modern age with the increased disease variant, people became more curious about the natural and organic nutrition. This current of thought has brought some problems with it which are mostly related to freshness. As fruits and vegetables are a good source of food for us they are also good hosts for microorganisms like bacteria and fungi too. Foods contaminated by microorganisms could cause serious health problems in addition to that, decayed fruits and vegetables create several problems during imports and exports, during their storage for food related companies and markets. To find a solution to these problems a freshness sensor is developed which works with the principle of measurement of ion concentration change occurred in fruits and vegetables. Performed tests show that according to ion concentration change we could determine the freshness of fruits and vegetables. This method doesn't need any chemical pretreatment and it is not a type of storage method like in literature. This sensor can be used easily during grocery shopping by consumers, by import and export quality controllers or by any food related factory since it could give an average time of usage and this sensor could prove even frozen foods' freshness.

Keywords: Freshness, fruit, vegetable, freshness sensor, spoilage.

1. Introduction

With the agricultural revolution, people have learned to manage earth and this improvement had prepared the basis of a diet habit based on both fruits and vegetables. Since that time the consumption rate of fruits and vegetables are dramatically increased correspondingly to the increment of the awareness of people. The major reason of this increment is about discoveries related to health benefits of fruits and vegetables like their high nutritive value and amount of the present vitamins, minerals, antioxidants and other beneficial chemicals.
As commonly known, consumption of a certain amount of fruit and vegetable could provide needed vitamin and other chemicals to the body in order to improve immune system as long as they are fresh. There are several parameters that can affect freshness such as temperature, light, humidity and microorganism growths. The effects of these parameters cannot be observable with the naked eye at first stages especially if the mentioned parameter is microorganisms. In this scenario, freshness loss is generally followed by mold formations which are caused by certain types of fungi families (Barth, Margaret, et al 2009). Generally, consumption of molded products causes allergies and respiratory system diseases but some of them may more serious and fatal diseases since they could produce Mycotoxins (Bush, Robert K., et al. 2006). Mycotoxins are poisonous compounds and some specific type of them like aflatoxin could lead to cancer. Even though fruits and vegetables have protective barriers against contamination like epidermis (a waxy cuticle layer) and acidity microorganisms could

pass them and could grow inside of them. Even though these microorganisms can exist at very harsh conditions like cold, they need nutrients and humidity to live, which vegetables and fruits could provide as an ideal host.
Besides health, freshness loss of fruits and vegetables causes national issues in terms of the economy since tons of fruits and vegetables wasted because they are not put into market on time and freshness loss also could lead problems between countries during import and export. For instance, Turkey has some problems about aflatoxin presence during their fruit export. This problem is very significant for Turkey since agriculture provides the very significant amount of income to our country. Since Turkey has wide fertile lands it has an important part in the world as a fruit producer. According to 2012 data of TUİK Turkey is the 8th most fruit producing country as shown in the Fig. 1.

