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Studies on the physical and chemical changes associated with development of broccoli curds to determine the maturity stage and the suitable age for harvesting

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Abstract

Two experiments were carried out on broccoli cultivar "Marathon" in the winter seasons of 2013-2014 and 2014-2015 at the farm of the Faculty of Agriculture, AL-Azhar University, Nasr City, Cairo. Curds of 5, 10, 15, 20, 25 and 30 days from the start of bud formation were used to study the changes occurred in the physical and chemical characteristics during developmental stages which stored under cold storage (8°C and 60-65% RH) to determine the maturity stage and the most suitable age for harvesting. The obtained results showed that there was a slow increase in the initial periods in the curd fresh weight and size until the age of 20 days which was followed by a sharp increase up to the age of 30 days exhibiting statistically a curvilinear shape. Meanwhile, the curd diameter increased from the start of curd formation up to the last examining age establishing a linear shape. Moreover, rapid accumulation in the contents of total chlorophyll, total carotene, titratable acidiy, ascorbic acid and total sugars were detected up to the age of 25 days then followed by a decline up to the last age showing statistically a curvilinear shape. In addition, a linear curve with T.S.S. and dry weight which increased steadily with the progress of age from the start of curd formation up to the last examined age of 30 days. Furthermore, storing the curd developmental stages at 8°C and 60-65% RH exhibited that the age of 25 days reflected the minimum loss in weight, unmarketable percentage, lower degradation in colour during storage and contained and the highest contents of total chlorophyll, T.S.S, ascorbic acid and total sugars. So, the curd maturity stage was determined at the age of 25 days from bud formation which consider fortunately the most suitable age for harvesting.

Key words: -broccoli, curds, maturity, harvesting

Introduction

Broccoli (*Brassica oleracea var. italica*., Plenck) is a cool season crop. It was planted in Egypt recently as a new nontraditional vegetable crop in the winter season and was grown in very limited areas. The word broccoli comes from the latin brachium which mean arm or branch. This plant develops somewhat branching clusters of buds on thick green stalks **(Johnstone and Brindle, 1976).** It has been grown in Europe for thousands of years and in U.S.A. from some centuries. The common English names are sprouting broccoli, calabrese and asparagus broccoli **(Tindall, 1983).** The curd is known to be rich in vitamin a, vitamin c, riboflavin and niacin beside have quite amounts of calcium, phosphor and iron. Broccoli has been considered as vegetable with potential anti-cancer activity due to high levels of glucoraphanin which can hydrolyses to form sulphoraphane and isothiocyanate. Moreover, antioxidants, vitamins and non-nutrient components such as flavonoids are present in curciferae crops which may decrease the risk for certain cancer **(Lindsay and astley, 2002).**

The more objective approach to determine the maturity stage of the curd came from evidences of some research work done on broccoli and some related crops during curd development. Thus, it was illustrated that there was a quick gradual increase in the broccoli curd fresh weight and diameter during the first stages of growth followed by a slight increase till the harvest stage **(Esmail, 1997).** Furthermore, it was found on cauliflower, that rapid increments occurred in the curd fresh weight and size till the age of 80 days then a decrease trend took place up to the last examined age **(Awad, 2014).** From the chemical point of view, the chemical contents reflected changes during the development of the part used as food in some vegetables. Thus, it was obvious that there was a gradual accumulation of the chemical contents in the early stages of development up to certain age then turned to decrease consistently with age proceed in chlorophyll in broccoli **(Tian *et al.*, 1995 and Esmail, 1997)**, total carotene in lettuce **(El- Zawily and Mashaal, 1984)** T.S.S in broccoli and cauliflower **(Esmail, 1997 and Awad, 2014)** titratable acidity in cauliflower **(Awad, 2014)**, ascorbic acid in cauliflower **(Gebczynski and Kmiecik, 2007 and Awad, 2014)**, total sugars in broccoli and cauliflower **(Esmail, 1997 and Awad, 2014)** and dry weight in cauliflower **(Awad, 2014)**.

Some scientific reports showed the effect of storage duration on the changes in the physical and chemical characteristics of various developmental stages in some vegetables. Concerning the deteriorations in the physical characteristics, it was clear that the spears of broccoli picked at three stages

of maturity and kept at three various temperature degrees exhibited that the mature spears lost less weight than those of the other two stages **(Stork, 1981).** On the same crop, broccoli, it was detected that the spears of 80 days age from transplanting showed the minimum unmarketable percentage comparatively to the other examined ages of 70, 75, 85 and 90 days during room temperature storage **(Tian *et al.*, 1995).** On the other hand, the changes in the chemical constituents proved that the broccoli curds of 20 days age kept higher values of total chlorophyll, T.S.S., ascorbic acid and total sugars after 2 days under room temperature storage whereas those of 5 days age showed a slight decline **(Abd El-Salam, 1966).** On cauliflower, it was clear that the curds at the age of 25 days from curd formation dominantly kept the highest concentration of ascorbic acid and sugars comparatively to the other examined ages of 5, 10, 15, 20 and 30days during all the storage periods **(Awad, 2014).**

The present work has involved studies on the models of plant physical and chemical attributes during development to provide knowledge and to have full understand about the determination of the maturity stage and the proper age for harvesting of the cultivar "Marathon" of broccoli.

