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Purple Cauliflower Curd Maturity Stage And Harvesting Age

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Abstract

Purple cauliflower cultivar Graffiti was grown at a private farm near Banha, Qalubia Governorate during the winter seasons of 2009-2010 and 2010-2011.Curds of 5,10,15,20,25and 30 days post curd formation was used to study the developmental stages and their physical and chemical properties.In addition, their keeping quality under room temperature were also investigated. Data revealed that there were continuous rapid increase in the curd fresh weight, size, diameter and stem diameter till the age of 25 days. This increase was followed by moderate decrease till the last age of 30 days in both curd fresh weight and size forming statistically a curve linear type meanwhile the diameter and stem diameter were increased slowly till the last age establishing a linear shape. On the other hand, quick accumulation in the contents of ascorbic acid,T.S.S.and anthocyanin were detected up to the age of 25 days then slow decreases were followed up to the age of 30 days building statistically a curvilinear design. From another point of view, the stored developmental stages under room temperature storage showed that the least loss in weight and unmarketable percentages were shown during storage from the age of 25 days meanwhile the highest contents of T.S.S, ascorbic acid and total sugars were kept in the curds of the same age. However, the maturity stage of the curd was determined at 25 days from curd formation which coincided with the most suitable harvesting age.

Key Words: purple cauliflower, maturity, harvesting.

Introduction

Cauliflower is one of several vegetables in the species Brassica oleracea,in the familyBrassicaceae.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 subtle charms and its health benefits. Purple cauliflower has a milder flavour than white cauliflower, its sweeter and without the bitternss sometimes found in the white cauliflower .Additionally, it has a much higher vitamins and mineral contents. Purple cauliflowers, which get its distinctive deep lavender colour from a flavonoid compound called anthocyanins, contains also a compound called glucoraphanin, both are linked to a reduced risk of cancer, diabetes, heart disease and neurological problems. Cauliflower is 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. Since these quality might be affected by the date of harvesting, this determination of the maturity stage and the most suitable stage for harvesting were the most important in this concern for the various varieties. Studies on the physical and chemical characteristics of the curd during development and storage may help in determine these features .Thus, a more objective approach to determine the maturity stage of the curd came from evidences of some research work done on cauliflower and some related crops during curd development . Thus ,on broccoli, it was found that a gradual increase in head fresh weight occurred till then followed by a slight increase up to the harvest stage (Marshall and Thompsom,1987**)**.On the same crop, broccoli, it was detected that positive increase in head dimensions was seen the progress of head development (Esmail, 2006).Many evidences on cauliflower curd and stem diameters cleard that this character increased with age advance in a curve linear shape (Salter,1969**)**.From another point of view, the chemical contents reflect that there were changes happened during the development of the part used as food in some cruciferae vegetables which were studied by some workers. Thus, it was detected that there was a gradual accumulation of total acidity in Brussels sprouts (Mady, 2008**)**, sugar in cabbage head (Sharaf, 1967), anthocyanin in red cabbage head (Kamal, 2004) and dry weight in cauliflower curd from the start till the end of these parts development. Another picture was caught up from the gathering of some other chemical contents such as ascorbic acid in red cabbage (Kamal, 2004**)** and T.S.S in broccoli which increased in the early stages of development up to certain age then decreased consistently with age advance.

The physical and chemical changes of the developing cole crops during storage had been a subject of some research works. On broccoli, it was found that spears picked at six stages of growth 5,10,15,20,25 and 30 days from bud formation and