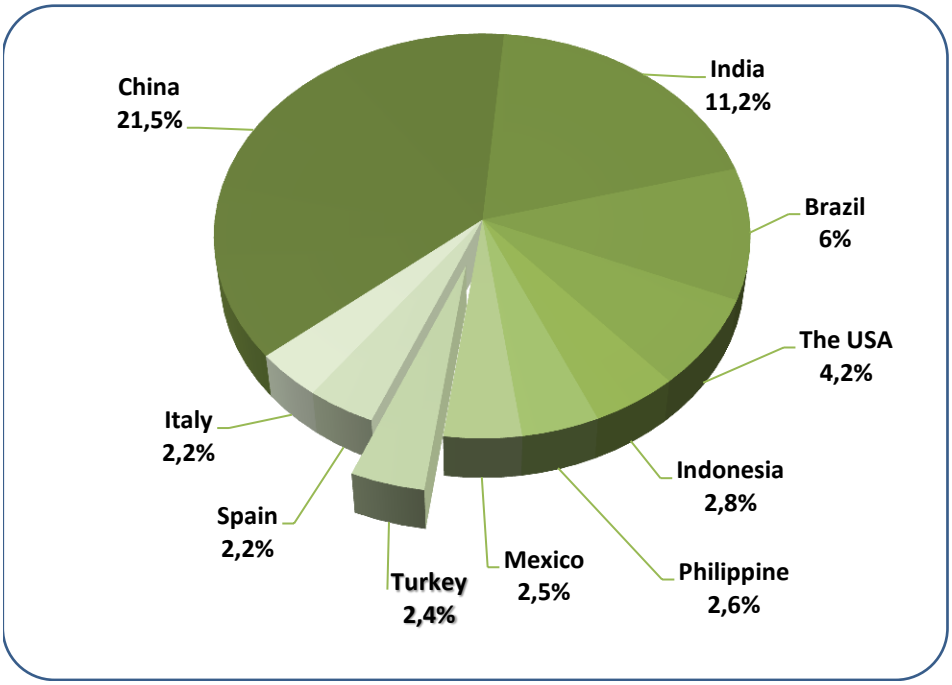

Figure 1.Fruit producer country data of TUİK in 2012

According to literature and our observations with declining, there are some specific changes occurred at vegetables and fruits as a result of chemical variations such as the decrease in nutritive value, increment or decrement in electrical resistance and electrical and thermal conductivity.
Starting from these freshness problems we decided to develop an electrical sensor which can be used to determine the freshness of fruits and vegetable according to change occurred at their electrical resistance with time.

2. Material And Methods

2.1.Sensor Design

The working principle of the designed sensor relies on measuring the ion concentration of the sample. The working mechanism of the sensor mainly governed by circuits and created a software program. There are four different circuits used in the system which are the processor supply circuit (A), liquid crystal display circuits (B), the measurement circuit (C and D) as shown in Fig. 2.
These circuits are designed by using a circuit design program called Dip Trace after the test is done manually by using circuit test boards. Especially, the measurement circuit is designed by using sensitive and low tolerated resistors in order to increase the sensitivity of performed measurements.

