PHYSIOLOGICAL STUDIES ON GROWTH AND STORAGE OF CAULIFLOWER *(Brassica oleracea botrytis group,* L.*)*

BY

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B.Sc.Agric. (Horticulture) Faculty of Agriculture,AL-Azhar University 2003

THESIS

Submitted in Partial Fulfillment of the Requirements for the Degree

Of

MASTER OF SCIENCE

In

AGRICULTURAL SCIENCES

(Horticulture - Vegetable Crops)

Department of Horticulture

Faculty of Agriculture, Cairo

AL-Azhar University

1435 A.H.

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Date: / / 2014

ACKNOWLEDGMENT

Great thanks to "**ALLAH**" the merciful the compassionate who gave me the knowledge and power to carry out this research work.

The writer wishes to express his deep gratitude to Dr. Shamel Ahmed Shanan, Professor of Vegetable of Crops, Department of Horticulture, Faculty of Agriculture, AL-Azhar University, Dr. Abd EL-Naem Said Abd EL-Rehim Prof. of Vegetable of Crops, Department of Horticulture, Faculty of Agriculture, AL-Azhar University, Dr. Rawia EL-Bassiouny Ibrahim Head of research, Post Harvest Section Horticulture Research Institute, Agriculture Research Center, Ministry of Agriculture, for their supervision, valuable guidance and constructive suggestions given throughout the course of this study.

Thanks are also extended to the staff members and my colleagues in Horticulture Research Institute and the Faculty of Agriculture, Department of Horticulture, AL-Azhar University for their kind help and encouragement during this study.

ABSTRACT

Two experiments were done in the winter season of 2009-2010 and 2010-2011 in a private farm at Qalubia Governorate to throw light on the physical and chemical changes happened in the curd of cultivar "Graffiti" of cauliflower during development and storage to determine the maturity stage and the most suitable age for harvesting. Two kinds of cold storage, wrapping by polyvinyl chloride (PVC) and sorts of polyethylene bags were tested to improve the storage ability of the curds. Studies on the models of developmental stages took place on curds labeled after the start of forming every 5 days for having the ages of 5, 10,15,20,25 and 30 days reflected that the rate of increase in the curd fresh weight and size exhibited statistically a curvilinear pattern while both the curd and stem diameters draw a linear figure. At the same time, there were moderate increases in the curd colour from (2.5 p 9/1 purplish white) at the beginning of curd development to (5 p 3/9 deep purple) at the end. Determination of the chemical contents showed that the titratable acidity increased continuously forming a linear shape in the field of statistics where ascorbic acid, T.S.S, total sugars, total anthocyanin and dry weight established a curvilinear type. Storage of the developmental stages under room temperature indicated that the minimum loss in weight, unmarketable percentage, T.S.S, ascorbic acid and total sugars contents were found in the curds of 25 days age during storage. So, it was clear that the curd maturity stage of the variety "Graffiti" was reached after 25 days and this age fortunately was the most suitable age for harvesting.

Cold storage of the whole curds and florets of 25 days age were stored under 0 ^{o}C and 90-95% R.H or at 0 ^{o}C for 7 days then shifted for 2 days to 10 ^{o}C under the same R.H. The obtained evidences showed that the lesser loss in weight and unmarketable percentage, higher visual quality, more concentration of ascorbic acid, T.S.S, total sugars, total anthocyanin and low activity of polyphenol oxidase enzyme occurred in the whole curds than comparatively the florets. On the other hand, cold storage at 0 ^{o}C was the most obvious in retaining both curds and florets characteristics much better than those stored under 0 ^{o}C for 7 days+10 ^{o}C for 2 days.

Packing of the whole curds at the age of 25 days by wrapping with polyvinyl chloride (PVC) stretch film and stored under cold storage at 0 ^{o}C and 90-95% R.H or at 0 ^{o}C for 7 days then under 10 ^{o}C for 2 days at the same R.H proved to be an effective tool. Using this method succeeded in minimizing loss in weight, unmarketable percentage and loss of visual quality beside keeping higher levels of ascorbic acid, T.S.S, total sugars, total anthocyanin and induced low activity in polyphenol oxidase in

addition establish the most suitable modifying conditions during storage. On the other hand, florets of 25 days age were packed in non-perforated and perforated polyethylene bags (23×17cm) provided with 15,30 and 45 holes and these unpacked florets were considered as control. The obtained results show that the perforated bags with 15 holes surpassed all the other perforated or non-perforated ones in reducing both loss in weight and unmarketable percentage and maintained the highest visual quality in the stored florets in addition to keeping the highest ascorbic acid, T.S.S, total sugars, lowering the activity of polyphenol oxidase and offer the most favourable modifying atmosphere during storage. Cold storage at 0 ^{o}C was the most effective one in maintaining the previous characteristics in good conditions than at 0 ^{o}C+10 ^{o}C for 2 days.

