Archives of Agriculture Sciences Journal
Print ISSN: 2535-1680
Online ISSN: 2535-1699

ARCHIVES OF AGRICULTURE SCIENCES JOURNAL

Volume 3, Issue 3, 2020, Pages 45–63

Available online at www.agricuta.edu.eg

DOI: https://dx.doi.org/10.21608/aasj.2020.117469

Biochemical evaluation of newly composed tercumin capsules

Mahmoud M. A.[a*], Abd El-Naem G. F.[b], Khalifa Y. A. M.[a]

[a]*Agronomy Department, Faculty of Agriculture, Al-Azhar University, 71524 Assiut, Egypt*
[b]*Biochemistry Department, Faculty of Agriculture, Minia University, Minia, Egypt*

Abstract

In the present study, bitter dry beans of lupine seeds (*Lupinus termis* L.) cultivar Giza-1, and powder of turmeric rhizomes, (*Curcuma longa* L.,), and grains of yellow corn (*Zea mays* L.) cultivar Giza-368 were used to prepare three tercumin capsules. Chemical composition and elementary analysis of all capsules and their sources were done. The tercumin capsules composed from three portions, the first one, is fine powdered lupine seeds (FPLS), the second portion is turmeric powdered (TP) and the third one is the grain husks of yellow corn (GHYC). Generally, these data ` that the three chosen crops studied here are good, complementary and inexpensive sources for composed capsules. While the crude protein (6.69 -34.15 %) and lipids (3.82-11.07%) and TSS (21.16-25.32%). From obtained, results turmeric rhizomes contain the highest content of lutein, zeaxanthin, β-cryptoxanthin and β-carotene followed by bitter lupines Giza-1, and husks of yellow corn grain. Lupine seeds, turmeric rhizomes and yellow corn grains contain large quantities of carotenoid pigments, which can be used as dietary supplements or as safe food additives. Results of carotenoid levels in three tercumin capsules show that lutein, zeaxanthin, β-cryptoxanthin and β-carotene content in tercumin capsule-2 are higher than those determined in tercumin capsule-3 and tercumin capsule-1. TPCs in both tercumin capsules and their sources tercumin capsules ranged from 2.18 to 29.48 mg/100g. TPCs in the yellow corn grains are higher than those found in the bitter lupine seeds Giza-1 (2.185 mg/100g) and turmeric rhizomes. TPCs concentrations in the tercumin capsules-3 are higher than those found in the tercumin capsules-1 and tercumin capsules-2. The levels of TPCs in the tercumin capsules-1, capsules-2 and capsules-3 are 20.1, 25.63 and 29.480 mg/100g respectively. Total flavonoid contents in tercumin capsules and their sources were assayed and the results indicate that turmeric powdered contained the highest level 4.97 mg/100 g CE followed by grain husks of yellow corn (GHYC) and the lowest level (1.396) was found in the powder of lupine seed Giza-1.The results also showed that tercumin capsule-3 contain the highest concentration (5.142) of TFs followed by tercumin capsule-1and tercumin capsule-2 contain the lowest concentration. These results showed that total alkaloids in turmeric rhizomes (1.82%) are higher than those determined in yellow corn grains (1.203%). The levels of TAs in turmeric rhizomes are always higher than those determined in yellow corn grains.

Keywords: *Zea mays*, lupine, lutein, tercumin, turmeric, zeaxanthin.

*Corresponding author: Mahmoud M. A.,
E-mail address: mohamedahmed.49@azhar.edu.eg