Materials and methods

Two experiments were carried out on the cultivar "Marathon" of broccoli in the winter seasons of 2013-2014 and 2014-2015 at the farm of the faculty of agriculture, Al- Azaher University, Nasr city, Cairo. The first experiment was carried out to follow the models of six developmental stages during the growing of curds to obtain definite knowledge about their physical and chemical changes occurred during the growing of curds. The second one was done on the previous curd ages stored under cold storage at 8°C and 60-65% RH to determine the maturity stage and the most suitable harvesting stage. Seeds of broccoli cv. "Marathon" were sown in seed bed on September 16th and 20th in the first and second seasons respectively. Seedlings were transplanted after 40 days from seed sowing in the open field in both the two seasons. Plant spacing in the open field took place 80 cm between rows and 30 cm between plants in the row. Each replicate consisted of 5 rows where each row was 6 m long and 80 cm wide establishing an area of 24 $m^2$for each plot. The agricultural practices were done whenever it was necessary. All the two experiments included 3 replicates and arranged in randomized complete blocks design. The flower buds were labeled every 5 days from the beginning of curd formation at 60 days age up to 85 days to have the ages of 5, 10, 15, 20, 25 and 30 days . The curds were harvested and immediately transferred to the laboratory where sound and healthy curds were chosen for the determination of the physical characteristics that included fresh weight, size and diameter and the chemical ones, chlorophyll, carotene, total soluble solids (T.S.S.), titratable acidity, ascorbic acid, total sugars and dry weight. The second experiment: comprised storage of the six curd developmental stages. (5, 10, 15, 20, 25 and 30) under the circumstances of cold conditions (8°C and 60-65% RH). Each of the six developmental stages of broccoli curds were packed in plastic boxes (30x20x20 cm). Samples of 3 curds were taken during storage from each replicate at 7 days interval to check the changes occurred in the physical and chemical characteristics.

Determination procedures:

1- The curd fresh weight was weighed in (g) by a balance. 2- The curd size was determined in cm^3 by immersing the curd in a container filled with water and the displaced water was measured by graduated jar. 3- The curd diameter was estimated in cm by vernier calipar. 4- The percentage of curds loss in weight was calculated by the following equation:

$$\text{Loss in weight \%} = \frac{\text{Loss in weight at sampling date}}{\text{The initial weight of the heads}} X 100$$

5- The percentage of the unmarketable curds was counted determined from the following equation:

$$\text{Unmarketable curds (\%)} = \frac{\text{Total number of unmarketable curds at sampling date}}{\text{The initial number of curds}} X 100$$

6- The color of curd was determined according to the American color chart described by **Nickerson, (1957).** 7- The chlorophyll and carotene contents were determined in mg/100g fresh weight after **Lichtenther (1987).** 8- The total soluble solids percentage content were determined by abbe refractometer described in **A.O.A.C., 1990.** 9- The titratable acidity content was determined in mg/100g fresh weight by using a standard solution of sodium hydroxide (0.1N) and phenolphthalein indicator according to **A.O.A.C., 1990.** 10- The ascorbic acid content was determined in mg/100g fresh weight as reported in **A.O.A.C., 1990.** 11- The total sugars content were determined in g/100g dry weight after **Smith *et al.*, 1956.** 12- The dry weight was determined in g/100g fresh weight by drying 100 g. fresh weight in an oven at 70 °c till constant weight was reached.

Results and discussion

A-Models of developmental stages:

The growth of broccoli curds cv. "Marathon" had been followed by measuring a number of physical attributes such as curd fresh weight, size and diameter as well as the chemical

contents including chlorophyll, carotene, total soluble solids (TSS), titratable acidity, ascorbic acid, sugars and dry weight.

a-Physical characteristics:

Presented data in Fig 1 show the curd changes occurred in the physical characteristics during development in the two seasons of 2013-2014 and 2014-2015. The obtained results exhibited a slow increments in the curd fresh weight and size during the different developmental stages till the age of 20 days then a rapid increase was followed up to the age of 30 days forming statistically a curvilinear type. The figures of curd diameter showed a gradual increase from the start of curd formation up to the end of the various studied developmental stages establishing a linear shape from the statistical point of view.