stored under room temperature conditions at (20±2°C and 52-56% R.H) showed that spears of 25 days age exhibited approximately the least loss in weight during the various storage periods (Esmail,1997) **.** On the same crop , broccoli, it was detected that the spears of 80 days age after transplanting was the best as compared with the other examined ages of 70,75,85 and 90 during storage due to the least unmarketable percentage (Tian et al.,1995)**.**Continuation of investigation on broccoli, pointed that the spears of 20 days from bud formation kept the highest T.S.S content than the various ages 5,10,15,25 and 30 days during storage under room temperature conditions at (20±2°C and 52-56 % R.H) (Esmali,2006).In another investigation on cauliflower, the curds harvested at maturity which 85 days from transplanting was more higher than than those of the immature 70,75,80 and 90 days during storage at **0**°C (Fritz et al.,1979**).** On cabbage, it was clear that heads harvested of 133 days proved to be the most obvious over 119,126 or 140 days in keeping the highest concentration of total sugars during room temperature storage (22±2°C) (Wally et al.,1978).Although, purple cauliflower has exceptional health benefits and its gaining popularities around the worlds, especially in USA and Europe, its well known in Egypt, where it has a great potential in domestic and export markets. This work was done to determine the optimum harvesting date of the purple cauliflower. The curd developmental stages and its keeping quality were also comprised in this work.

Material and methods

This investigation was carried out at Emyay near Banha, Qalubia Governorate, A.R.Egypt.The soil type of this area is silty loam. Cultivar "Graffiti" of cauliflower Brassica oleracea var botrytis was grown during the two successive winter seasons of 2009-2010 and 2010-2011. Seeds were sown in seedbed on September 1st and transplanted on October 15th for the first and second experiment and seedings were transplanted 70 cm apart between rows. Within each row, the distances between the plants were 75 cm and normal cultivar practices were followed whenever needed. The developing buds were labeled when they began to form curds. Hand –harvesting of curds began 5 days after labeling and continued at a 5 days intervals, finaly sampling took place at 30 days from curds formation (the 35 days curd was excluded as it became over mature and began to separate). The curds of each of the six ages 5,10,15,20,25 and 30 days old were harvested by cutting the main stem and the outer leaves (a few leaves were left to protect the curds).The curds were immediately transported to the postharvest laboratory of the Horticulture Department, Faculty of Agriculture Al-Azhar University. Sound and uniform curds of each age were represented in three replicates (comprised of 3 curds each) and devoted to physical (curd fresh weight,size,diameter and curd stem diameter) and chemical (titratable acidity, ascorbic acid,T.S.S,total sugars,anthocyanin and dry weight) analysis. The various examined developmental curd ages were stored under room temperature conditions at 22±2°C and 55-58% R.H.Each of the stored curds was labeled, weighted and placed in carton box, each box contained three curds. Cauliflower samples were monitored every 2 days. Three randomly selected boxes of each treatment were used to determine the changes in physical (loss in weight and unmarketable percentage) and chemical (total soluble solids, ascorbic acid and total sugars contents) properties.

Determination procedures

The fresh weight of the curds was determined by a balance and the size in cm by immersing the curd in a container filled with water and the displaced water was measured by a graduated jar. The diameter was estimated in cm using ruler. The percentage of loss in weight was calculated as:

$$\frac{\text{Loss in weight at the sampling date}}{\text{The initial weight of curds}} \times 100$$

The percentage of unmarketable curds were calculated according to the equation:

$$\frac{\text{Total number of unmarketable curds at the sampling date}}{\text{The initial number of curds}} \times 100$$

Furthermore the titratable acidity was determined as mg/100g fresh weight by using a standard solution of sodium hydroxide (0.01N) and phenolphthalein indicator (A.O.A.C.,1990). The ascorbic acid was determined as mg/100g fresh weight using the dye 2.6 dichlorophenol indophenol method (A.O.A.C.,1980).The total soluble solids (T.S.S) were determined as percentage by refractometer(A.O.A.C.,1980) .The total sugars were determined as g/100g dry weight (Smith et al., 1956).The total anthocyanins were determined as mg/100g fresh weight (Ranganna.,1979).The dry weight was determined as g/100g fresh weight by subjecting 100g of fresh weight to dry in an oven at 70c till constant weight was reached (A.O.A.C., 1980).The obtained physical and chemical results of the curd developmental stages were statistically analyzed by using Goodness of Fite methods (George,1963).

