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NUTRITIONAL ASSESSMENT OF CHROMOPLASTS (PLASTIDS) ISOLATED FROM TOMATOES.

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ABSTRACT

The present investigation was carried out in an attempt to evaluate the gross chemical composition, total lipid fractions as well as total fatty acids of the isolated tomato chromoplasts (plastids). The fruit of tomato plant *(Lycopersicon esculentum)* is largely composed of elongated tomato cells (pericarp) filled with organelles called chromoplasts (carotenoid-containing plastids). These plastids scattered throughout the cell, are rich in nutrients, particulary protein (32.45%) and lipids (16.80%). They can be released from the cells by rupture of their cell membranes. Plastids and their cell contents can be utilized by the food processing industry for the preparation of special food products. This study was designed to examine the macronutrient and the micronutrient content of isolated tomato plastids and, therefore, determine its potential nutritional value and health value of the human diet.

Besides, because of the high content of protein and low carbohydrates content of tomato plastids they could be used for some people requiring low-sugar products for medical reasons (diabetics, those having cardiovascular disease, and others for weight loss for health reason).

Moreover, their high crude fiber content prevents constipation and diverticulitis. Because of their high content of linoleic acid, an essential fatty acid that reduces serum cholesterol, tomato plastids may prevent the development of cardiovascular disease.

INTRODUCTION

Tomato is an important agriculture commodity worldwide. Because of their year-round availability tomato and tomato products merit attention, even terms of value of nutrients existing of low concentration (Abushita *et al.*, 1997). The tomato fruit is largely composed of elongated tomato cells filled with organelles called chromoplasts (Plastids). These plastids scattered throughout the cell are rich in nutrients, particularly protein and lipids. The fruit of the tomato plant (*Lycopersicon esculentum*) is largely composed of pericarp filled with chromoplasts (carotenoid-containing plastids). Lycopene, a micronutrient, is responsible for the deep red color of the chromoplast . It is believed to have anticancer and anticholesterol properties due to its antioxidant properties (Agarwal and Rao, 1998). Epidemological studies have also shown that the increased consumption of lycopene-rich foods, such as tomatoes and tomato products , is associated with a low risk of cancer (Giovannucci, 1999). In addition to lycopene, both lutein and B-carotene are also present in tomatoes in a much smaller amounts (Shi and Maguar, 2000). The plastids can be released from the tomato cells by rupture of their membranes and then isolated. The tomato plastids are the site of the biosynthesis of protein, lipids, carotenoids (Lycopene), starch and sugar (Agarwal and Rao, 1998; and Galili, 1995). Many people require low-sugar products for medical reasons (diabetics, cardiovascular disease and others for weight loss). Therefore, tomato chromoplasts having high protein and lipids content and low sugar content, might be useful in meeting these human needs (Ferro-Luzz and Bianca, 1995; Hansen and Chiu, 2005; Seira-Majem *et al*,1995 and Trichopoulou *et al*., 1995).

The present study was designed to evaluate the gross chemical composition, total lipid fractions as well as total fatty acids of the isolated tomato plastids.

MATERIALS AND METHODS

5 Kilograms of ripe tomato fruits (*Lycopersicon esculentium* variety GS12) were obtained from Assiut University farms during June 2006.

Preparation of tomato plastids:

Tomato plastids were prepared according to (Hansen and Chiu, 2005) method. The ripe of tomato fruits were cut in ca 1 × 3cm pieces. The cut pieces (100g) were put into a waring blender containing 100ml of 0.1M citrate buffer (pH 6.5 at 10°C). The blender was run at full speed for 5s to release the plastids from the preicarp cells. Blending time is critical for the isolation of the plastids. Whereas increase in blending time, determined experimentally, resulted in the tearing of the chromoplast membranes. Seeds, epidermis (Skins) membranes and cell wall materials (Pomace) were removed by filtration through cheesecloth and glass wool. The filtrate, containing the plastids, was then centerifuged for 30min in a sorvall centerifuge at 5000rpm and 10°C.

The deep red intact chromoplasts (~80mg/100g of tomato juice) were centerifuged and isolated from the amber supernatant liquid (129ml). They were pooled to eliminate individual tomato variations. The pooled plastids were dried in a vacuum oventill complatily dried and kept in sealed brown bottles at (-20°C) until used.

Chemical composition of tomato plastids:

Moisture, crude lipids, crude protein, crude fiber and ash contnt of isolated tomoto plastids were determined according to AOAC (1990) methods. Total carbohydrates was calculated by difference.

Lipid composition:

Tomato plastid lipids were extracted by chloroform: methanol (2: 1 v/v) as described by Folch *et al*. (1957). The total lipids were fractionated on silica gel G coated thin layer plates using a solvent system of petroleum ether: diethyl ether: glacial acetic acid (80: 20: 1, v/v/v) as described by Mangold and Malins (1960). Total lipid fractions were identified and determined according to the methods described by Blank et *al*., (1964).