1. Introduction

The price of medication is becoming terrible extensive and it will be unavailable during the coming decades and for these reasons, we have to find alternative solutions. The authors introduce an acceptable alternative is called tercumin capsules targeting diabetic patients. The tercumin capsules composed from three portions, the first one, is fine powdered lupine seeds (FPLS), the second portion is turmeric powdered (TP) and the third one is the grain husks of yellow corn (GHYC). *Lupines termis*, a member of the Leguminosae family was claimed as anti-diabetic plant (Newairy *et al.*, 2002). The anti-diabetic effect of plant extracts could be linked to stimulation β cells-based insulin secretion or insulin action (Salimifar *et al.*, 2013). Lupine is a leguminous seed used to prepare food supplements or foods (Lucas *et al.*, 2015). Turmeric (*Curcumin longa*) belongs to the genus *Curcuma*, a member of ginger family, *Zingberaceae* (Wickenberg *et al.*, 2010; Yue *et al.*, 2010). Curcumin ameliorated Insulin resistance, the metabolic derangements recorded in obesity and diabetes, and decreased lipid peroxidation in the diabetic status (Al-Saud, 2020).The primary colouring pigment of turmeric i.e., curcumin is used as a food color in spices, mustard, cheese, potato flakes, cereals, pickles, soups, yogurt, ice creams, etc., in Asiatic and Western cuisines. Studies have indicated that turmeric is non-toxic to humans even upon taking 8000 mg/day taken continuously (Cheng *et al.*, 2001). Curcumin powder, an extract of turmeric rhizomes, was the most active component of spice turmeric (an essential component of curry powder), which makes 2-5% of turmeric spice (Shishir *et al.*, 2005). A mixture of turmeric powder and lime has been used as a household remedy to treat inflammation and assist in wound healing (Akbik *et al.*, 2014). Turmeric is a rhizomatous medicinal perennial plant (*Curcuma longa*) and has a rich history of being used in Asian countries, such as China and South East Asia (Kocaadam and Sanlier, 2017). Previous studies have shown that the maize kernel contains anthocyanins, phenolic acids (e.g. *p*-coumaric acid, vanillic acid and procatechuic acid) and flavonoids (e.g. quercetin and hesperidin) (Thiraphatthanavong *et al.*, 2014). It has been reported in the literature that phenolics of the maize kernel have OH radical scavenging and ∝-glucosidase inhibition activities (Nile and Park, 2014). Corn kernels (yellow) were previously reported to contain high levels of lutein and zeaxanthin (Hao *et al*., 2005; Humphries and Khachik, 2003; Moros *et al*., 2002). Lutein and zeaxanthin have been shown to prevent age related macular degeneration (Mozaffarieh, *et al*., 2003). The macular pigment carotenoids (MP), lutein, zeaxanthin, and *meso*-zeaxanthin are widely recommended as dietary supplements for the prevention of visual loss from age-related macular degeneration (AMD) and other ocular diseases, but the basic and clinical science supporting such recommendations is underappreciated by clinicians and vision scientists. The main objectives of the present investigation were: (1) To prepare different Tercumin capsules as alternatives, (2) to evaluate the phytochemical constituents, (3) to evaluate the levels of carotenoids in the composed capsules and their sources, (4) to maximize the usefulness of field crops.

2. Materials and methods

2.1 Samples

In the present work, bitter dry beans of lupine seeds (*Lupinus termis* L.) cultivar Giza-1 were provided from Agricultural Research Centre, Giza, Egypt. Powder of turmeric rhizomes, (*Curcuma longa* L.,), was purchased from the local market. Grains of the yellow corn (*Zea mays* L.,) cultivar Giza-368 was provided from Sids station, Agricultural Research Centre, Giza, Egypt.

2.2 Preparation of tercumin capsules

The tercumin capsules composed from three portions, the first one, is fine powdered lupine seeds (FPLS), the second portion is turmeric powdered (TP) and the third one is the grain husks of yellow corn (GHYC). In the present work, three capsules were prepared as follows: First capsule was prepared by mixing, 50% of FPLS + 25% TP + 25% GHYC), all portions were mixed, sieved and analyzed. Second capsule was prepared by mixing, 25% of FPLS + 50% TP + 25% GHYC), all portions were mixed sieved and analyzed. Third capsule was prepared by mixing, (33.33% FPLS + 33.33% TP + 33.33% GHYC) all portions were mixed sieved and analyzed.

2.3 Approximate analysis

Chemical composition of FPLS, TP, GHYC and the three capsules were carried out according to official methods of the Association of Official Analytical Chemists (AOAC, 2000). All determinations were performed in triplicates and means will be reported. Determination of dry matter (DM) and total ash content (TAC %) were determined according to the official method (AOAC, 2000).

2.4 Elementary analysis of samples

All elements except (Na, K, and P) were determined according to the official method (AOAC, 2000), using the ICPES (Inductively Coupled Plasma Emission Spectrometer) (type ICAP 6200), Na and K were determined by flame photometer and Phosphorus was determined using the Spectrophotometer using ***flame*** photomrssi. All determinations were done in Faculty of Agriculture, Assuit University, Assuit, Egypt. Crude lipids were determined according to the (AOAC, 1984). The Kjeldahl procedure was used to determine the total nitrogen content according to the (AOAC, 1984). The crude protein was then calculated by multiplying nitrogen content by 6.25 and 5.75 as a factor for lupine seeds and corn grains respectively.

2.5 Extraction and determination of total soluble sugars

Extraction and determination of total soluble sugars (TSS) content was determined using the phenol-sulphuric acid method according to Dubois *et al*. (1956).

2.6 Determination of total reducing sugars

Determination of total reducing sugars (TRS) was extracted and determined according to the method described by Miller (1959). The difference between the percentage of total soluble sugars and total reducing sugars was taken as the percentage of non-reducing sugars.

