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CHANGES IN NUTRITIONAL QUALITY OF ZUCCHINI (*Cucurbita pepo* L.) VEGETABLES DURING THE MATURITY

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ABSTRACT

Monitoring of changes in nutrients composition of vegetables during different stages of maturity help to determine optimal harvesting date; therefore, collecting vegetables with higher nutritional value and eating quality. Changes in chemical composition as well as total phenolic and flavonoids content of three Zucchini cultivars; namely, Eskandrany (ES), Amjad F_1 (AMF_1), and New Eskandrany F_1 ($NESF_1$) grown in Egypt, with development of maturity stage were investigated. The results showed that dry matter, protein, oil, ash, and crude fiber contents of Zucchini vegetables were decreased with the advancement of maturity stage. However, gradual increase in total carbohydrate content was observed with the development of maturity. In addition, total phenolics and flavonoids contents were decreased in the more developed fruits. Based on the obtained results, it could be concluded that although there is an increase in yield of vegetables at later maturity stage, but vegetables at early stage of maturity contain high content of nutrients and health promoting compounds, such as protein, ash, crude fiber, and phenolics and flavonoids.

Keywords: Zucchini, Maturity, Crude fiber, Carbohydrates, Total phenolics and Total flavonoids.

INTRODUCTION

High dietary intake of fruits and vegetables is strongly associated with a reduced risk of developing chronic pathologies, such as cardiovascular diseases, diabetes, various types of cancer, among others as established by a number of epidemiological studies and clinical trials (Erdman *et al.,* 2007; and Henríquez *et al.,* 2013). This may be partly due to the presence of antioxidant (such as Vitamin C) and many other bioactive phytochemicals. A daily intake of a minimum of 400 g of fruits and vegetables, excluding tubers like potatoes and cassava has been recommended for the prevention of these chronic diseases. However, limiting forces behind the low consumption of fruits and vegetables in developing countries include the reliance on only few crops to meet dietary requirements, lack of access to most wild fruits and high cost of commonly consumed food. While only few crops are commercialized on a significant global scale (FAO, 1997), most other species are neglected and thus underutilized. Among such species are the Cucurbits, the gourd fruits of the *Cucurbitaceae* family with about 120 genera and 825 species (Tyagi *et al.,* 2012).

Zucchini (*Cucurbita pepo* L.) that belongs to Fam. *Cucurbitaceae* is one of the most popular vegetable crops for human nutrition, not only in Egypt, but also all over the world. According to the statistics of Ministry of Agriculture in Egypt, the total cultivated area in 2011 was 84571 feds., produced about 633521 tons and by average of 7.491 tons/fed (Abd El-All *et al.,* 2013). Zucchini is an economically important plant and is cultivated throughout the world for oil and medical purposes. Pharmacological effects comprising antidiabetic, antihypertensive, antitumor, antimutagenic, immunomodulating, antibacterial, antihypercholesterolemic, intestinal antiparasitic, antalgic, antiinflammation effects and utilization possibilities of various Zuchini species have been reported (Kostalova *et al.,* 2009). All summer squash are a rich source of nutrients, especially the natural antioxidants beta-carotene, folic acid, and vitamins C and E. They contain healthful minerals including potassium, iron, calcium, magnesium, phosphate, copper, and zinc. Research has shown that Zucchini seeds also contain traces of cancer-preventing substances, known as protease trypsin inhibitors, which inhibit activation of viruses and carcinogens in the digestive tract. One-half cup of boiled Zucchini has only 18 calories, 0.3 grams of fat, and 1.0 mg of sodium. Each half-cup serving provides 0.8 grams of protein, 3.9 grams of carbohydrate, and 1.3 grams of dietary fiber (Anne, 1998).

A diet rich in vegetables provides many biologically active compounds, which fulfill an important role in preserving health and in the prevention of various diseases (Wadas *et al.,* 2012). In recent times, natural antioxidants have raised considerable interest among nutritionists, food manufacturers and consumers because of their presumed safety and potential therapeutic value. Indeed, recent research trends indicate a shift towards identifying non-nutritional antioxidants in functional foods (Takeoka and Dao, 2003). More than 5000 phytochemicals have been identified in plant foods and many more remain to be discovered (Shahidi and Naczk, 1995). Phenolic compounds have been proposed to be the potent and important contributors in reducing oxidative stress due to their antioxidant activity. Therefore, food industry is concentrating on foods containing various bioactive compounds for health promotion and disease prevention (Dong *et al.,* 2007).