Results and discussion

A- Models of developmental stages.

The curd growth of cauliflower var "Graffiti" has been followed by measuring a number of physical and chemical attributes such as fresh weight, size , diameter, curd stem diameter , titratable acidity, ascorbic acid,T.S.S total sugars,anthocyanin and dry

weight .Growth curves based on these measurements showed characteristic forms which have been the subject of our discussion.

a- Physical characteristics.

Data regarding the curd physical characteristics were shown in Fig (1) In the two seasons of 2009-2010 and 2010-2011. There was a trend of increases in curd fresh weight during the different developmental stages up to the age of 85 days from sowing after which a slight decrease took place till the last examined age of 90 days forming statistically a curvilinear type. The curd size of the various examined ages increased rapidly till the age of 80 days then continued slowly up to 85 days age which was followed by a slight decrease till the age of 90 days establishing a curve linear figure. The figures of curd diameter show a gradual increase from the beginning up to the end of development which gave rise to a linear shape from the statistical view. The values of curd stem diameter reflect steady gradual increase during the period from 65 to 85 days age then a slight increments were followed till the age of 90 days giving statistically a linear type manner.

b- Chemical characteristics.

The data obtained on the changes in the curd chemical contents are exhibited in Fig (2). The levels of titratable acidity during curd development show rapid increases till the age of 80 days then a slow increase till the age of 90 days draw statistically a curvilinear type. The curd content of ascorbic acid exhibit clearly quick increase with age advance till the age of 85 days after which a slight drop happened in the following last ages building statistical curvilinear shape. The changes in curd T.S.S content reflect steady increases up to the age of 85 days after which a slight drop occurred in the last age of 90 days which suggest a curvilinear relationship between the T.S.S content and the growing ages. The following of total sugars during curd development indicate quick increases during development till a peak was reached at the age of 85 days that followed by a slow decrease trend in the late periods of growth reflecting a curvilinear shape from the statistical point of view. The determination of the anthocyanin concentration during the curd various developmental stages show continuous increases with the proceed ages till the age of 85 days after which there were a slight decreases up to the last tested age of 90 days establishing statistically a curvilinear design. The changes in dry weight content during curd development clear continuous increases from the first tested age of 65 days till the final one of 90 days forming a linear shape in the statistic view.

On discussing the previous results of curd development, it is obvious that the increase in the curd physical characters may be attributed to the considerable cell expansion after the early period of cell division (Hulme ,1970)**.**In more detaile, cell divission in first phase of growth consist entirely from the divission of meristematic cells. Certain daughter cells are pushed away from the zone of division to 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. From another point of view, the increase in the previous plant characteristics during its growth cycle may be physiologically explained through the work done on the fruits of watermelon (Pratt,1971) and tomato **(**Abd-Elrahman et al.. 1975) which related the periods of increase to the progressive increase in the levels of IAA,GA3 and cytokinins in the periods of curd growth then tended to lessen in the latter stages of development. If we have a look to the obtained data on the chemical contents, the results revealed continuous increase in the curd titratable acidity with the progress of age that may be attributed to the continuous synthesis of organic acids (Ashmawi,2011). On the other hand, the trend of ascorbic acid , total soluble solids, total sugars and anthocyanins show that these contents increased till the curd age of 85 days which was followed by a decrease drop. It is easy to say that the natural occurring ascorbic acid is L-ascorbic acid and other ascorbic analogues. Fruit synthesis 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 hoxose 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 Liao and Paula, 1987). The same picture of T.S.S during curd growth put forth 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 and from the curds , the inversion of insoluble compounds to simpler soluble forms beside respiration which may add or withdraw these contents.So,the prevalence of one or more of these factors during curd development may accumulate or lessen the content of T.S.S (Hulme, 1970)**.** Concerning total sugars, it is known that the main sugars transport from the leaves to the fruits during growth is sucrose. 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 (Bollard,1970) .So, in the early growth of curd that characterized with high sugars, the accumulation of these sugars may be higher than the rate of conversion to starch and cell-wall materials whereas in the late stages the opposite picture may be true. The product of anthocyanin which is anthocyanin a glycoside composed of a glycone and sugar, therefore the importance of sugars amount in anthocyanins formation was assured as it was found that red cabbage shoots