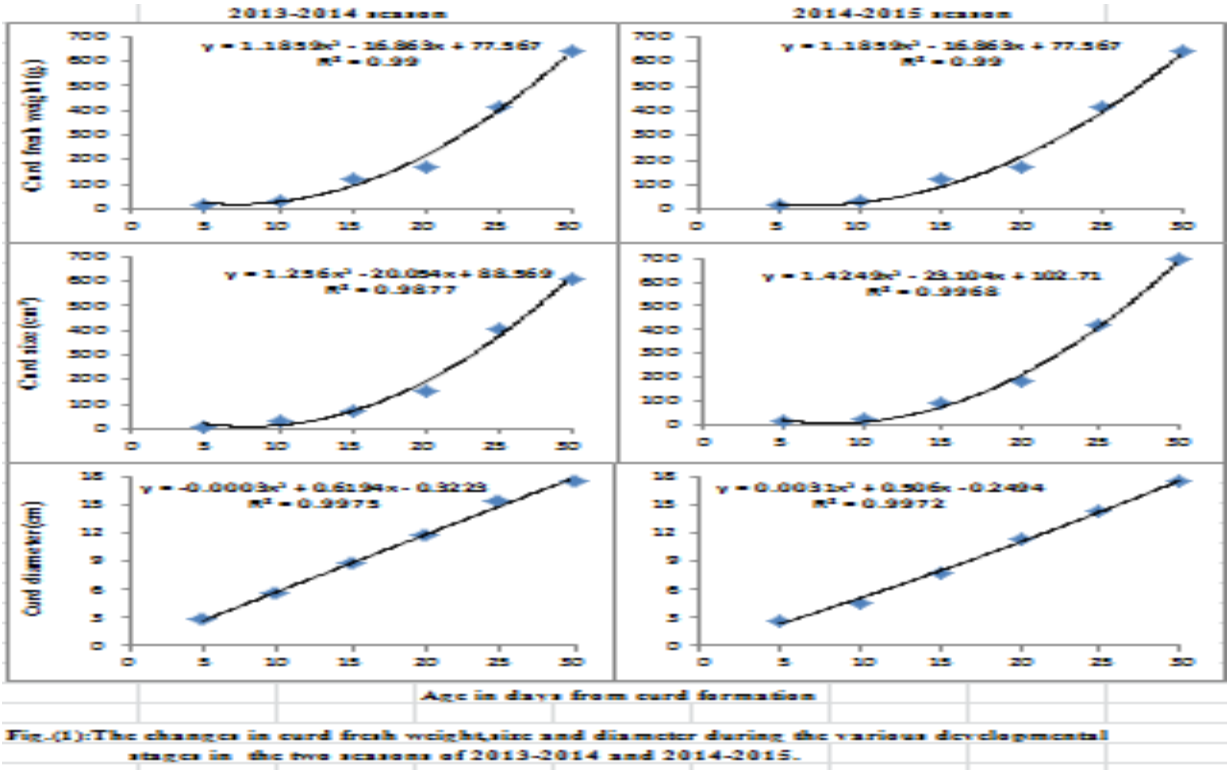

Fig.(1):The changes in curd fresh weight,size and diameter during the various developmental stages in the two seasons of 2013-2014 and 2014-2015.

b- Chemical characteristics:

The obtained results on the changes in the curd chemical contents during growth are exhibit in Fig 2 The data show that there was a continuous accumulation in the curd total chlorophyll and total carotene contents till the age of 25 days which was followed by a drop up to the final checked age of 30 days building from the point of statistics a curvilinear shape. The obtained figures on T.S.S. indicate that these contents increased steadily with the progress of age from the start of curd formation up to the last examined age of 30 days reflecting statistically a linear figure. The picture of the titratable acidity demonstrate that it increased steadly till the age of 20 days then this increase turned to be more quick up to the final examined age of 30 days suggested a curvilinear shape. The curd ascorbic acid content was increased rapidly with the proceeded of age till 25 days which was followed by a decrease till the last age of 30 days suggesting statistically a curvilinear type. The changes in curd total sugars content accumulated in high speed from the start of curd formation till the age of 25 days which was followed by a sharp decrease up to the final examined one of 30 days suggest statistically a curvilinear shape. The data show that the curd dry weight content was increased continuously and gradually from the first examined age of 5 days till the final one of 30 days forming statistically a linear curve. If we have a look to the previous results of curd development, it is quite possible to say that the increase in the physical characteristics of the curd may be attributed to the considerable cell expansion after the early period of cell division **(Hulme, 1970 and Abo El- Hamd, 1981).** In more details, cell division in the first phase of growth consists entirely from the division of meristematic cells. Certain daughter cells are pushed away from the zone of division and produced the next phase of growth which is cell enlargement. These cells are supplied with large quantities of water and food which may become several times of their former size **(Edmond, *et al.*, 1975).**