Growth rate and chemical composition studies of Zucchini should help growers to determine the frequency of harvest, and nutritionists to learn more about the relationship of maturity to quality and food value (Lorenz, 1951). Harvest time, storage, and variety selection can affect eating quality; therefore, it is necessary to understand basics of Zucchini development and maturation. Although studies have shown optimum storage conditions for mature Zucchini depending on cultivar (McCollum, 2004), few studies were found on baby summer squash. It has been reported that chemical composition of Zucchini considerably depends on the size of harvested fruits and much less on the cultivar (Kmiecik and Lisiewska, 1989; Orłowski and Jadczak, 2000). In addition, Lester (2006) has concluded that vegetables and fruits size has a major impact on the concentration of available phytonutrients, such as β-carotene, ascorbic acid and folic acid. Therefore, this study was aimed to determine the changes in nutrients composition of Zucchini vegetables with development in maturity stage to select proper harvest time to collect vegetables with high eating and nutritional quality.

MATERIALS AND METHODS

Zucchini squash vegetables

Three Zucchini *(Cucurbita pepo* L.) cultivars: Eskandrany, Amjad F1 and New Eskandrany F1 were grown under Assiut governorate conditions at the Experimental Farm of Faculty of Agriculture, Assiut University, Assiut, Egypt, during summer 2014. It is well known that the highest growth rate of Zucchini is occurred before 6 days after full bloom; therefore, the fruits of Zucchini cultivars were collected at different stages of maturity: 1, 2, 3, 4 and 5 days after full bloom. The collected vegetables were crushed and dried in an electrical oven at 50°C for 24 hours and grounded to obtain meal.

Proximate composition analysis

Proximate analysis was carried out using the standard procedures of the Association of Official Analytical Chemists (AOAC 2000). Moisture content was obtained by heating the fresh samples to a constant weight in a thermostatically controlled oven at 105°C. The ash content was determined by igniting a 2.00 g test sample in a muffle furnace at 550°C, the percentage of residue weight was expressed as ash content. Nitrogen was determined using the Kjeldhal method and crude protein was calculated by multiplying the percentage nitrogen by the conversion factor of 6.25. The dried sample was extracted with petroleum ether (boiling point 40-60 0C) using a soxhlet apparatus to obtain the crude lipid content. Crude fiber content was estimated by consecutive acid and alkali digestion of sample followed by washing, drying, ashing at 600°C and calculating the weight of ash free fiber. Total carbohydrate was calculated by difference according to Pellet and Sossy (1970). Triplicate determinations were carried out for each sample and the means were reported. The energy value was calculated from proximate constituent as described by Wilson *et al.*, (1974) and Seleet (1990) as follow:

Energy (Kcal/100g) = (protein content×4) + (fat content×9) + (carbohydrate content × 4).

Total phenolics content

The amount of total phenolics was determined using modified Folin-Ciocâlteu colorimetric method (Singleton *et al.,* 1999). Dried Zucchini vegetables extracts (25 µl each) were dissolved in methanol and further dilution were performed to obtain readings within the standard curve made with gallic acid. The extracts were oxidized by Folin-Ciocâlteu reagent (120 µl) and after 5 min, 340 µl of Na_2CO_3 was added for neutralization. The samples were kept for 90 min in the dark at room temperature followed by the reading of the absorbance at 750 nm. The results were expressed as milligram of gallic acid equivalents/100 g sample (mg GAE/ 100 g sample).

Total Flavonoids content

The aluminium chloride colorimetric assay was used for flavonoids determination, as described by Marinova *et al*., (2005). Extraction of flavonoids from the samples (n=3) was achieved by homogenizing 2 g of the sample in 50 mL distilled water in pestle and mortar. The mixture was transferred into a rotary shaker for 12 h to ensure full extraction. The mixture was then filtered and the filtrate (extract) made up to 50 mL. Precisely, 1 ml of extracts or standard solution of catechin (20, 40, 60, 80 and 100 mg/ L) was added to test tubes containing 4 ml of redistilled water. Then 0.3 ml of 5% NaNO2 was added. After 5 min, 0.3 ml 10% AlCl3 was added. Immediately, 2 ml 1M NaOH was added and the total volume was made up to 10 ml with redistilled water. The solution was mixed thoroughly and the absorbance of both the samples, blank and standard, were read at 510 nm using UV–Visible spectrophotometer Model UV 1601 version 2.40 (Shimadzu). Total flavonoids content was expressed as mg catechin equivalents.

