Review Article

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Vegetable Pigments: Effect of Ph and Heat- A Review

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Abstract

Commonly, vegetables are prepared at home on the basis of convenience and taste rather than nutrient losses. many studies have been conducted in the recent past to investigate the impact of cooking methods and Ph on the retention of pigments and stability of nutrients in coloured vegetables. The results of these studies vary widely leading the consumer to question the best method of preparing and cooking coloured vegetables, A literature search was conducted to identify studies that evaluated the effects of cooking techniques on the levels of Chlorophyll and carotenoids in vegetables The objective of this review is to evaluate the most recent studies and draw conclusions that will enable: (a) the consumer to identify the impact of cooking methods and Ph on the retention of pigments of coloured vegetables and (b) identify the critical phases during cooking, when colour and nutrients might be lost. The present study concentrated on chlorophyll and carotenoid pigments.

Keywords: Chlorophyll; Carotenoids; Cooking methods; Ph; Vegetables.

Introduction

The bright colors of many vegetables contribute a lot to their attractiveness. The colours result from the pigments contained in their tissues. The chief pigments of vegetables and fruits may be classified as water insoluble and water soluble [1].

Chlorophyll pigments are largely insoluble in water and dominant in unripe fruits. they're held close to the cytomembrane in tiny bodies referred to as chloroplasts. Chlorophyll-a is intense blue green in colour and chlorophyll-b is dull yellow green in colour. This pigment is present in green leafy vegetables, capsicum, beans, peas and chillies [2].

Carotenoids are widely distributed natural pigments accountable for the yellow, orange, and red colours of fruits and vegetables. Carotenoids are often divided into carotenes containing solely carbon and hydrogen, and xanthophylls made up of carbon, hydrogen, and oxygen [3]. Carotenoids owe their name to carrots (Daucus carota), and xanthophyll is derived from the Greek words for yellow and leaf. This pigment remains unaffected by heat or acidic medium however turns slightly blue in alkalescent medium. Thus, the colour of the vegetables and fruits containing carotene remains unchanged on cooking [4].

Report suggests that 5 to 78% of the β-carotene is degraded when vegetables are cooked by different domestic methods. Considerable quantities of carotenoids may also be lost during household cooking of vegetables [5]. Thus, information on the possible losses of carotenoids from vegetables, during traditional cooking methods is of major importance. There are documented evidence on

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loss of β-carotene after boiling, stewing, frying, blanching, and pressure cooking cooking.

Methods of cooking *[6]*

Boiling in water: This is one of the common methods used in homes. The vegetables are washed, cut, cooked in excess of water for 20-30 minutes and the excess of water is rejected. This leads to considerable loss of water soluble vitamins and minerals.

Steaming: The vegetables are washed and cut and placed in vessels containing small amounts of water and steamed in a cooker under ordinary pressure for 20-30 minutes. The losses of nutrients are minimal in this method of cooking.

Pressure cooking: The vegetables are washed and cut and placed in vessels containing small amounts of water and cooked in steam under pressure for 10-15 minutes. The losses of nutrients are similar to those occurring in steaming under atmospheric pressure.

During boiling and steaming, the cells expand suddenly, and gases escape from the spaces in between the cells. The heat damages chloroplasts hence releases natural cell acids to turn green pigments into olive-green. This change occurs in the first few seconds of cooking, and the air pockets change the color of the chloroplasts. when these molecules are collapsed by the sudden rush of heat on to the vegetable they become brighter.

B. Texture

Cooking in general affects the texture of all foodstuffs. The cellulose present in them becomes softer and this makes the foodstuffs also softer for example, cooked vegetables are much softer than raw. Cooking in an alkaline medium softens the cellulose much faster and gives the foodstuffs a mushy appearance whereas cooking in an acidic medium makes the texture hard and such foodstuffs have to be cooked for a longer period. The texture of the food, after cooking is also dependent on the method which is used for cooking [7]. Moist heat methods i.e. boiling, steaming, pressure cooking and stewing makes the foodstuffs soft and tender.

The objective of the present study was to determine the effect of different domestic cooking methods on chlorophyll and carotenoids retention in string beans (Phaseolus vulgaris, L.) and carrots (*Daucus carota* L.) the commonly consumed vegetables. chlorophyll and β-carotene were chosen for the present studies since they form the main pigments contributing to the health benefits of Vitamin A in human. The study was aimed to find the effect of culinary treatments like steaming boiling and prolonged cooking at different cooking durations (4 and 8 min) on the chlorophyll and carotenoid pigments of string beans (*Phaseolus vulgaris,* L.) and carrots (*Daucus carota* L.) in the first phase followed by change in ph of the cooking water in the second phase.

Sample preparation

Upon arrival at the department of Nutrition and Dietetics laboratory, the fresh vegetables were washed under tap water and excessive water dripped off. Edible portions (600 g) of the vegetables were separated and cut to small pieces, in edible parts were removed. The vegetables were divided into five portions with 100g for each application. One portion was retained raw and others were subjected to different cooking treatments by altering the Ph. The colour change, texture and doneness were observed. The variations were compared with control (uncooked).