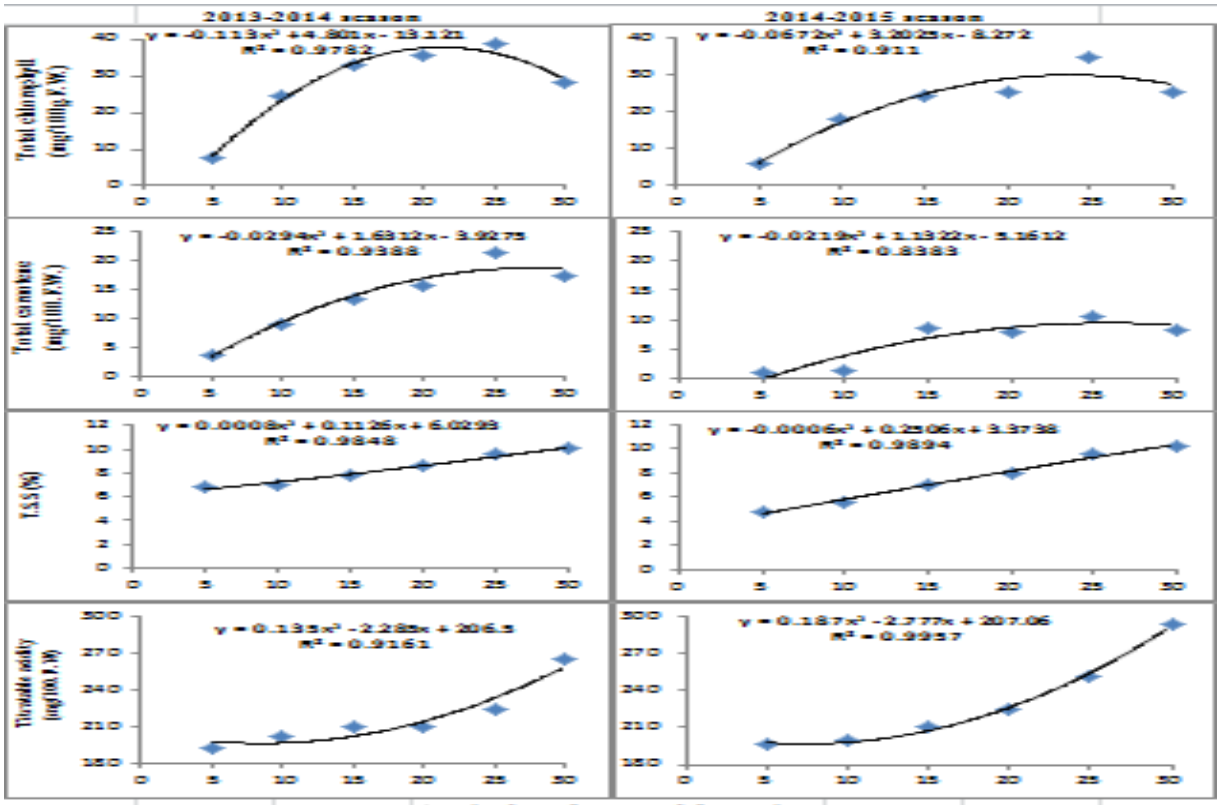

Fig.(2): The changes in the curd contents of chlorophyll,carotene,T.S.S and titratable acidity during the various developmental stages in the two seasons of 2013-2014 and 2014-2015.