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INTRODUCTION

Cauliflower is one of several vegetables in the species Brassica oleracea, in the family Brassicaceae. The cauliflower head is composed of a white inflorescence meristem and made up of undeveloped tightly clustered florets attached to a single stem that form a compact head called a curd. A good quality curd must be fully developed, compact, regular in shape, globular and firm. When the curds became too mature, the flowerets begin to separate and develop a coarse "ricey" appearance. Recently, cauliflower has been having a renaissance, thanks not only to appealing coloured varieties shouring up in the market, but also to consumers who have rediscovered the vegetable attractive appearance and its health benefits.

Purple cauliflower has a milder flavour than white cauliflower, accompanied with sweety taste without bitterness sometimes found in the white cauliflower and has much higher vitamins and mineral contents. This purple coloured cauliflowers get its distinctive deep lavender colour from flavonoid compound called anthocyanins beside a compound called glucoraphanin which both are linked to reduced risk of cancer, diabetes, heart diseases, neurological problems, alzheimer, cataracts and some of the functional declines associated with age proceed **(King and Barker,2003).**

In more details the previous pharmacological studies demonstrate that generally Brassica vegetables appear to be especially protective against cancer due to their secondary metabolites such as flavonoids and other phenolic compounds that act as antioxidants or glucosinolates and other sulphur containing metabolites which induce detoxification enzymes in mammalian cells and reduce the rate of tumour development.

The present work has involved studies on the models of curd development of cauliflower variety "Graffiti" to provide knowledge and to have full understand about the determination of curd maturity and the most proper stage for harvesting. Also, this trial gave spot light on the extend of storage ability and maintain of quality by some postharvest tools such as cold storage, wrapping and polyethylene bags.

REVIEW OF LITERATURE

First: Models of developmental stages:

This part of the review is endeavours to describe in a comparative way some aspects of the physical and chemical properties of cauliflower and some other similar vegetables concerning their development. Needless to say that good quality is obtained when harvesting is done at the proper stage of maturity. So, the growth of cauliflower curd has been followed by measuring number of attributes such as fresh weight, size, diameter, stem diameter, colour and the contents of titratable acidity, ascorbic acid, total soluble solids, total sugars, anthocyanins and dry weight to determine the maturity indices and the proper stage of harvesting.

A- The developmental stages:

a- Curd physical characteristics:

1- Fresh weight:

A more objective approach to determine the growth of vegetable crops is the check of fresh weight. On cabbage, it was reported that the head fresh weight increased with accelerated speed at the beginning of development then slowed down with the proceed of age **(Bailey, 1963, Isenberg et al, 1975, Lill & Read, 1983 and Nilsson, 1988).** However, most observations on broccoli gave similar conclusion. For example, it was found in many tested varieties of broccoli that a quick gradual increase in head weight occurred till the preharvest period then followed by a slight increase up to the harvest stage ***(*Marshall and Thompson, 1987)**, The question of the relation between fresh weight and maturity in cauliflower has been comprehensively discussed where it was found that curd fresh weight showed distinguished continuous gradual increase of growth due to natural cell development **(Pearson and Headly, 1988).**

2- Size:

The size of cole crops is one of the important incidences which is considered in determining the maturity stage and the most suitable harvesting age. On cabbage, the active growth of cabbage plant commenced with the head size increase constantly at accelerated rates until the head begins to harden **(Morrison, 1962 and Bailey, 1963).** Similarly, it was found in another trials that the head of cabbage plant increased quickly in size till its maximum that has been reached through the harvesting period **(Theunissen and Sins, 1984 and Kamal, 2004)**. On composite family, it

was shown that the size of artichoke head increased in continuous and gradual steps during the growth season **(Abd El- Salam, 1966).**

3- Diameter:

Visual methods of determining maturity are usually employed for many vegetables such as the diameter of cauliflower curd which is the most characteristic feature during it's development. Thus, it was found in some experiments on cauliflower that continuous gradual increase in curd diameter occurred with the progress of development **(Arnold, 1959, Salter, 1969 and Wurr et al., 1990).** The same was true on broccoli where a positive increase in head dimensions was observed as it approaches maturity **(Borchers, 1968 and Pearson and Headly, 1988).**

4- Stem diameter:

The curd stem diameter is also one of the greatest value in following the growth of the curd. On cauliflower, for example, many evidences cleared that curd stem diameter increased with age advance in a curvilinear shape **(Henry and Edwin, 1964 and Salter, 1969)**. On kohlrabi, it was shown in similar trend that the diameter of the swollen stem increased gradually during development **(Uffelen et al., 1990 Beshir, 2003 and Ashmawi, 2011).** On some other curciferae vegetables such as broccoli the same view was noticed reflecting a continuous increase in head stem diameter which was correlated with the progress of head development **(Esmail, 1997).**

5- Colour:

The changes in colour during growth of vegetable plants were written in many reports. Hence, it was noticed on strawberry fruits that the change from No. 754 red colour to full colour lasted between 1 to 2 days at 21^0C. When these fruits were harvested at 50% red colour or less and left to develop to full colour the obtained fruits were smaller and poorer in both flavour and texture than those harvested at 75% of red colour **(Smith and Heinze, 1958)**. Further studies on pigments synthesis in strawberry fruits variety "sequoia" during development after petal fall reflected that the net synthesis of pigments of chlorophyll and carotenoids extends up to 28 days after which anthocyanine synthesis commences from 28 to 35 days **(Woodward, 1972)**. On the same crop, strawberry, it was found later that red colour concentrations increased with the proceed of fruit maturity **(Awad, 1989).**

b- Curd chemical characteristics.