which have plenty quantity of sugars formed more anthocyanins easily than the low one (Mazza and Miniati ., 1993) .Explanation of the continuous increase in curd dry weight during growth may be due chiefy to some reasons, the increase in sugars as the curd dry weight in cauliflower composed mainly from sugars (Nilsson,1988) ,the progressive accumulation of nutrients which sink in the curd from another plants beside the reduction in curd moisture content (El-Sherbeiny,1999).

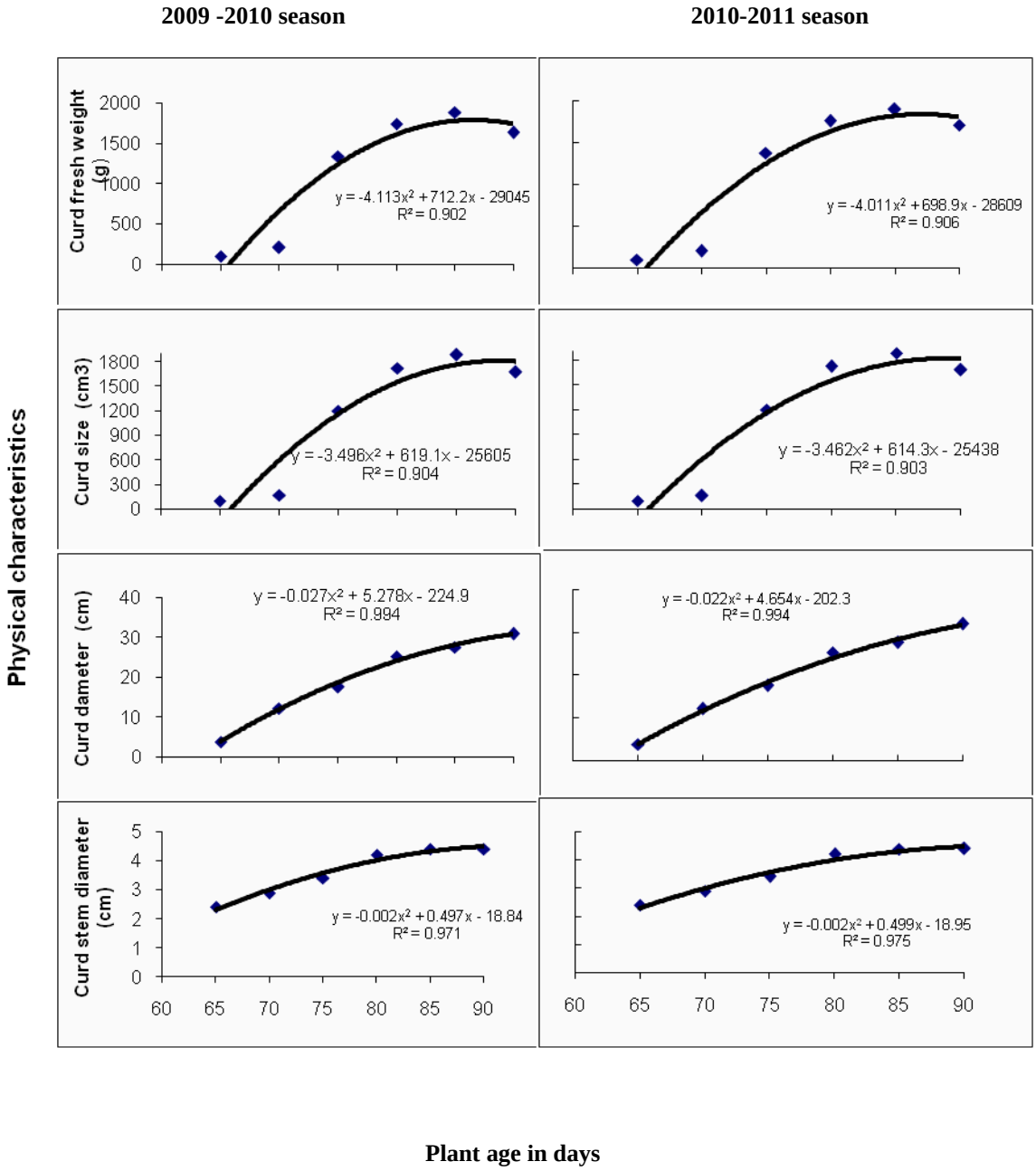

Fig.(1): The changes in the different physical characteristic during the various developmental stages in the two seasons of 2009-2010 and 2010-2011.