Statistical Analysis:

The collected data were analyzed with analysis of variance (ANOVA) Procedures using the Duncan test. Differences between means were compared by LSD at 5% level of significant (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Changes in dry matter content

Dry matter contents of Zucchini vegetables of three studied cultivars at different stages of maturity are shown in Fig 1. The results showed that there is no significant difference (p<0.5) in the initial dry matter content among the cultivars. However, the dry matter content was gradually decreased with development in maturity time from day one to day 5 after full bloom. This result indicates that the moisture content of Zucchini vegetables was increased with the development of maturity. In addition, dry matter content decreased during maturity of Zucchini vegetables. After 5 days of full bloom, the dry matter content was decreased by 35.5% for ES, 31% for AMF_1, and 25.6% for $NESF_1$ fruits. Biesiada *et al.*, (2007) reported that in Zucchini the vegetables of smaller size contained higher amounts of dry matter. It is well known that carbohydrate, especially starch, is the major content of dry matter. Other minor constituents of the dry matter (dried flesh) are proteins, fats, cell wall constituents (crude fiber), and minerals (called ash).

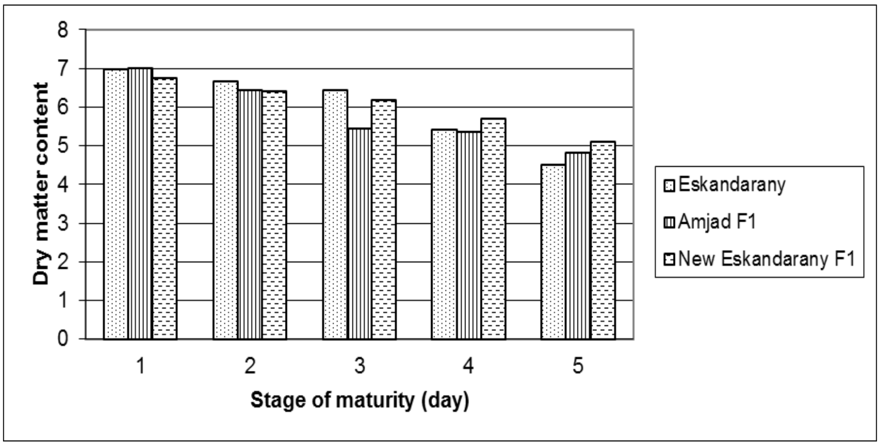

Fig 1: Changes in Dry matter content (%) of Zucchini vegetables with the development of maturity stage (day).

Changes in chemical composition

Fig 2 shows the protein content of Zucchini vegetables during different maturity stages. The highest initial content of protein was found for vegetables of AM F_1 cultivar (33.47% dry basis) followed by ES (32.62%) and $NESF_1$ (32.05%) cultivars. Statistical analysis showed no significant difference ($p<0.5$) in the initial protein contents among the studied cultivars. The protein content of all cultivar vegetables was gradually decreased with the advancement of maturity. The decrement rate in protein content was different among cultivars. The protein content was decreased by 5.95% for ES, 13.15% for AMF_1 and 4.77% for $NESF_1$ cultivars after 5 days of full bloom. This may be correlated with the decrease in dray matter content with the development of maturity.

