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The Effect of Infrared Radiation on Native Enzymes – A Study on Potato

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Abstract: *Infrared heating have many significant advantages over conventional heating. It has many applications in food processing operations namely Drying, Baking, Roasting, Blanching, Pasteurization, Sterilization, Frying, Thawing, Broiling, and Cooking. The objective of this work is to do blanching using catalytic infrared dryer to inactivate peroxidase and catalase enzymes which are responsible for deterioration of potatoes (Solanum tuberosum) and is compared with conventional water blanching prior to hot air drying.*

Keywords: *Blanching, Catalase enzyme, Infrared heating, Peroxidase enzyme, Potato (Solanum tuberosum).*

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I. Introduction

Potato- "The Future Food" is the world's number one non-grain food commodity and the world potato production is over 364 million tonnes with China, India, Russia, Ukraine and United States being the leading producers (FAO, 2013)[1]. Potatoes are a very good source of many nutrients, including potassium, vitamins B6 and C, niacin, pantothenic acid, and dietary fibre. However, just like many fruits and vegetables, fresh-cut potatoes are prone to browning after cut. Browning may be the symptom of an ongoing degenerative process that is activated after the cut surface contacted with oxygen. Various approaches have been applied to extend the shelf life but are generally constrained due to their high cost, low efficiency or potential health hazards. Therefore, it is desirable to develop a simple, safe and cost-effective method to extend the shelf life of fresh-cut potatoes for commercial use. So blanching is one of the methods for inactivating enzymes.

Blanching is a thermal process most often associated with solid food commodities such as fruits and vegetables. For inactivating enzymes, modifying texture, preserving colour, flavour, and nutritional value and removing trapped air; blanching is the heat treatment given to fruits and vegetables. Blanching is required prior to dehydration since temperatures associated with dehydration are insufficient to inactivate enzymes within the product. It prevents discoloration, softening and off flavour development during subsequent storage. In many food industries inactivation of peroxidase enzyme is considered as an end point for blanching process even though some quality deterioration may be caused by other enzymes [2]. Water blanching, Steam blanching, Infrared blanching, Chemical blanching, Oil blanching, Microwave blanching are some of the types of blanching.

Normally enzyme inactivation is achieved by heating them to a desired temperature (70-100 ^{0}C) using hot water or steam or microwave energy and holding the products for a period of time (FMC, 2003)[3]. Large amount of energy is required for hot water and steam blanching. In a water blanching operation, the water needs to be procured and heated firstly and after a certain amount of blanching operations this water needs to be replaced since it becomes saturated with sugars leaching from the fruits and vegetables. This results in not only excessive energy consumption due to re-heating of the water to the blanching temperatures but also consumption of high amounts of water. It can also cause undesirable changes in product texture but can also cause significant losses of solids, nutrients, phytochemicals, and/or flavours.

Due to the advantages of the infrared heating, it could be an alternative method for blanching and drying. Infrared radiation (IR) or the term infrared alone refers to energy in the region of the electromagnetic radiation spectrum at wavelengths longer than those of visible light, but shorter than those of radio waves and is based on 'Stefan-Boltzmann law'. IR spectrum is divided into three regions. The near IR band contains energy in the range of wavelengths closest to the visible, from approximately 0.750 to 1.300 µ (750 to 1300 nm). The intermediate IR band (also called the middle IR band) consists of energy in the range1.300 to 3.000 µ (1300 to 3000 nm). The far IR band extends from 2.000 to14.000 µ (3000 nm to 1.4000 x 10^4 nm). Infrared heating has

many applications in food processing operations this includes Drying, Baking, Roasting, Blanching, Pasteurization, Sterilization, Frying, Thawing, Broiling, and Cooking[4]. Infrared radiation energy with specific wavelength could penetrate into product and directly heat water or desired components to achieve the purposes of blanching and drying. Water absorbs heat energy very efficient in the range of medium and far infrared wavelengths. Since the air and medium does not heat at the medium and far infrared regions, the energy transfer is highly efficient. When infrared heating is used for blanching, no water or steam is needed.

II. Materials And Methods

2.1. Water Blanching

Take fresh potatoes that are firm with no dark or soft spots. Slice them with uniform thickness not more than 1.5 ± 0.05 mm and heat them in water for 5 min at 90^0C. Immediately dip the slices in cold water (< 16 ^{0}C) for 5min and air dry them at room temperature.

1.1 **1.2** **1.3** **1.4** **1.5** **1.6**

Fig 1: 1.1 Selection of raw potatoes 1.2 Heating water to 90 ^{0}C 1.3 Sliced potatoes having uniform thickness 1.4 Heating slices in hot water 1.5 Dipping slices in cold water 1.6 Air drying

2.2. Infrared Blanching

The flameless catalytic infrared emitter has the heating elements housed in a circular stainless steel casing. The diameter of the emitter surface is 27.94 cm (surface area, 613.36 cm^2) [5]. Potato samples were exposed to infrared in a 3.8 cm deep steel pan of 27.94 cm diameter with a 23 cm long handle. Distance from the emitter is 10cm and the exposure time is 7minutes.