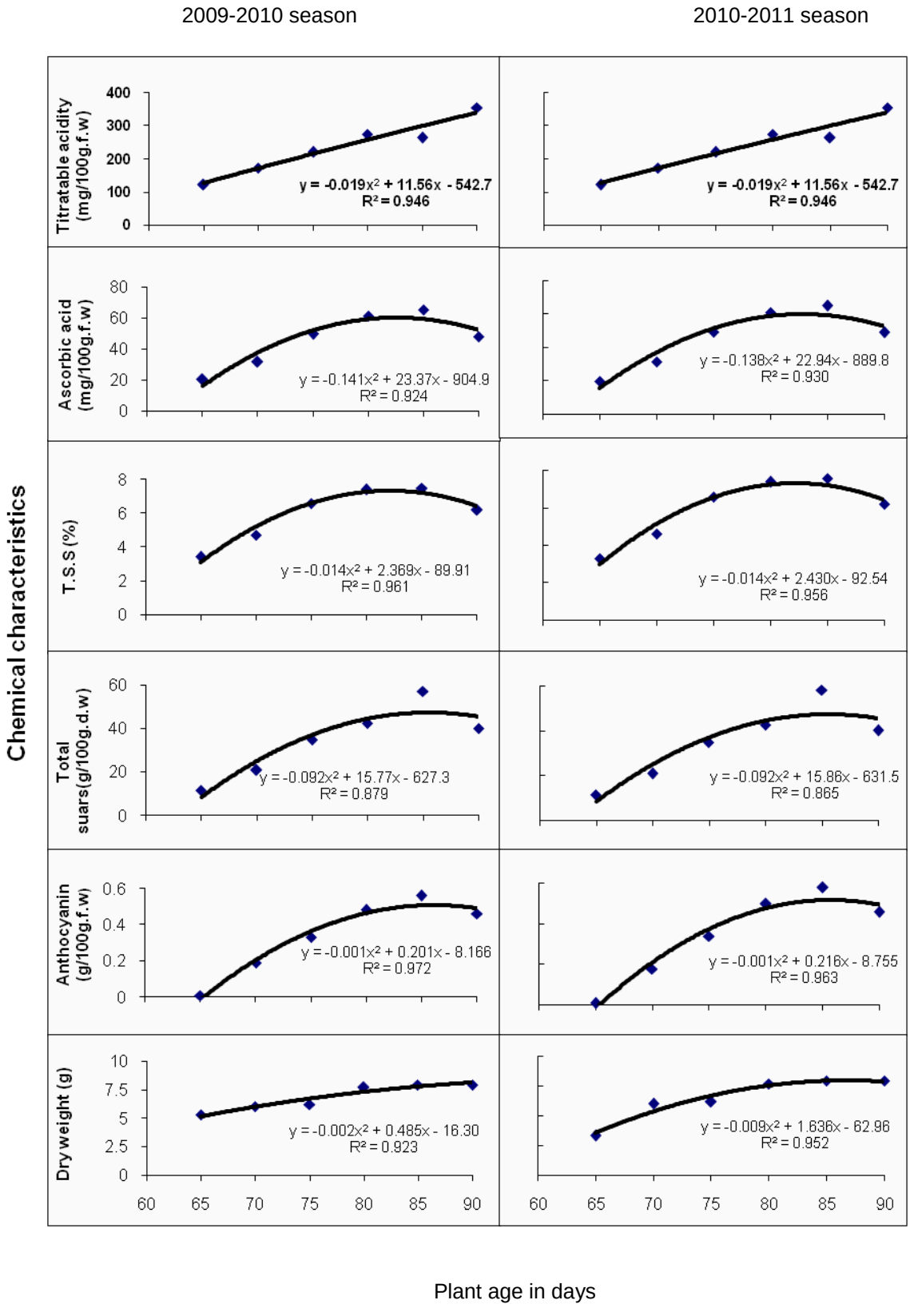

Fig.(2): The changes in the different chemical characterstics during the various developmental stages in the two seasons of 2009-2010 and 2010-2011.

B- Storage of developmental stages.

Recognition of the proper picking stage of the curds depends on the highest quality required for market accompanied with the ability to be stored for long periods. However, the forementioned basic data cleared the features of the various curd developmental stages of the variety "Graffiti" of cauliflower . More informations are endeavors to describe the behavior of the different curd during storage which may put basis to determine the curd maturity stage and the most suitable age for harvesting.

a- Physical changes.

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 occurred with the extension of the storage periods . When the results of the various ages were put in comparison, the first demonstration is that the curds of 25 days age exhibited approximately the least loss during the various storage periods. The data of the unmarketable percentage show that this percentage increased gradually in all the stored ages till the end of the storage periods. However, the results were in favaur of those curds of 25 days age which exhibited the least percentage of unmarketable curds throught the various storage periods.

b- Chemical changes.

The chemical changes in the various stored curd ages are presented in Table (2) . The effect of different storage periods on the T.S.S content in the various developmental curd ages exhibit a gradual decrease trend with the elapse of storage periods. However, the curd age of 25 days kept comparatively the highest T.S.S content during the various storage periods. The changes happened during storage in ascorbic acid content in the various curd ages reflect that this vitamin decreased in all the various ages with the elongation of the storage