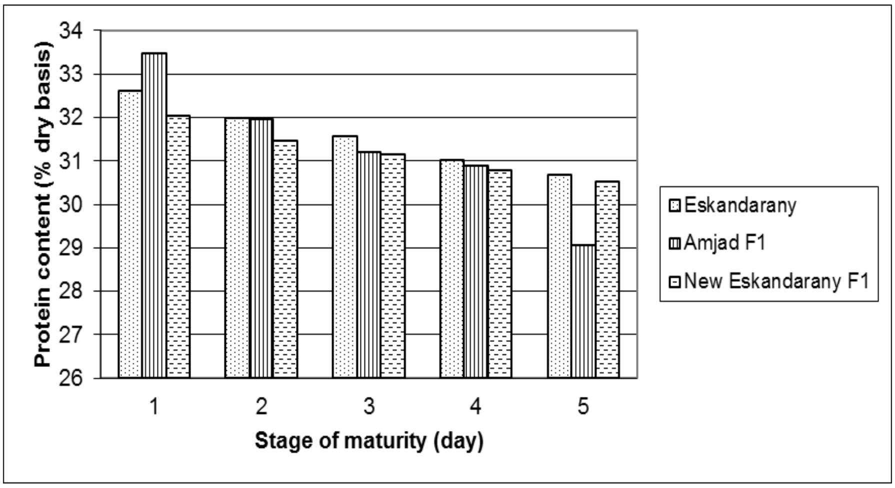

Fig 2: Changes in protein content of Zucchini vegetables with the development of maturity stage.

Highest initial content of total carbohydrate (Fig. 3) was also found for vegetables of AM F1 cultivar (43.07% dry basis); however, no significant difference ($p<0.5$) was found between initial content of ES and NES F_1 cultivars. In contrast with other contents of nutrient, the total carbohydrate content of all vegetables was significantly increased with the advancement of maturity. Total carbohydrate was increased by 21.14% for ES, 19.89% for AMF_1 and 14.18% for $NESF_1$ cultivar vegetables. Biesiada *et al*., (2007) found that total sugars content of Zucchini was increased insignificantly with advancement of maturity. The pasty texture of Zucchini is attributable to starch. Starch provides substrate for conversion to sugars during the latter stages of Zucchini maturation and during subsequent storage. Zucchini with low dry matter, generally less than 16%, lack sufficient starch levels to produce a combination of pasty texture and degree of sweetness for acceptable eating quality.

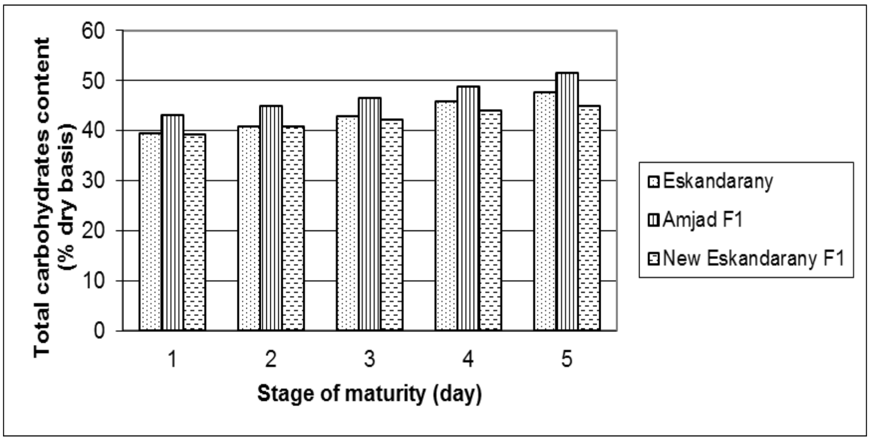

Fig 3: Changes in total carbohydrate content of Zucchini vegetables with the development of maturity stage.

The crude oil content of Zucchini vegetables at different stage of maturity is shown in Fig 4. The crude oil content was found to be 5.47% (dry basis) for both ES and AMF1 and 5.84% for NESF1 cultivar vegetables. The crude oil content of all cultivar vegetables was almost constant and no significant change (p<0.5) was observed with the development of maturity stage. Changes in ash content of Zucchini vegetables of ES, AMF_1, and $NESF_1$ cultivars with advancement of maturity are shown in Fig 5. The highest initial content of ash was found for $NESF_1$ (13.81% dry basis) followed by ES (13.54%) and the lowest content was found for AMF1 (10.44%) vegetables. For the changes with maturity, the results indicated that the content of ash was gradually decreased with the advancement of maturity stage for all cultivars. Biesiada *et al.,* (2007) found that phosphorus, potassium and calcium were decreased with development of Zucchini vegetables.