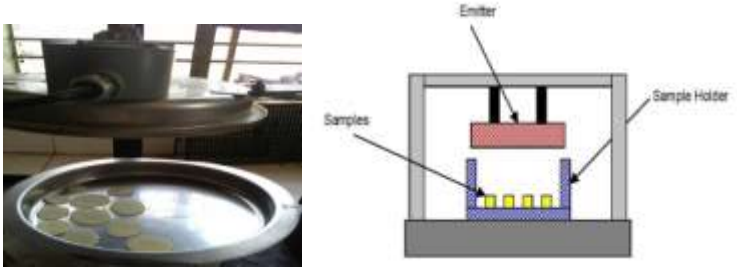


Fig 2: Catalytic Infrared dryer

2.3. Colour Comparison Test

This is a physical process done to know whether the enzymes are inactivated are not. We compare the unblanched sample with blanched sample at regular intervals of time with respect to colour. If discoloration happens it indicates that the enzymes are not inactivated.

2.4. Catalase Enzyme Test

Cut small and thin pieces of potato tuber, place them in Petri dish filled with water. Take a few small pieces and put them in two separate test tubes, marked A & B. Fill both the tubes with appropriate amount of water. Keep the test tube A in the stand. Boil the pieces of potato tuber placed in tube B. Drain out water from both the test tubes. Now add H_2O_2 solution (30 parts of water to 1 part H_2O_2) so as to completely immerse the pieces of potato tuber. Note the changes occurring in both the test tubes [6].

$$2H_2O_2 \xrightarrow{\text{Catalase}} 2H_2O + O_2$$

Hydrogen peroxide → Water + Oxygen

2.5. Peroxidase Enzyme Test

Cut small and thin pieces of potato tuber, place them in Petri dish filled with water. Take a few small pieces and put them in two separate test tubes, marked A & B. Fill both the tubes with appropriate amount of water. Keep the test tube A in the stand. Boil the pieces of potato tuber placed in tube B. Drain out water from

both the test tubes. Add 2% alcoholic solution of gum guaiacum (benzidine) solution to both the test tubes so that pieces/ slices of potato tuber are completely immersed. Allow the test tubes to remain undisturbed for 10-15 minutes. Remove all gum guaiacum solution from both the test tubes. Add dilute solution of hydrogen peroxide (3% commercial hydrogen peroxide in 30 parts of water) to both the test tubes. Observe the changes [6].

$$A.H_2 + H_2O_2 \xrightarrow{\text{Peroxidase}} A + 2H_2O$$

III. Results And Discussion

1.1 COLOUR COMPARISON TEST

3.1.1 3.1.2 3.1.3 3.2.1 3.2.2 3.2.3

3.3.1 3.3.2 3.3.3

Fig 3: 3.1.1 Unblanched potato after slicing 3.1.2 Unblanched potato after 1 hour 3.1.3 Unblanched potato after 2 days 3.2.1 Water blanched potato after cooling 3.2.2 Water blanched potato after 1 hour 3.2.3 Water blanched potato after 2 days 3.3.1 Infrared blanched potato after slicing 3.3.2 Infrared blanched potato after 1 hour 3.3.3 Infrared blanched potato after 2 days.

For Unblanched sample discoloration can be observed where as for water blanched samples and Infrared blanched samples there is no colour change. This shows that the enzymes are activate in unblanched sample and are inactive in water blanched and infrared blanched samples.

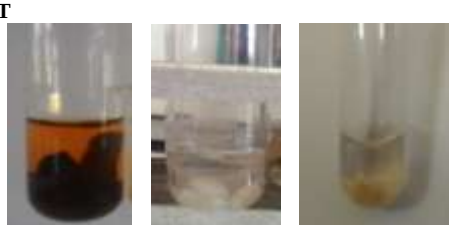
3.2. CATALASE ENZYME TEST

4.1 4.2.1 4.2.2 4.2.3

Fig 4: 4.1 Activity of catalase enzyme 4.2.1 Catalase activity in unblanched sample 4.2.2 Catalase activity in water blanched sample 4.2.3 Catalase activity in infrared blanched sample

From Fig 4.1 Evolution of bubbles can be seen in test tube A and there is no evolution of bubbles in test tube B. Catalase brings about decomposition of hydrogen peroxide into water and oxygen. Oxygen evolution, therefore, is an indication of activity of catalase. The oxygen bubbles are not evolved in test tube B. This is because enzyme is destroyed (denatured) when potato slices are boiled (at high temperature). Hence, there is no enzyme activity.

3.3. PEROXIDASE ENZYME TEST



5.1 5.2 5.3

Fig 5: 5.1 Peroxidase activity in unblanched sample 5.2 Peroxidase activity in water blanched sample 5.3 Peroxidase activity in infrared blanched sample

Potato slices in test tube A (Fig 5.1) changes to blue colour very rapidly and there is no change in colour in test tube B (Fig 5.2 & 5.3). Absence of blue colour indicates absence of enzyme activity in test tube B, enzymes having been denatured due to high temperature. Peroxidases are of wide occurrence in the plant tissues and oxidise various substrates (viz. phenols, amines, etc.) in the presence of H_2O_2 as electron acceptors, Hydrogen peroxide with addition of hydrogen atoms and electrons from water.

IV. Conclusion

Infrared heating was an effective method for blanching fruits and vegetables with high processing efficiency. By using catalytic infrared dryer inactivation of catalase and peroxidise enzymes is achieved with no requirement of water whereas for conventional blanching large amounts of water are needed. In food industries, for drying fruits or vegetables the current processing technologies involves a two step process where blanching is followed by dehydration which takes more time whereas catalytic infrared blancher/ dryer takes less time as it is a one step process where blanching and dehydration occurs simultaneously.

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