periods. However, the most striking observation pointed that the curds of 25 days age dominantly kept the highest concentrations of ascorbic acid all over the storage periods. The same was true for total sugars as these contents in all the stored curd ages exhibited a gradual decrease with the extend of the storage periods. However, it is apparent that the age of 25 days comparatively reserved the highest total sugars during storage. The general trend of loss in weight was expected because this criterion resulted during storage from the loss of water by transpiration and dry matter by respiration (Hulme, 1970 and Abd – Elmonem , 1992).At the same time the appearance of the unmarketable curds during storage was also expected. This feature may be attributed to the continuous chemical and biochemical changes happened in 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 the soluble pectin form (Stork,1981 and Said, 1990).

Following the chemical changes in the various curd ages during storage, it is obvious that a general trend of decrease took place in the contents of T.S.S, ascorbic acid and total sugars. However, the question of the exterted decrease in T.S.S may by accounted to the continuous loss in these contents through respiration (Hulme , 1970 and Awad, 1984). In explaining the decrease trend happened in ascorbic acid content during storage, it is known, that ascorbic acid plays an important role as a catalyst in respiration and has vital part in the biological and biochemical oxidation- reduction reactions during the various processes occurring in stored fruits (Ming-Long Liao and Paul ,1987) and thus, this universal component in plant cells may be exhausted by rapid oxidize at least with five enzyme systems (Hulme , 1970) .From another point of view, the gradual decrease in total sugars content during storage of curds may be attributed to its utilization in respiration (Mertens and Tranggono , 1989).