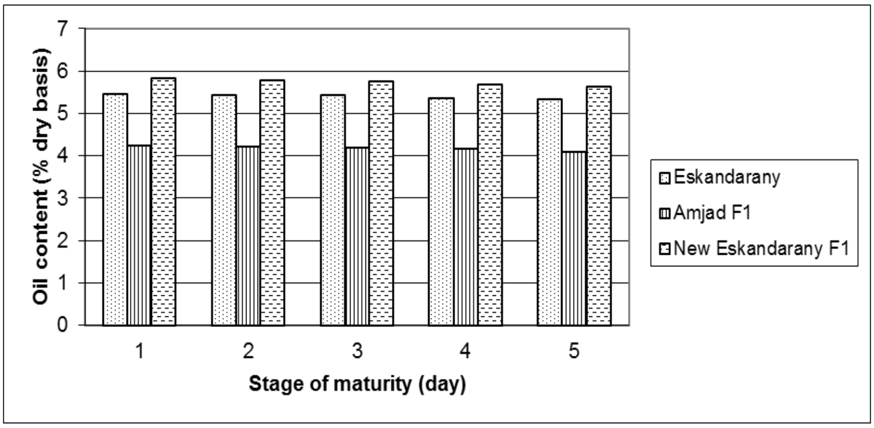

Fig 4: Changes in crude oil content of Zucchini vegetables with the development of maturity stage.

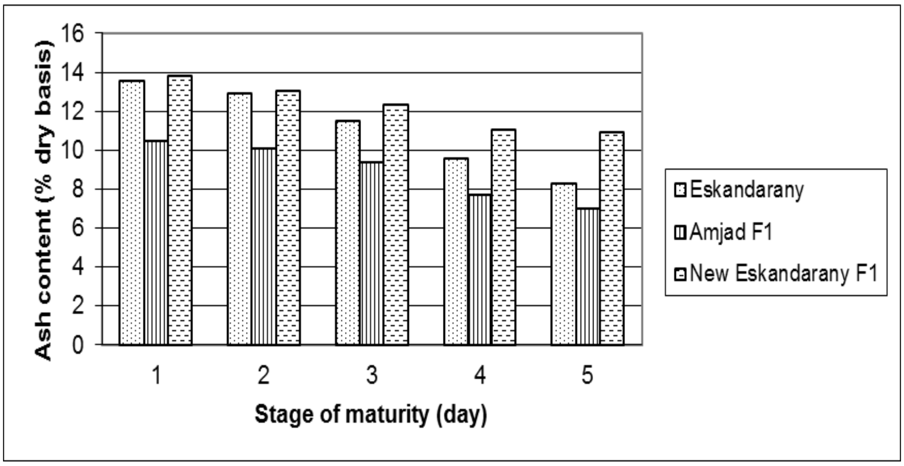

Fig 5: Changes in Ash content of Zucchini vegetables with the development of maturity stage.

Crude fiber contents of Zucchini vegetables of the three cultivars are shown in Fig 6. No significant difference ($p<0.5$) was found in initial content of crude fiber among the studied cultivars. However, the crude fiber content was slightly decreased with the advancement of maturity stage. The results also showed that the energy (kcal/100g) value of Zucchini vegetables was increased for all cultivars with the development of maturity (Fig 7). This may be attributed to the increase in total carbohydrate content, the major source of energy, with the development of fruit maturity.