The methyl ester of fatty acids of tomato plastids lipid were prepared according to Rossell *et al*., (1983) and separated using gas liquid chromatography apparatus (PY.B-Unicam Pro GC) with a flame ionization detector in presence of a nitrogen as a carrier gas. The separations were carried out at 190°C (1.5 × 4mm) column (SP 2310) paked with cyanopropyl phenyl silicone. The nitrogen, hydrogen and air flow rates were 30, 33 and

330ml/min; respectively. The chart speed was 0.4cm/min. Peaks identification was established by comparing the retention times with standard methyl esters.

RESULTS AND DISCUSSION

Gross chemical composition of tomato plastids:

The gross chemical composition of tomato plastids are presented in table (1) and Fig. (1). The mean values of the gross chemical composition of tomato plastids were 16.80%, 21.70%, 32.45%, 19.37% and 7.78% for lipid, crude fiber, protein, carbohydrate, and ash; respectively calculated on dry weight Basis. Such values are in relative agreement with Hansen and Chiu (2005) findings. The data confirmed that tomato plastids had a much higher protein concentration (32.45%) compared to wheat flour (11.7%) and rice (6.8%) as previously outlined by Hansen and Chiu (2005). Therefore tomatoes are often utilized in food dishes with pasta and rice for undernourished people, especially malnourished young children.

On the other hand, the total crude fiber of tomato plastids was (21.70%) much higher than that of rice flour (1.0%) and wheat flour (3.1%) as outlined by Hansen and Chiu (2005) findings. Therefore, the addition of tomato plastids to an extruded-product formula, made from white flour or rich flour dishes, would enrich them with crude fiber.

Moreover, the high concentration value of crude fiber for tomato plastids compared to other vegetables indicate that it probably could reduce serum and liver low density lipoprotein (LDL) cholesterol levels and thus be beneficial in the prevention of aterioschlerosis (Garca-Diez *et al.*, 1996).

On the other hand, the mean values of crude lipid, carbohydrates and ash of tomato plastids were 16.80%, 19.37% and 7.78%, respectively on dry weight basis. Such values are in rather good agreement with Hansen and Chiu (2005) finding on tomato plastids.

Table (1): Mean values of gross chemical composition of tomato plastids.

(On dry weight basis)

Estimates	Sample (1)	Sample (2)	Sample (3)	Mean*
Moisture	12.88	13.40	13.14	13.14
Crude lipid**	18.75	16.60	15.05	16.80
Crude fiber**	19.64	23.76	21.70	21.70
Protein**	30.50	33.55	33.30	32.45
Carbohydrates**	21.72	16.83	19.57	19.37
Ash**	7.39	8.16	7.78	7.78

* Mean of three replicates.

** D.W. Basis.

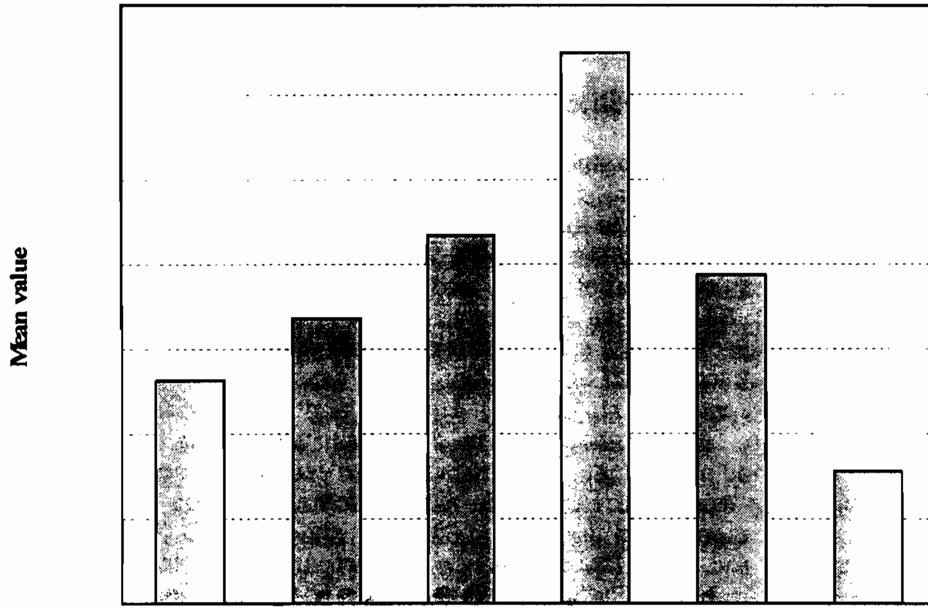

Figure (1): Mean values of gross chemical composition of tomato plastids

Total lipid fractions of tomato plastids:

The fractionation of total lipids of tomato plastids are presented in Table (2). The data revealed the presence of eight fractions namely: polar lipids, monoglycerides, 1, 2-diglycerides, sterols, 1, 3-diglycerides, free fatly acids, triglycerides and Hydrocarbon & sterol ester. The major component of the total lipids was triglycerides amounting to (64.11%) followed by polar lipids (22.20%), Hydrocarbon & sterol ester (4.15%), 1, 3-diglycerides (3.56%), 1, 2-diglycerides (3.25%), sterols (2.15%) and finally monoglycerides (1.56%).