1- Titratable acidity.

The changes in titratable acidity content during growth of vegetable crops were reported in some experiments. It was noticed in a trial on cabbage to follow the change in titratable acidity during development that this content increased during the various growth stages up to the age of 98 days from transplanting **(Sharaf, 1967).** On the previous crop, cabbage, the chemical analysis of the harvesting heads of four different harvest dates pointed that the titratable acidity increased continuously in heads with age progress **(Wally et al., 1978).** The same was true on red cabbage where the levels of titratable acidity in the head increased in gradual steps with age advance towards maturation **(Kamal, 2004).** Also, similar trend was shown on Brussels sprouts as the content of titratable acidity increased always in gradual succession till the last examined age **(Mady, 2008).**

2- Ascorbic acid:

The content of ascorbic acid is one of the main important contribution to the mankind nutrition which is high available in vegetable crops. The general view of some experiments pointed that ascorbic acid content in vegetables generally increased during development then a drop occurred. Hence, it was found in cabbage that the maximum level of ascorbic acid in heads was attained at the age of 126 days from sowing after which a decline occurred till the age of 147 days **(Wally et al., 1978)**. This picture was also true in cauliflower **(Fritz et al., 1979)** and broccoli **(Esmail, 1997)** .This tendency was detected on red cabbage as the vitamin, ascorbic acid, increased steadily up to the age of 120 days after which a slight decrease happened till the final age of 150 days **(Kamal, 2004**). Similar trend was observed too on Brussels sprouts, when the content of ascorbic acid in the sprouts increased steadily with age progress up to 30 days age then a slight decrease occurred till the age of 50 days **(Mady, 2008).** On kohlrabi, the view was clear enough to assure the aforementioned trend showing that ascorbic acid content increased gradually with age advance up to the age of 60 days after which a slight decrease occurred up to the age of 100 days **(Ashmawi, 2011).**

3- Total soluble solids:

The total soluble solids percentage had long been presumed strongly associated with the taste of vegetables, Thus, many experiments were done to determine these important contents. On cabbage, plants harvested at 126, 133, 140 and 147 days from sowing showed small variations in the head T.S.S. percentage **(Wally et al., 1978).** On red cabbage, the data of this

characteristic revealed that the head T.S.S. content increased steadily with age progress up to 120 days then a slight drop occurred in the last three ages of 130, 140 and 150 days **(Kamal, 2004).** Recently, it was found on Brussels sprouts that the obtained values of T.S.S. increased sharply from the start of sprouts formation till the age of 25 days after which moderate increments were followed up to the age of 50 days **(Mady, 2008).** In another investigation on kohlrabi, it was noticed that the T.S.S. percentage increased rapidly with age advance up to 80 days from transplanting then a reduction took place till the last examined ago of 100 days **(Ashmawi, 2011).**

4- **Total sugars:**

The total sugars in vegetable plants are considered one of the most important aspects in human nutrition. So, many trials were done to follow the changes in this content in large number of vegetable crops during their development. On cabbage, it was found that the content of sugars increased up to the age of 98 days from sowing **(Sharaf, 1967)**. On another variety of cabbage, it was noticed that the content of total sugars in the heaps leaches increased up to 140 days from transplanting then turned to a decrease trend till the final harvest examined age of 170 days **(Nilsson, 1988).** Following research work on broccoli reflected that total sugars increased from the start of spears formation till the age of 20 days which was followed by a slight decrease till 30 days age **(Esmail, 1997).** On red cabbage, it was found that the content of total sugars in head leaves increased slowly from the age of 40 to 90 days then turned to be sharp up to 120 days after which a slight decrease occurred till 150 days **(Kamal, 2004).** This Previous trend was seen not long ago on kohlrabi where it was shown that the total sugars content increased up to 60 days from transplanting then a decrease trend took place till the final age of 100 days **(Ashmawi, 2011).**

5- Anthocyanins:

The importance of anthocyanins is their ability to cast back the fascinating colour in red cauliflower and other plants. Regardless of the colour, anthocyanins are an important constituents in human diet since it acts as antioxidants **(Ghosh and Madhavi, 1998).** The available information about it's changes during development are scanty. On strawberry, it was noticed that the changes in anthocyanins constituents increased with the proceed of fruit maturity **(Wang and Hsinshan, 2000).** This picture was noticed in another experiment on the red cabbage where the concentration of anthocyanins increased continuously during the development of plants **(Kamal, 2004)**.