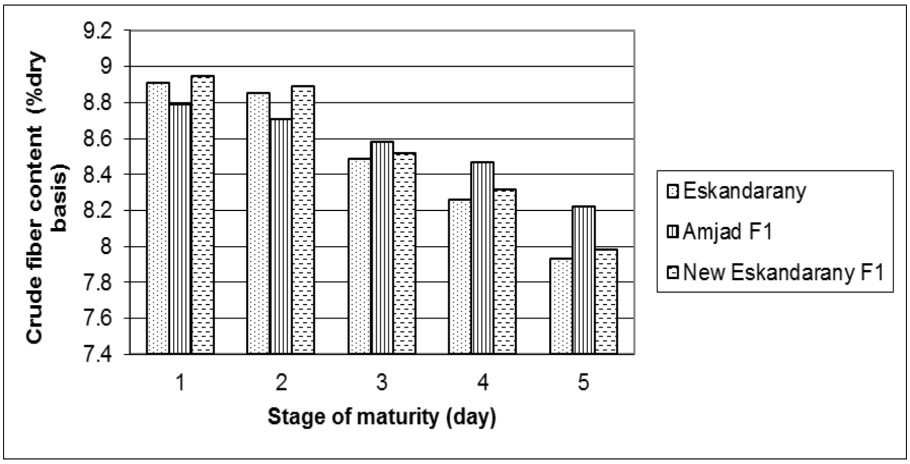

Fig 6: Changes in crude fiber content of Zucchini vegetables with the development of maturity stage.

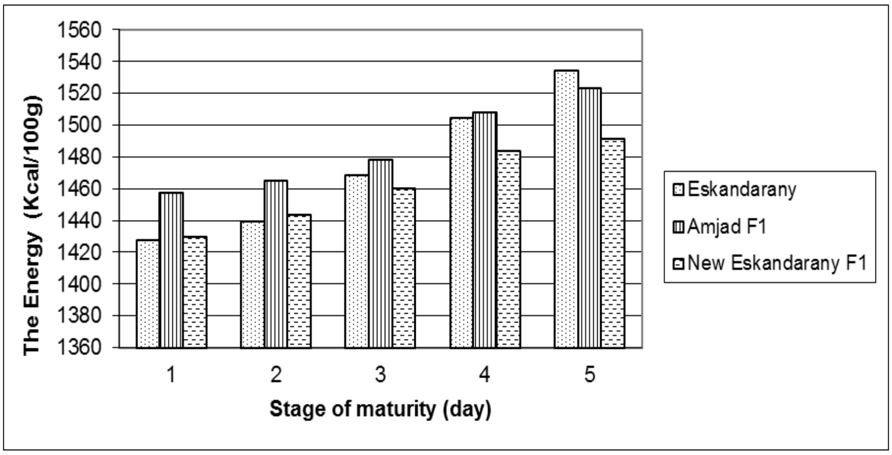

Fig 7: Changes in the energy value (kcal/100g) of Zucchini vegetables with the development of maturity stage.

Changes in total phenoics and flavonoids content

Highest total phenolic content was found for ES (597.22 mg GAE/100g) followed by NESF1 (589.29mg GAE/100g) vegetables and lowest content was found for AMF1 (545.64 mg GAE/100g) after full bloom (Fig 8). However, significant decrease (p<0.5) with different percentage was observed in these contents with the development of maturity from day 1 to day 5. Similar trend of results was found for the total flavonoids content of the studied cultivars (Fig 9). The daily intake of polyphenols has received much attention due to the health benefits from their antioxidant/anti-radical, anti-carcinogenic, anti-inflammatory, antiviral, and antimicrobial activities. This group of chemical compounds is widely distributed in vegetables and can be classified based on their chemical structure, ranging from simple molecules such as phenolic acids, to highly polymerized compounds such as tannins (Pietta *et al.,* 2003; Iswaldi *et al.*, 2013). 10 phenolic acids, 16 flavonoids, and 17 other polar compounds with their derivatives were identified in the whole Zucchini vegetables (Iswaldi *et al.*, 2013).

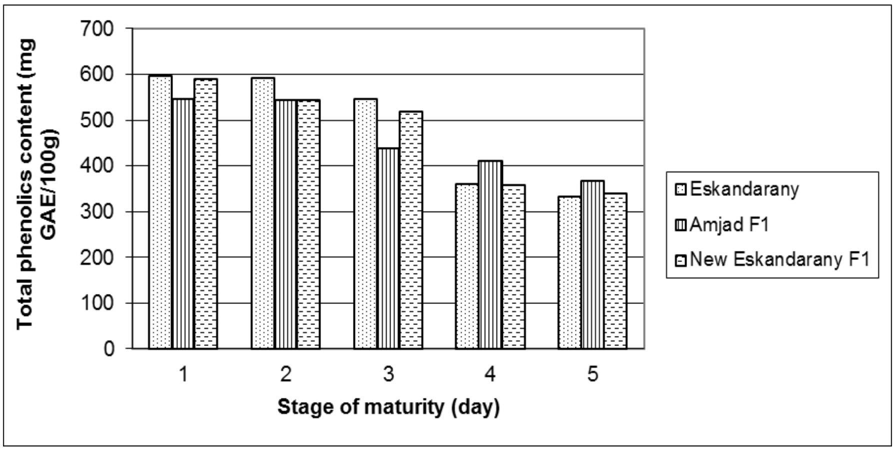

Fig 8: Changes in total phenolics content of Zucchini vegetables with the development of maturity stage.