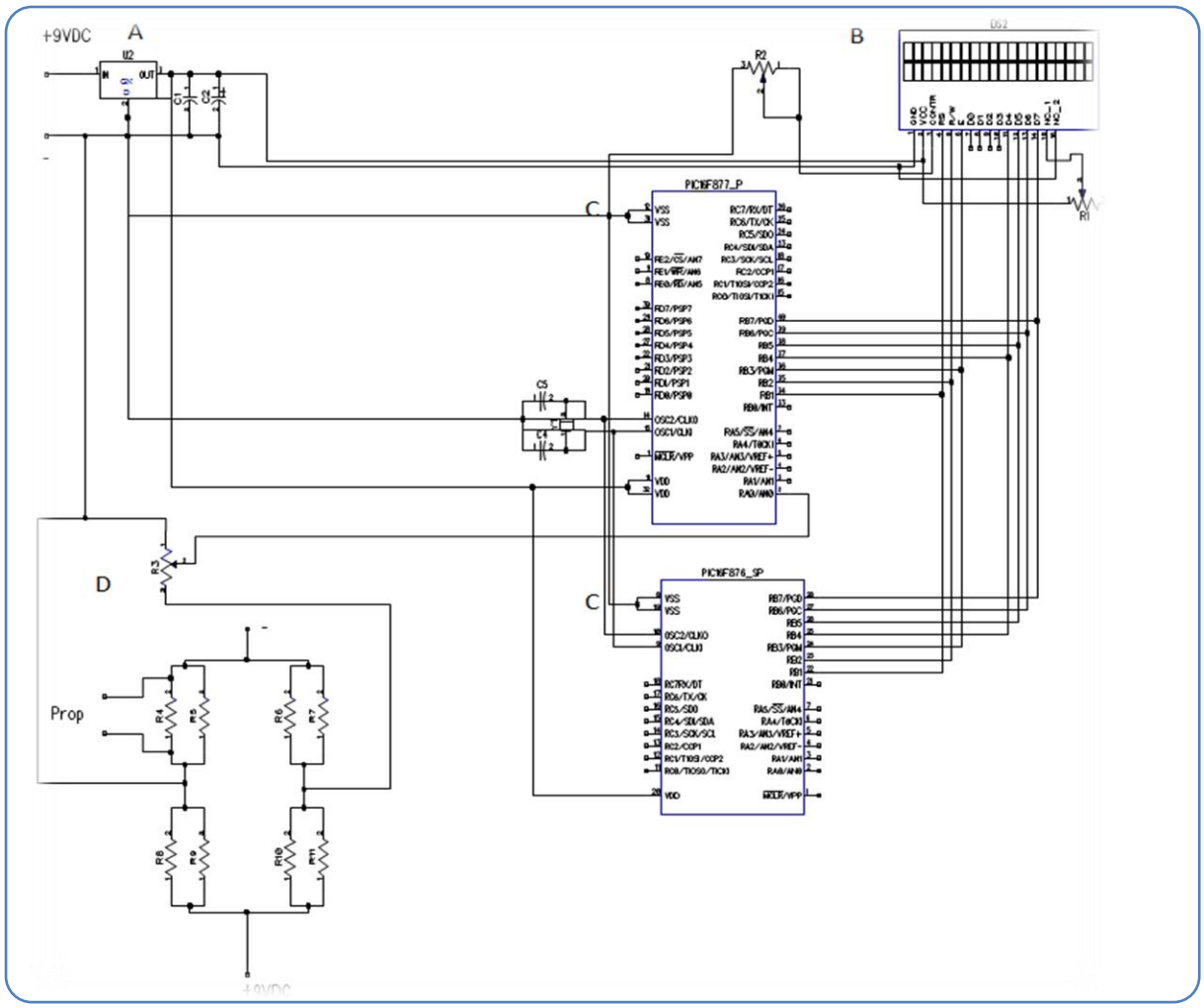

Figure 2. Circuit design used at the first prototype

Mainly according to the size of the developed circuits, the shape of the first sensor prototype is drawn by using a design program called Rhinoceros as shown in Fig 3.

Figure 3. Designed sensor by using Rhino design program

In addition to its physical design, the software program for the test results is created and installed a PIC by using a program called Visual PIC. The logic of the program depends on our tests performed at the

laboratory. Three different critical intervals were chosen for each sample to determine their freshness. If the value is in the first interval it means the sample is fresh, if the measurement result is in the second interval it means the sample is about to lose its freshness and for the values, in the third interval the result will be written: "the sample is rotten it cannot be consumed".
The designed sensor mainly consists of three parts as the outer view those are display part, control panel and measurement probes as shown in Fig. 4.