Table (2): Total lipid fractions of tomato plastids:

Fractions	% of total lipids
Polar lipids	22.20
Monoglycerides	1.56
1,2 –diglycerides	3.25
Sterols	2.15
1,3-diglycerides	3.56
Free fatty acids	1.25
Triglycerides	64.11
Hydrocarbon & sterol	4.15

Carlson *et al.*, (1981) separated the total lipids of tomato seed oil to neutral lipid compounds and polar lipid compounds and the neutral lipid compounds consisted of 78.5% triglycerides, 0.5% sterol, 5.0% 1,2-diglycerides, 2.4% 1,3-diglycerides, 2.5% unidentified compound, 4.7% free fatty acids, 5.9% monoglycerides, trace methyl ester and 0.5% sterol ester.

Fatty acid composition of tomato plastids:

Table (3) shows the fatty acid composition of tomato plastid lipid. The total unsaturated acids were (60.75%) of the total fatty acids. The major fatty acids of the tomato plastid lipid was linoleic acid (essential fatty acid) in concentration of (52.49%), followed by palmitic acid (26.25%). Total saturated fatty acids were (39.25%) of the total of fatty acids.

Table (3): Fatty acid composition of tomato plastids lipid .

Fatty acids	Carbon chain	% of total fatty acid
Myristic	C14: 0	1.50
Palmitic	C16:0	26.25
Palmitoleic	C16: 1	0.80
Stearic	C18: 0	5.85
Oleic	C18: 1	2.62
Linoleic	C18: 2	52.49
Linolenic	C18: 3	4.84
Arachidic	C20: 0	5.65
Total saturated		39.25
Total unsaturated		60.75

The dominant saturated fatty acid was palmitic acid (26.25%). Hansen and Chui (2005) reported that the tomato plastids are on excellent source of the essential fatty acid linoleic acid, a polyunsaturated fatty acid (C18: 2) that is a cholesterol-lowering fatty acid. Linoleic acid aids in the prevention of platelet aggregation leading to blood clotting in blood vessels and is described by Renaud (1990). Palmitic acid, the salurated fatty acid was found in large quantities in tomato plastids. Palmitic acid and oleic acid have a neutral affect on serum cholesterol when the dietary intake of cholesterol is low as shown in Cebus monkeys (Khosla and Hayes, 1993).

It is worth noting that an intake of 30% total fat or less of total energy had been recommended by many nutritionists worldwide, with only 10% coming from saturated fatty acids and the rest coming from monounsaturated (10%) and polyunsaturated fatty acids (10%) to decrease cardiovascular disease prevalent in Egypt. Fortunately the fatty acid profile of tomato plastids comply with such requirements as an excellent source of essential fatty acid linoleic acid, a polyunsatured acid (C18: 2) that is a cholesterol-lowering fatty acid.

Conclusions

On the basis of the present investigation tomato plastids have the potential to increase the nutritional and health value of the human diet because of their high protein content, and low carbohydrates. Besides, because of their high content of linoleic acid, an essential fatty acid that reduces serum cholesterol, they may prevent the development of cardiovascular disease. Moreover, their high crude fiber content prevents constipation and diverticulitis. Tomato plastids could be used for some people requiring low-sugar products for medical reasons (diabetics, those having cardiovascular disease, and others for weight loss for health reason).

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التقييم الغذائى للبلاستيدات المستخرجة من الطماطم

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أجرى هذا البحث بهدف التقييم الغذائى للبلاستيدات المستخرجة من ثمار الطماطم حيث تم التقدير الكيميائي الإجمالى، وتجزؤات الليبيدات الكلية، وتركيب الاحماض الدهنيه بها.

وتتكون ثمار نبات الطماطم من خلايا البيريكارب المملوءة بالكروموبلاست (أى البلاستيدات الغنية بالكاروتينيدات).

وهذه البلاستيدات التى توجد فى الخلايا يمكن فصلها من الخلايا عن طريق تكسير جدرها الخلويه ثم عزلها وتعتبر بلاستيدات الطماطم غنية فى مكوناتها الغذائية حيث تحتوى كما أظهرت نتائج البحث على ٣٢,٤٥% بروتين، ١٦,٨٠% ليبيدات .وبالتالى يمكن استخدامها فى اغراض التصنيع الغذائى لانتاج منتجات غذائيه لها دورها الصحى والغذائى الهام

ونظراً لارتفاع محتوى بلاستيدات الطماطم من البروتين وانخفاض محتواها من الكربوهيدرات فإنه يمكن استخدامها للأفراد الذين يحتاجون لتركيزات منخفضة من السكر فى وجباتهم لأسباب طبية (مثل مرضى السكر، مرضى القلب، الذين يحتاجون لخفض أوزانهم لأسباب صحية).

وبالإضافة إلى ما تقدم فإنه تتميز بلاستيدات الطماطم بارتفاع محتوياتها من الألياف الخام يساعد على منع الإصابة بحالات الإمساك، والتهاب القولون.

كما أن تميزها بارتفاع محتواها من الحامض الدهنى الضرورى اللينوليك الذى يخفض من تركيز الكولسيترول فى سيرم الدم مما قد يتسبب فى منع الإصابة بمرض القلب.