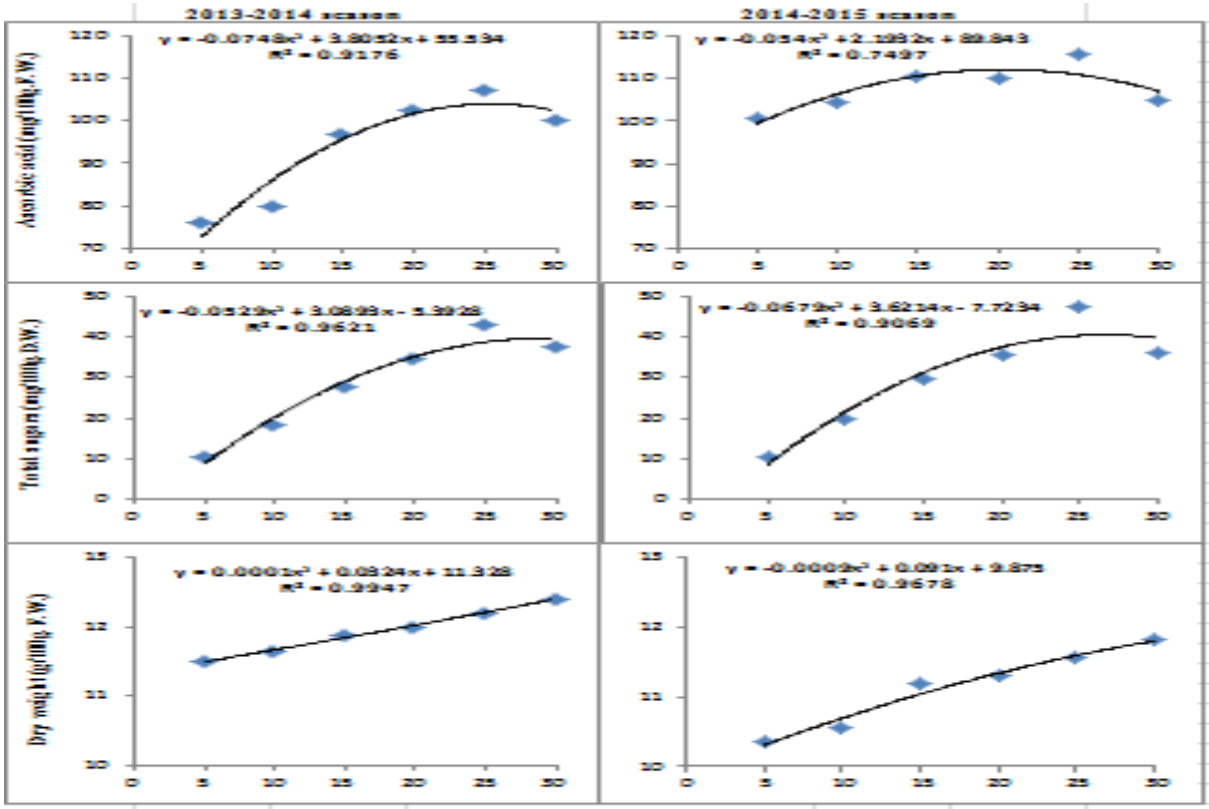

Fig.(3): The changes in the curd contents of ascorbic acid ,total sugars and dry weight during the various developmental stages in the two seasons of 2013-2014 and 2014-2015.

From the physiological point of view, the work done on the fruits of watermelon **(Pratt, 1971)** and tomato **(Abd El-Rahman *et al.*, 1975 and Abo El-Hamd 1981)** related the periods of increase to the changes happened in the levels of IAA, GA3 and cytokinins. These growth substances may increase progressively in the early periods of curd growth then tended to lessen in the lately stages of development. Further look to the other changes in the chemical contents of the curd during development, it is easy to notice that the contents of total chlorophyll, total carotene, titratable acidity, ascorbic acid, total sugars contents increased till the age of 25 days which was followed by a decrease drop till the last examined age of 30 days. Hence, it is obvious that the spread of chlorophyll colour in the curd may be related to the capable of some mature green tissues to biosynthesis chlorophyll and the capacity to synthesize chlorophyll is probably a form of chlorophyll restoration **(Bazzaz and Robeiz, 1978).** On the other hand, the progressive diminish of chlorophyll with aging may be attributed to the chlorophyllase activity in the breakdown of chlorophyll by catalyzing the removal of the phytol group **(Hulme, 1970).** On the other hand, the increase in total carotene may be due to the changes in provitamin A **(Simonne *et al.*, 1997).** To explain the trend of continuous increase of T.S.S., it may be clear to our knowledge that the changes in T.S.S. during the curd growth are the resultant of some aspects such as the movement of water and soluble solids to or from the curds, the inversion of insoluble compounds to simpler soluble forms beside respiration which all may add or withdraw these contents. So, the prevalence of one or more of these factors during curd development may accumulate these contents in the curd **(Abu-Zinada, 1988 and Emam, 1993).** Continuous increase of titratable acidity content in the curd with the progress of age may be attributed to the continuous synthesis of organic acids meanwhile the decrease occurred may be attributed consumption by respiration **(Abo-El-Hamd, 1981).** Concerning the changes in curd ascorbic acid, it is easy to say that the natural occurring ascorbic acid is L- ascorbic acid and the other ascorbic analogues. Fruits synthysize this vitamin from the precursor of hexose sugars which depends on an adequate photosynthetic activity **(Hulme, 1970)**. Thus, the increase in this vitamin during curd development may be due to the high rate of hexose sugars synthesis and in the contrary the decrease may be attributed to its exhaustion during respiration and its transfer to the oxidized form **(Ming – long L. and Paul, 1987).** Regarding the changes in total sugars during curd development, it was reported that the main sugar transport from the leaves to the fruits during growth is sucrose which accumulated during the first stages of curd growth while part of this sugar is used for the synthesis of pectic substances and other cell-wall materials, the other part converted to the usual storage product starch which decreased these contents in the older stages of the curd **(Bollard, 1970 and Hulme, 1970).** In seeking to follow the results of curd dry weight, it is clear that this material increased rapidly during the development from the start of curd formation up to the last examined age of 30 days. This increase supposed to be chiefly a result of both the increase in sugars content **(Nilsson, 1981)** and the progressive accumulation of nutrients which sink in the curd from other plant parts beside the reduction in head moisture content **(Bollard, 1970, Esmail, 1997 and El- Sherbeiny, 1999).**