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

When the results of the various stored curd ages were put in comparison, the first demonstration is that curds of 25 days exhibited comparatively the longest shelf life, the least loss in weight, the minimum percentage of unmarketable curds and kept the highest concentration of T.S.S, ascorbic acid and tota lsugars during storage.

These characteristics gave strong sign that the maturity stage occurred at the age of 25 days for the cultivar "Graffiti" of cauliflower. This age was characterized with a range of 1866.11 to 1945.70g in weight, 1882.30 to 1888.50cm^3 in size, 27.5 to 27.6 cm in diameter, 4.4 to 4.5 cm in stem diameter, 261 to 263 mg/100g fresh weight in titratable acidity, 61.10 to 65.20 mg/100g fresh weight in ascorbic acid, 7.00 to 7.50% in T.S.S, 57.00 to 57.20g/100g dry weight in total sugars,0.56 to 0.59mg/100g fresh weight in total anthocyanin and 7.85 to 7.90g/100g fresh weight in dry weight.

At the same time, these physical and chemical characteristics of the age 25 days are the most suitable features for marketing .Thus, in this cultivar the maturity stage coincided with the harvesting age of 25 days from bud formation.

Table 1. The changes in the physical characteristics of the various curd developmental stages during storage under room temperature conditions (22+2°C and 55 – 58 R.H).

Characteristics	Age In days	Storage periods (days)							
		2009 – 2010 season				2010 – 2011 season			
		2	4	6	8	2	4	6	8
Loss in weight (%)	5	19.20	38.30	69.70	-----	21.30	39.60	68.30	-----
	10	12.40	23.60	42.10	-----	12.00	22.80	43.10	-----
	15	10.10	17.40	31.50	-----	9.80	18.10	32.70	-----
	20	7.60	14.10	27.30	-----	8.40	15.30	29.10	-----
	25	5.30	10.90	22.70	36.20	5.00	10.00	23.40	37.80
	30	5.30	11.40	25.20	-----	4.60	10.50	24.80	-----
Unmarketable (%)	5	50	80	100	-----	50	85	100	-----
	10	50	80	100	-----	50	85	100	-----
	15	50	80	100	-----	50	80	100	-----
	20	40	70	100	-----	40	75	100	-----
	25	0	20	70	100	0	20	70	100
	30	60	70	100	-----	60	75	100	-----

Table 2: The changes in the chemical characteristics of the various curd developmental stages during storage under room temperature conditions (22±2°C and 55 – 58 R.H).

Characteristics	Age In days	Storage periods (days)							
		2009 – 2010 season				2010 – 2011 season			
		0	**2**	**4**	**6**	**0**	**2**	**4**	**6**
T.S.S (%)	**5**	**3.40**	**3.00**	**2.40**	-----	**3.50**	**2.70**	**2.20**	-----
	10	**4.70**	**3.10**	**2.60**	-----	**4.50**	**3.00**	**2.50**	-----
	15	**6.60**	**4.20**	**3.00**	-----	**7.00**	**4.90**	**3.80**	-----
	20	**7.40**	**4.80**	**3.20**	-----	**7.30**	**5.00**	**4.10**	-----
	25	**7.50**	**5.40**	**4.10**	**2.30**	**7.70**	**5.40**	**4.70**	**2.80**
	30	**6.00**	**5.10**	**3.80**	-----	**6.10**	**5.00**	**4.00**	-----
Ascorbic acid (mg/100g.f.w)	**5**	**20.30**	**16.20**	**12.10**	-----	**19.50**	**16.90**	**10.00**	-----
	10	**31.80**	**28.30**	**24.80**	-----	**33.20**	**30.50**	**26.10**	-----
	15	**49.50**	**39.70**	**30.90**	-----	**52.00**	**43.90**	**33.60**	-----
	20	**61.20**	**53.40**	**42.30**	-----	**68.10**	**60.60**	**49.80**	-----
	25	**65.10**	**58.00**	**49.40**	**43.50**	**71.30**	**66.90**	**58.70**	**53.10**
	30	**48.20**	**41.20**	**35.40**	-----	**53.40**	**45.10**	**38.80**	-----
Total sugars (g/100g.d.w)	**5**	**11.50**	**8.20**	**5.40**	-----	**12.10**	**9.40**	**6.00**	-----
	10	**20.90**	**14.70**	**8.90**	-----	**21.30**	**15.70**	**9.10**	-----
	15	**34.80**	**25.40**	**16.00**	-----	**35.70**	**26.90**	**17.80**	-----
	20	**49.50**	**42.80**	**33.20**	-----	**50.30**	**44.10**	**33.90**	-----
	25	**57.00**	**50.10**	**41.50**	**34.10**	**57.60**	**50.00**	**42.70**	**35.00**
	30	**40.10**	**28.10**	**19.90**	-----	**40.20**	**29.00**	**18.00**	-----