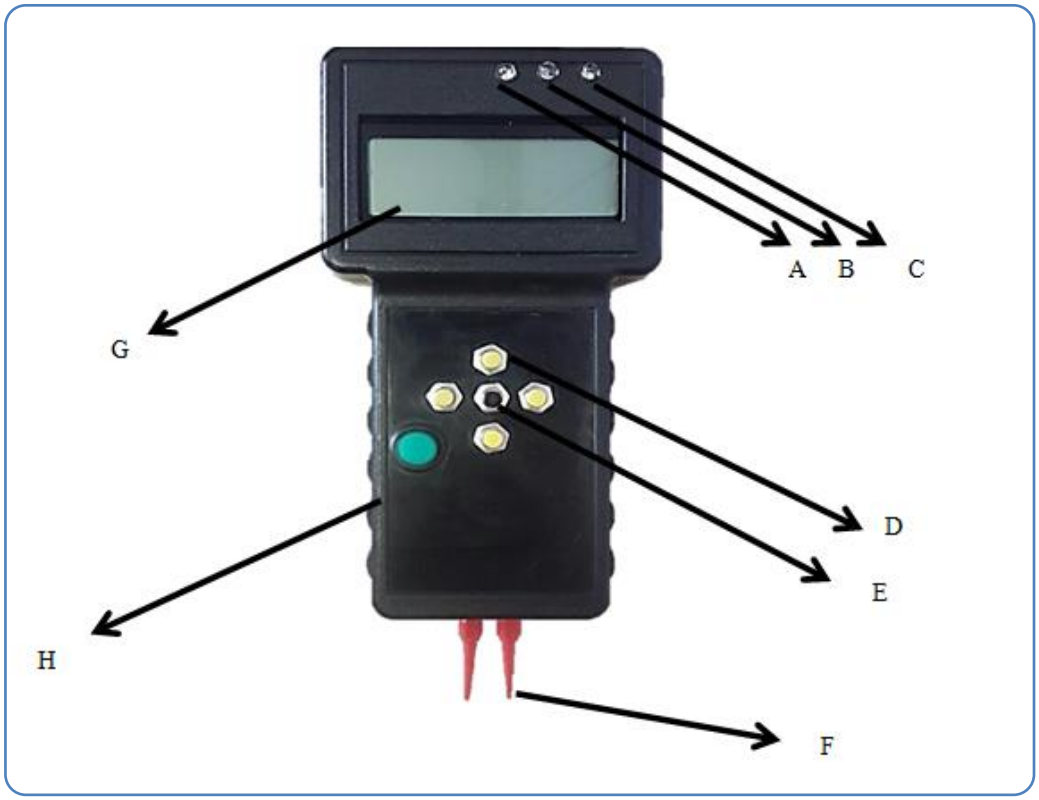

Figure4. Components of the first sensor prototype

The first prototype was able to reach some of the design goals such as the result visualization part. This part consists of a liquid crystal display (G) and three different colored light emitting diodes (LEDs). The colors of the LEDs used are red (A), blue (B) and green (C) respectively. Red LED is for the third result interval which means read means the sample is rotten while blue color means the sample is about to lose its freshness and green colored LED means sample is fresh. These colors make the result understanding time shorter and easy for anybody at any age which is important for us since one of the target clients is the last consumers. For the selection of the sample of interest from the menu, there are a selection (E) and direction keys (D) which are located at the center of the sensor. Since each sample has different critical value selection of sample is very important for a true decision about sample's freshness. There are also two electrodes at the bottom of the sensor where the measurement is mainly governed.
By stabbing these electrodes to sample freshness measurement can be done by using information about ion concentration of the sample. These electrodes should be made from a material whose resistivity is high so it will not cause any problem during sensitive measurements. Also, these electrodes should be stainless to not affect the result. The other key parameter about the electrodes is their distance which should be constant during all measurements and electrodes should be stabbed completely to the sample otherwise sensor couldn't make its measurement and it we will see a message on the display which says Measurement is failed". As the last component of the sensor, there is a power off-on key as all other electronic devices have.

2.2. Freshness Measurement Studies & Samples

Freshness measurement can be performed for only previously introduced samples. That means samples which were observed at laboratory conditions in terms of freshness and rotting process including microscopic examination of microorganism formations can be tested by this sensor. The laboratory study result is different for each sample since each sample has different chemical compositions that make them unique in terms of freshness thresh hold values.

Each kind of sample should be tested and observed for a while for several times to find their optimum thresh hold value. These values can be easily changed according to the acidity of the sample, for instance, orange and lemon has close values while apple has very different critical range values. This situation can be explained according to their ph values which are 2.3 for lemon while 3.6 for apple.

During this experiment, by using the first prototype some measurements were performed which were with lemon, orange, strawberry, tomato, potato, pepper, apple, and banana. These samples were chosen according to present climate, the ratio of problems during import and export and, the consumption rate. The consumption rate is commonly related to the nutritive value of foods such as their vitamin, mineral and antioxidant content. Also, some fruits and vegetables are known to have good impacts on certain types of diseases. Such as high potassium content of banana makes banana consumption is a good preventer of stroke (Duyn et al. 2000). Another example of preventer foods is the apple because the consumption of apple could reduce to lung cancer under favor of its high flavonoid content (Boyer. et al. 2004)

3.Result And Discussion

According to performed measurements, we prove that by using this sensor freshness of fruits and vegetables can be determined according to change in their ion concentration. In order to reduce the damage done to sample used electrode scales could be lowered at new models. Also, product range could be improved by adding milk and milk product thresh hold values to our program.

Performed literature search proved that there is no other freshness sensor which works with the same working principle

4.Conclusion

As a conclusion, the problem caused by the uncertainty of freshness of fruits and vegetables can be overcome by this new and, creative freshness sensor without any chemical treatment which could damage the nutritional value of samples.

Additionally, this novel device could be considered as an innovative project which could be a solution for microorganism caused respiratory diseases and allergy like diseases by detecting contamination before microorganism colonies become visible with naked eye by measuring ion concentration changes occurred at samples. Besides, it could be an answer for economic problems of import and export branch, also storage problems of food related companies, markets, and farmers.

Acknowledgment

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