B- Storage of developmental stages:

Determination of the proper picking stage of the fruits in general depends on the top quality for market accompanied with the ability to be stored for longest periods. Thus, this work was endeavors to describe the behavior of the different ages of broccoli curds during storage which may facilitate and enable us to determine the maturity stage of curd and the most suitable age for harvest.

a- Physical characteristics:

The physical changes in the various stored curd ages are presented in Table 1 The results of the loss in weight percentage clear that a continuous loss in weight happened in all the examined ages with the extend of the storage periods. When the results of the various ages were put in comparison, the first point to be observed is that the curd age of 25 days exhibited the least loss during the various storage periods meanwhile the age of 5 days showed the highest one. The unmarketable percentage increased gradually in all the stored ages till the end of the storage periods. On the whole, when the obtained values are compared, it is obvious that the age of 25 days showed the minimum percentage of unmarketable curds during the various storage periods whereas the highest one existed from the age of 5 days. The obtained data in Table 2 show that there was stability in the yellow green colour up to 14 days storage in all the stored ages which was followed by a slight deterioration in this colour till the stored day of 21 in all the examined ages. However, the curd age of 25 days show the minimum yellow green colour degradation in the various storage periods.

b – Chemical characteristics:

The chemical changes in the various stored curd ages are shown in Table 3. The general picture threw light on the total chlorophyll content which reflect a gradual slow degradation in this content with the elapse of the storage periods. The most favourable result came from the curd of 25 days age which lost comparatively the least chlorophyll content during the various storage periods meanwhile the lowest appeared in the age of 5 days. Regarding

the content of T.S.S., it is obvious that this content increased in all the stored ages up to 7 days storage then a drop happened till the end of storage days. The age of 25 days which showed the longest storage period contained the second highest T.S.S. content after the age of 30 days during storage whereas the least appeared in the age of 5 days. The obtained data revealed that ascorbic acid was correlated with a gradual slow drops in this content in all the various ages during the storage periods. The most clear observation is that the age of 25 days kept dominantly the highest concentration of this vitamin all over the storage periods meanwhile the lowest content happened in the curd age of 5 days. Concerning the total sugars content in all the stored curd ages, a gradual slow decrease trend occurred with the elongation of the storage periods. It is apparent that the age of 25 days comparatively to the other ages contained the highest total sugars during the whole storage periods meanwhile the minimum content appeared in the age of 5 days.

To discuss the effect of the storage periods on the different curd ages, it is obvious that the most favourite results came from the curds of 25 days age which exhibited the least loss in weight and the minimum unmarketable percentage during all these periods. However, these criterions which appeared with the extend of the storage periods was expected. The increase in the loss in weight may due to the loss of water by transpiration plus the loss in dry matter by respiration **(Cabezas *et al.*, 2002)** and the increase in the unmarketable curds of the various developmental stages during storage was attributed due to the continuous chemical and biochemical changes happened in the curds during storage which led to moisture condensation and transformation of complex compounds to simple forms of more liability to fungus infection such as the changes from the solid protopectin to soluble pectin form **(Villanueva *et al.*, 2005, Guerra *et al.*, 2011 and Raja *et al.*, 2011).** Best results were obtained from the curds of 25 days age as it was characterized with the minimum percentages in both characteristics all over the whole storage periods. Regarding the results of the changes in curd coloure during cold storage of the various developmental stages, the curds age of 25 days persented the minimum green colour degradation in the various cold storage periods. This, degradation may be attributed to the breakdown of chlorophyll content during cold storage periods as a result of chlorophyllase activity **(Abo-El-Hamd, 1981).** Following the chemical changes occurred during cold storage in the various curd ages, it is obvious that a general trend of decrease took place in the contents of total chlorophyll, T.S.S., ascorbic acid and total sugars with the extension of storage. However, the curd age of 25 days showed the least loss in these contents during cold storage at 8ºC. However, the diminish in curd total chlorophyll content during cold storage may be from the biochemical pathways of chlorophyll metabolism and lipid peroxidation. Evidences, however, suggested the involvement of at least four enzymes in the initial chlorophyll degradation **(Hulme, 1970)** which increased its activity with yellowing **(Rodriguez *et al.*, 1987 and Sabater and Rodriguez, 1978).** On the other hand, it is clear from the data that T.S.S. increased gradually in all the examined ages till 7 days of cold storage then a slow decrease occurred up to the end of storage periods. The highest content of T.S.S. was noticed in the age of curd 25 days. However, the tendency of T.S.S. to increase at first may be attributed to the quick conversion of insoluble solids to soluble ones and to the high rate of moisture loss. The vice versa for this explanation may be true in clearing the decreases in T.S.S. occurred at the end of the storage periods **(Abo-El-Hamd, 1981).** In explaining the decrease trend happened in ascorbic acid content during cold storage periods in all the stored curd ages, this may be attributed to the important role played by this vitamin as a catalyst in respiration beside the vital part in the biological and biochemical oxidation-reduction reactions during the various processes occurring in the stored fruits **(Youngjae Shin *et al.*, 2008 and Wang *et al.*, 2012).** On the account of the obtained results on total sugars, the decrease in these content during cold storage of curds may be attributed to its utilization in respiration **(Whiting, 1970, Ben Chekroun *et al.*, 1997, Cabezas *et al.*, 2002 and Raccuia and Melilli, 2007).**