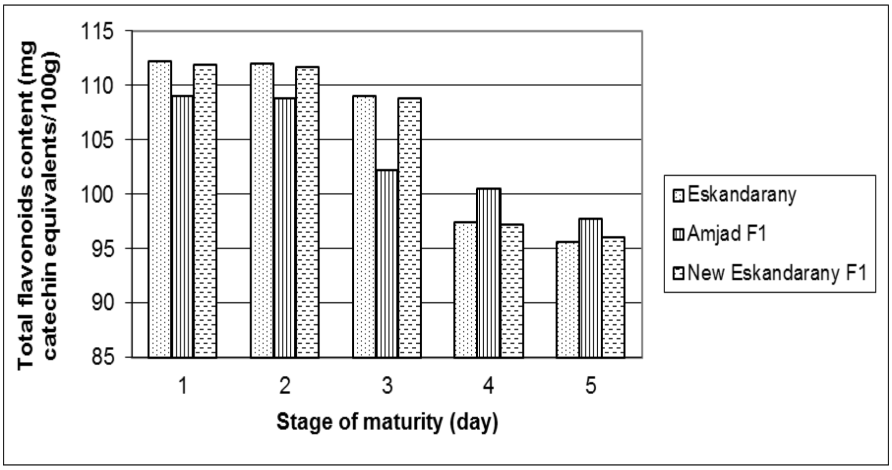

Fig 9: Changes in total flavonoids content of Zucchini vegetables with the development of maturity stage.

CONCLUSION

With the advancement of maturity stage of Zucchini vegetables from day 1 to day 5 after full bloom, dry matter, protein, oil, ash, and crude fiber contents were decreased. However, gradual increase in total carbohydrate content was observed with the development of maturity. In addition, total phenolics and flavonoids contents were decreased in the more developed fruits. Therefore, and based on the obtained results, earlier term of harvest appeared to be favorable for Zucchini vegetables with high nutritive value and eating quality.

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التغيرات التغذوية التى تحدث فى خضار الكوسة الصيفية خلال النضج

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التغيرات الحادثة فى التركيب التغذوى للخضر تشير إلى المساعدة فى معرفة أو تقدير الوقت الأمثل للحصاد مما يؤدى إلى جمع الخضر ذات المحتوى الغذائى العالى والجودة الغذائية عند تناولها. فى هذه الدراسة تم تقدير التركيب الكيميائى والمواد الفينولية والمواد الفلافونيدية لثلاثة اصناف من الكوسة الصيفية المزروعة فى مصر وهى الإسكندرانى وأمجد ف١ والإسكندرانى الجديد ف١. ولقد أوضحت النتائج أن كلا من:- كمية المادة الجافة والبروتين والزيت والرماد والالياف الخام فى خضار الكوسة الصيفية حدث لها تناقص بالتقدم فى مرحلة النمو. وكذلك لوحظ أن محتوى الكربوهيدرات حدثت به زيادة تدريجية مع التقدم فى مراحل النمو. بالإضافة إلى أن محتويات المواد الفينولية والمواد الفلافونيدية حدث بها تناقص فى الخضار المتقدمة فى النمو. وبناءا على هذه النتائج المتحصل عليها فإنه يمكن القول بأن:- بالرغم من انه توجد هناك زيادة فى إنتاجية الخضر فى مراحل النضج المتاخرة إلا أن الخضر فى المراحل المتقدمة فى النمو تتميز بمحتواها العالى من المغذيات والمركبات المفيدة للصحة مثل البروتين والرماد والالياف الخام والمواد الفينولية والمواد الفلافونيدية.

الكلمات المفتاحية: الكوسة الصيفية- النضج- الالياف الخام- الكربوهيدرات- المواد الفينولية- المواد الفلافونيدية.