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مرحلة اكتمال النمو والعمر المناسب للحصاد لقرص القنبيط البنفسجي

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أجريت هذه الدراسة على أقراص القنبيط صنف "جيرا فتى" لدراسة التغيرات الطبيعية والكيماوية خلال نموها وتخزينها لتحديد درجة اكتمال النمو والموعد المناسب للقطف. وقد تم زراعه نباتات التجربة خلال موسمي شتاء 2009- 2010و2010- 2011 بجهة إمياى بمحافظة القليوبية لدراسة مراحل نمو القرص حيث تم تعليم البراعم عند بداية تكوينها كل خمسة أيام للحصول على أقراص ذات أعمار 5و10و15و20و25و30 يوما لدراسة صفاتها الطبيعية والكيماوية.

أوضحت النتائج زيادة كل من الوزن الطازج للأقراص وحجم الأقراص زيادة سريعة بتقدم العمر حتى 25 يوما ثم تبعها انخفاض طفيف حتى عمر 30 يوما في حين كان معدل الزيادة في قطر القرص وقطر الساق القرصية سريعا حتى عمر 25 يوما أعقبها زيادة بطيئة حتى عمر 30 يوما. أما محتوى الأقراص من الحموضة الكلية وحامض الأسكوربيك والمواد الصلبة الذائبة الكلية والسكريات ومحتوى الأنثوسيانين ونسبة المادة الجافة فقد زادت الحموضة الكلية والمادة الجافة خلال مراحل النمو حتى عمر 25 يوما ثم تبع ذلك زيادة طفيفة حتى عمر 30 يوما أما حامض الأسكوربيك والمواد الصلبة الكلية والسكريات الكلية ومحتوى الأنثوسيانين فقد زادت حتى عمر 25 يوما ثم تبع ذلك نقصان في هذه المكونات الكيماوية في العمر الأخير 30 يوما.

لتحديد مرحلة اكتمال النمو ودرجة القطف المناسبة لهذا الصنف فقد خزنت الأعمار السابقة فى صناديق كرتون مفتوحة تحت ظروف حرارة الغرفة (22±2م^5) وتم تقدير بعض الصفات الطبيعية والكيماوية للأقراص كل يومين خلال التخزين. واتضح أن أقل فقد في الوزن وكذلك نسبه الأقراص الغير صالحة للتسويق كانت فى العمر 25 يوما عن باقي الأعمار الصغيرة والكبيرة كذلك كان أقل فقد في كل من المواد الصلبة الذائبة الكلية وحامض الأسكوربيك ونسبة السكريات كان في العمر 25 يوما عن باقي الأعمار.

وتجمل نتائج البحث أن أقراص القنبيط صنف " جيرافتى" وصلت إلى مرحلة اكتمال النمو عند 25 يوما والذي كان في نفس الوقت أنسب عمر صالح للقطف .