C- Determination of the maturity stage and the most suitable age for harvesting:

When the previous results of the various stored ages were compared, the first demonstration observed is that the curds of 25 days exhibited the least loss in weight, the minimum percentage of unmarketable curds, the lesser degradation in colour and at the same time dominantly kept the highest concentrations of total chlorophyll, T.S.S., ascorbic acid and total sugars during storage. Therefore, it can be concluded that the curd age of 25 days coincided with the maturity stage of the cultivar "Marathon" of broccoli. This curd age was characterized in the two combined seasons by 416.65 g an average of fresh weight, 465.61 cm^3 size and 14.97 cm diameter beside the contents of 34.69 mg/100g fresh weight chlorophyll, 15.96 mg/100g fresh weight carotene, 9.31% T.S.S, 238.00 mg/100g fresh weight titratable acidity, 115.66 mg/100g fresh weight ascorbic acid, 45.09 g /100 g dry weight total sugars and 12.1 dry weight. From the previous data, it is reasonable to say that the curd maturity stage of the cultivar "Marathon" of broccoli was reached after 25 days age from bud formation and this age was fortunately the most suitable age for harvesting.

Table 1. Changes in loss in weight and unmarketable percentage in the various developmental stages during cold storage at 8ºC and 60-65% RH in 2013-2014 and 2014-2015 seasons.

Age in days	Storage periods in days					
	2013-2014 seasons			2014-2015 seasons		
	7	14	21	7	14	21
Loss in weight (%)						
5	43.89	58.69	70.34	35.39	57.21	68.44
10	34.84	53.80	61.66	24.52	41.71	52.13
15	21.20	28.89	34.55	13.65	17.43	25.18
20	6.67	11.74	16.78	11.44	17.16	21.54
25	4.21	9.95	14.56	9.32	15.60	19.23
30	6.67	12.15	18.94	11.82	17.68	22.04
Unmarketable curds (%)						
5	40	80	100	50	70	100
10	40	70	100	50	70	100
15	20	70	100	30	80	100
20	30	60	100	20	70	100
25	0	20	70	0	20	70
30	50	80	100	60	80	100

Table 2. Changes in colour in the various curd developmental stages during cold storage at 8ºC and 60-65 % R.H in 2013-2014 and 2014-2015 seasons.

Ages in days	**2013-2014 season**				**2014-2015 season**			
	Storage periods in days							
	0	**7**	**14**	**21**	**0**	**7**	**14**	**21**
5	5GY 6/8 strong yellow green	5GY 6/8 strong yellow green	5GY 6/8 strong yellow green	7.5GY moderate yellow green	2.5 GY 7/10 strong yellow green	2.5 GY 7/10 strong yellow green	5 GY 7/10 strong yellow green	7.5GY moderate yellow green
10	5GY 5/6 moderate yellow green	5GY 5/6 moderate yellow green	5GY 5/6 moderate yellow green	7.5GY moderate yellow green	5 GY 6/8 strong yellow green	5 GY 6/8 strong yellow green	7.5 GY 6/8 strong yellow green	7.5GY moderate yellow green
15	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	7.5GY moderate yellow green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	7.5GY moderate yellow green
20	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	7.5GY moderate yellow green	10GY 4/5 dark yellowish green	10GY 4/5 dark yellowish green	10GY 4/5 dark yellowish green	7.5GY moderate yellow green
25	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green
30	10GY 4/5 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	7.5GY moderate yellow green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	2.5GY 4/6 dark Yellowish green	7.5GY moderate yellow green

Table 3. Changes in the various curd developmental stages during cold storage at 8ºC and 60-65% RH in 2013-2014 and 2014- 2015 seasons.