2.7 Determination of vitamin C (L – ascorbic acid)

The indophenol method (2,6-dichlorophenol indophenol) as modified by Mondy and Ponnampalam (1986), was used for determination of L-ascorbic acid concentration**.**

2.8 Determination of total carotenoids content

Carotenoids content in samples were extracted by first placing one g flour in a glass, adding 50 ml acetone and agitating for 12 h to extract the pigments. Total Carotenoid contents were determined according to Saric *et al*. (1967).

2.9 Extraction and determination of total phenolic compounds (TPCs)

The concentrations of extraction and determination of total phenolic compounds (TPCs) in the methanolic extracts were determined by the method described by Singleton and Rossi (1965) with some modifications. One milliliter of sample was mixed with 1 ml of Folin and Ciocateu's phenol reagent. The total flavonoid content was determined as catechin equivalent (CE) (6.25–200μg/mL) and was expressed as g of CE/100 g according to the method described by Zhishen *et al.* (1999).

2.10 Determination of total alkaloids

Determination of alkaloid content was done by the alkaline precipitation gravimetric method described by Harborne (1973). Alkaloid content was calculated and expressed as a percentage of the weight of sample analyzed. The absorbance was at 565 nm against a blank.

2.11 Statistical analysis

The obtained data was present as the mean ± SD for each correlation was calculated using Microsoft Excel according to Gomez and Gomez (1984).

3. Results and Discussion

3.1 Biochemical evaluation of capsule sources

3.1.1 Dry rhizomes and seeds

The chemical composition of dry seeds, grains and rhizomes is undertaken including ten chemical constituents and the results are given in Table (1). The dry matter (DM) present in rhizomes and seeds was assayed in order to evaluate storageability of product and the quality of the grains in comparison to standard values found in the literature. The dry matter values obtained in the present study ranged from 88.27 to 93.11% with 90.7% as average. Moisture percentage in the corn grain directly influences the germination and deterioration processes, therefore, keeping the water content at low levels, both difficult the embryo germination as well as blunts seed attack by fungi and other microorganisms (Silva *et al.*, 2000). These data show that bitter lupine seeds contain the higher crude protein level (34.15%) in lupine cultivar Giza-1 and lower levels were reported in the yellow corn grains (9.70 %), and powder turmeric rhizomes (6.69%). Paes (2008) reported that the amount of crude protein in dry corn grains is around 8 to 10%. Bjarnason and Vasal (1992) indicated that the protein amount present in corn may vary according to seed type, being inconstant due to alterations caused by the presence of mutant genes in seed endosperm. The Crude lipid in lupine seeds reached to be 11.07% (Giza-1), the yellow corn seed (3.99 %), and powder turmeric rhizomes (3.82%). Crude lipids in the lupine seed ranged from (3.82 to 11.07 %). The lowest level was reported for powder turmeric rhizomes and the highest one was found in the seed of Giza-1 bitter lupine. The obtained results indicated that the lupine seeds contained higher protein levels, such results are close to those reported for soybean seeds by Abdel-Raheem *et al.* (2016). The seeds of lupine cultivars have been used with increasing frequency as a source of proteins replacing proteins of animal origin or soybean in feed compounds. It contains 33-40% crude protein, 5-13% oil and relatively beneficial amino acids profile (Pisarikova and Zraly, 2009). Data found in this study confirmed these values. The determination of ether extract in corn is necessary to drive its utilization in oil production or as animal feed, since corn oil is more caloric than starch as described by Mittelmann *et al.* (2006). There are also claims that the seeds are rich in dietary fiber and beneficial phytochemical components (William, 2000). Results showed that ash average in all analyzed samples varied from 1.4 to 3.51% (Table 1). Ascheri and Germani (2004) mentioned that the ash in corn may vary from 1 to 2%, which was corroborated in the present study. The compound of curcumin contains carbohydrate (69.4%), protein (6.3%), fat (5.1%), mineral (3.5%), and moisture (13.1%) (Prasad *et al.*, 2014). Evidences accumulating suggest that curcumin may regulate lipid metabolism, which plays a central role in the development of obesity and its complications (Olojede *et al.*, 2009). Data showed that the powder turmeric rhizomes contain higher TSS level (25.32%) than those reported for bitter lupine Giza-1, (23.19 %) and the yellow corn seed (9.70 %). Results also showed that concentrations of TSS ranged from 21.16 to 23.19 % and the highest level is determined for bitter lupines (Giza-1) and the lowest one for yellow corn seeds. Levels of L-ascorbic acid (vitamin C) are higher in bitter lupines Giza-1 (10.3 mg /100g) followed by powder turmeric rhizomes (1.7 mg /100g) and yellow corn seeds (0.12 mg /100g). Bitter lupines could be a good source of vitamin C as shown in the analysis. L-Ascorbic acid is ideal antioxidant, which plays a vital role in protecting the body from infection and diseases. The human body is not known to synthesize vitamin C. It is obtained from dietary sources or food supplements, particularly fruits and vegetables (Vasudevan *et.al* 2011). Corn is an important source of carbohydrates, proteins and vitamins precursors, as well as corn has also been reported as some grain rich in phytochemical compounds such as carotenoids, anthocyanins and other flavonoids. Altogether, these phytochemical substances are named as phenolic compounds which are obtained from vegetal and microbial sources and are been related to high antioxidant activity (Lopez-Martinez *et al.*, 2009; Zilic *et al.*, 2012). Generally, these data indicated that the three chosen crops studied here are good, complementary and inexpensive sources for composed capsules. While the crude protein (6.69-34.15 %), crude lipids (3.82-11.07%) and TSS (21.16-25.32%).