Cooking Treatments

a. Boiling in open pan for 10 minutes followed by closing

b. Prolonged cooking

c. Steaming

d. Addition of vinegar (1 tsp)

e. Addition of alkali- Baking soda (1/2 tsp)

f. Control (uncooked).

Boiling

Vegetable (100g) was added to 250 ml of water that has just reached the boiling temperature in a stainless steel pot, cooked for 4 or 8 min, Samples were drained off and cooled rapidly.

Prolonged cooking

Vegetable (100 g) was added to 500 ml of water that has just reached the boiling temperature in a stainless steel pot, cooked for more than 10 minutes. Samples were drained off and cooled rapidly.

Steaming

Vegetable (100g) was placed on tray in a steam cooker covered with a lid and steamed over boiling water for 7-10 min under atmospheric pressure. The samples were rapidly cooled.

a. Green vegetable- Chlorophyll

All the variations were compared to the raw, cut vegetables.

Boiling of string beans in open pan for 10 minutes followed by closing resulted in bright green colour. The heat breaks down the cell structure in the pigment. This results in change of color. Cooking vegetables in an uncovered pan for few minutes helps to eliminate volatile acids and prevents formation of Pheophytin that results in formation of olive-green colour [8]. Boiling is more similar to the steaming but still had a brighter appearance compared to control (Fig. 1). Chlorophyll pigments are sensitive to heat and cooking. The magnesium atom present in the centre is easily replaced by hydrogen ions or other metal ions. As the cooking process continues (Prolonged cooking) the colour of the string beans changed from the bright green colour to the olive green. Excessive heating exposes the plants own acids to the chlorophyll which in turn makes the cooked product dull green [9]. Steaming turned string beans to a dark green colour. After few minutes the beans was a little bit darker and a more distinct green in colour compared to control.

In phase II when the PH was altered by addition of vinegar the colour of string beans turned almost immediately to a much lighter shade of green. After 5 minutes the color was considerably lighter. Magnesium present in the structure of chlorophyll is rather easily displaced by hydrogen molecule when heated in the presence of organic acids. A pale greenish grey compound known as Pheophytin-a or an olive-green Pheophytin-b results. Chlorophyll-a is more readily converted to pheophytin than chlorophyll-b [10]. when the PH was reduced to alkaline phase by adding baking soda there was not much immediate reactions After 5 minutes the colour was slightly darker than the control. The phytyl and methyl groups of chlorophyll are displaced and a bright green water-soluble sodium salt of chlorophyllin compound is formed.

b. Yellow-orange vegetable-carotenoids

The pigments that color these vegetables are deep orange colour called carotenoids. They are very stable pigments. All the variations were compared to the raw, peeled, carrots. Steaming resulted in darker and brighter orange colour of carrots. They appeared to have similar color to that of raw carrots. Boiling resulted in more yellow pigments than the raw carrots. Not only were they lighter, but they seemed more yellowish in color than orange (Fig. 2). The loss in intensity of colour is not only due to oxidation of the unsaturation of carotene but also shift from trans to cis form [11]. Keeping a lid on the cooking vessel had some advantage as there was about more retention of carotenes in these vegetable. seem more yellow than the raw carrots. Not only are they lighter, but they seem more yellowish in color than orange.

In phase II when the Ph was altered by addition of vinegar there was immediate change in the colour. The carrots reduced to a lighter shade compared to control. when the PH was reduced to alkaline phase by adding baking soda the colour turned darker. The colour is little affected by acid, alkali and the volume of the water. According to Nunn M et al. 2006, more investigations are needed to provide a better understanding of the oxidative phenomena of carotenoids during cooking since different vegetables have different chemical and physical characteristics.

Fig. 1: Chlorophyll pigments - Beans

Fig. 2: Carotenoid pigments - carrots

Conclusion

The boiling and steaming methods on chlorophyll had the least color change, although they seemed little brighter. A second color change occured in response to acidic water: The magnesium ion in the center of the chlorophyll molecule is replaced with a hydrogen atom, causing the green to dull. Chlorophyll-a becomes grey-green pheophytin-a, and chlorophyll-b turns into yellowish pheophytin-b. When the boiling water was slightly alkaline, then chlorophyll retained green. Accordingly boiling in open pan and latter closing can be followed for glv to maintain the natural colour of chlorophyll. Colors of carotenoids did not fade much in response to heat. Some change occurred, in carrots. The taproots change from red-orange to more yellow when cooked. Boiling resulted in intense yellow than the raw carrots. Steaming resulted in brighter orange than the rest of the carrots. There was an immediate change in the carrot when acid was added It turned lighter, while addition of baking soda led to little bit darker. cooking methods and Ph had a strong impact on the pigment retention of pigments in green and yellow vegetables. However, upon considering all the evidence steaming can be suggested as the best cooking methodto preserve the most of the phenolic compounds, particularly flavonoids and glucosinolates.

Key Messages

Cooking in general affects the texture of all foodstuffs Considerable quantities of vegetable pigments may also be lost during household cooking methods.

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