Age in days	Storage periods in days							
	2013-2014 seasons				2014-2015 seasons			
	0	7	14	21	0	7	14	21
Total chlorophyll (mg./100 g.f.w)								
5	7.77	6.53	3.44	-	4.07	4.00	3.60	-
10	24.57	14.95	14.07	-	11.5	8.20	3.71	-
15	33.23	15.15	15.00	-	15.37	11.73	10.78	-
20	35.55	28.12	24.88	-	15.09	11.43	11.29	-
25	38.96	28.33	25.34	6.54	30.42	18.59	13.36	8.11
30	28.34	22.53	18.22	-	22.67	13.41	12.27	-
T.S.S. (%)								
5	6.76	7.20	4.22	-	4.76	7.55	2.56	-
10	7.00	7.60	4.64	-	4.97	6.95	2.96	-
15	7.89	8.26	5.26	-	7.09	7.20	6.12	-
20	8.65	9.60	5.68	-	9.03	9.60	6.26	-
25	9.56	9.96	6.56	5.10	9.60	9.85	6.90	5.50
30	10.02	10.42	6.50	-	10.20	11.00	6.60	-
Ascorbic acid (mg/100g. f.w)								
5	76.00	70.66	66.66	-	100.67	95.00	90.00	-
10	80.00	80.26	73.33	-	104.67	102.00	85.33	-
15	96.67	84.6	75.33	-	110.67	107.93	92.33	-
20	102.67	90.00	80.00	-	110.00	111.66	88.00	-
25	107.33	102.00	93.33	86.64	124.00	115.33	95.66	83.33
30	100.00	93.33	79.99	-	104.8	94.33	73.33	-
Total sugars (g/100g.d.w)								
5	10.21	9.26	6.54	-	10.49	7.70	6.79	-
10	18.4	17.90	9.17	-	19.92	11.79	7.50	-
15	27.88	25.88	15.82	-	29.46	22.52	11.56	-
20	34.86	34.67	18.73	-	35.67	27.3	15.71	-
25	45.64	40.53	29.89	9.56	47.69	44.2	28.63	11.23
30	37.43	32.34	15.73	-	36.12	29.49	11.97	-

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دراسة على التغيرات الطبيعية والكيماوية المرتبطة بتطور نمو أقراص البروكلى لتقدير مرحلة إكتمال النمو والعمر المناسب للقطف

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أجريت تجربتان على أقراص البروكولى صنف مارثون لدراسة التغيرات الطبيعية والكيماوية خلال مراحل تطورها المختلفة وتخزينها وذلك لتحديد درجة إكتمال النمو والعمر المناسب للحصاد خلال موسمى الشتاء 2013-2014و 2014-2015 بمزرعة كلية الزراعة جامعة الأزهر بمدينة نصر حيث تم تعليم الأقراص من بداية تكوين البراعم الزهرية كل خمسة أيام للحصول على أقراص ذات أعمار 5و10و 15و20و25و30 يوما لدراسة الصفات الطبيعية والكيماوية عليها.

وأشارت النتائج إلى زياده بطيئة فى الوزن الطازج للقرص وحجم القرص حتى عمر 20 يوم ثم تحولت تلك الزيادة لتكون سريعة حتى عمر 30 يوم مكونة شكل curvilinear إحصائيا بينما زاد قطر القرص زياده منتظمة من بداية تكوينه حتى نهاية الأعمار المختبره مكونا شكل linear إحصائيا أما محتوي الأقراص من الكلوروفيل والكاروتين والحموضة المعايرة و حامض الأسكوربيك والسكريات الكلية فقد ذادت زيادة تدريجية حت عمر 25يوم ثم حدث نقص فى محتوى الأقراص من هذه الصفات حتى عمر 30 يوم مكونة شكل curvilinear إحصائيا بينما زاد محتوي الأقراص من المواد الصلبة الذائبة والوزن الجاف زيادة مستمره من بداية تكوين القرص حتى عمر 30 يوم مكونا شكل linear إحصائيا.

ولتحديد درجة إكتمال النمو والعمر المناسب للحصاد تم تخزين ألاعمار التى تم الحصول عليها على درجة حرارة 8 درجة مئويه و رطوبة نسبية 60-65% وقدرت بعض الصفات الطبيعية والكيماوية للأقراص كل سبعة أيام حيث أوضحت النتائج أن أقل فقد فى وزن الأقراص وفى نسبة ألأقراص الغير صالحة للتسويق و فى تدهور اللون كانت فى ألأقراص عمر 25 يوم كما تميزت هذه ألأقراص بأقل فقد فى محتوياتها من الكلورفيل والمواد الصلبة الذائبة وحامض ألأسكوربيك والسكريات.

و من هذه النتائج المتحصل عليها من الدراسة وضح أن أقراص البروكلى صنف مارثون وصلت إلى مرحلة إكتمال النمو عند عمر 25 يوم من بداية تكوين البراعم الزهرية وهو أيضا العمر المناسب للحصاد.