Table (1): Analytical data for approximate composition of the some rhizomes and seeds.

Constituents	Lupine seeds Giza-1	Turmeric rhizomes	Yellow corn grains (Giza-368)
Dry matter	93.11±1.69	88.27±1.17	90.71±1.27
Total ash content	3.47±0.35	3.51±0.35	1.40±0.14
Crude Fiber	9.37±0.94	5.89±0.59	3.75±0.38
Crude lipids	11.07±1.11	3.82±0.38	3.99±0.40
Total Nitrogen	5.47±0.55	1.07±0.11	1.55±0.16
Crude Protein	34.15±3.42	6.69±0.67	9.70±0.97
Total soluble sugars	23.19±2.32	25.32±2.53	21.16±2.12
Total reducing sugars	13.03±1.30	11.54±1.15	14.70±1.47
Total non-reducing sugars *	10.16±1.02	13.78±1.38	6.46±0.65
Vitamin (mg /100g)	10±1.0	1.7±0.17	0.12±0.01

*Total non-reducing sugars TNRS was calculated by differences between TSS- TRS, Value± SD.

3.1.2 Elementary analysis in capsules and their sources

The results in Table (2) show that the levels of some elements are higher in seeds of *L. termis L* than those found in turmeric rhizomes and yellow corn husks. Sodium contents in powder turmeric rhizomes (2.13%) are higher than those reported in yellow corn husks (1.04%), and seeds of lupine bitter Giza-1 (0.25%). Results also show that Zn ion concentration reached to be 12.5 and 9.7 mg, in the powder of lupine seed and capsule-1 respectively. Potassium (K^+) contents in dry lupine seeds, powder turmeric rhizomes and yellow corn grains ranged from 0.63 to 1.25 % and the highest content was determined in the powder turmeric rhizomes followed by seeds of bitter lupine Giza-1 (0.75 %) as well as the lowest one is found in yellow corn seeds contains (0.63%). Phosphorus percent (P %) in powder curcumin rhizomes (1.52%) are higher than those reported in all samples and the lowest one is found in yellow corn seeds (0.29 %). These results are in good agreement with those reported by Cortes-Gomez *et al.* (2005).

Table (2): Elementary analysis of Tercumin capsules and their sources.

Element	Capsule sources			Tercumin capsule		
	Bitter Lupine Giza-1	Tumeric rezones	Yellow corn husks var. Giza-368	Capsule-1 (½ FPLS + ¼ TP + ¼ GHYC)	Capsule-2 (¼ FPLS + ½ TP + ¼ GHYC)	Capsule-3 (⅓ FPLS + ⅓ TP + ⅓ GHYC)
Cu (mg)	11.2	0.47	10.1	6.63	10	12
Fe (mg)	6.2	2.9	3.2	4.9	8.0	6.7
Li (mg)	1.1	0.9	0.7	1.1	1.4	1.5
Zn (mg)	12.5	9.32	7.35	9.7	8.5	8.7
Mn (mg)	9.5	9.8	6.3	6.7	8.6	6.0
Mg (%)	0.72	1.72	1.64	0.63	0.95	0.91
K^+ (%)	0.75	1.25	0.63	0.89	1.25	0.85
Na (%)	0.25	2.13	1.04	1.07	2.30	1.24
Ca (%)	0.78	1.79	0.33	0.97	1.08	0.71
P (%)	0.75	1.52	0.29	0.89	0.94	0.69
Ca/P ratio	1.040	1.778	1.138	1.090	1.15	1.03

Phosphorus is always found with calcium in the body, both contributing to the blood formation and supportive structure of the body. This led to the concept of calcium/phosphorus ratio (Ca/P). If the Ca/P ratio is low, calcium will be low and there will be high phosphorus intake which leads to calcium loss in the urine more than normal. If the Ca/P of any food is above one that food is considered "good" and "poor" if the ratio is less than 0.5. A Ca/P ratio above two helps to increase the absorption of calcium in the small intestine Mahmoud *et al.*, (2016). Calcium (0.33-1.79%) makes lupine seeds, turmeric rhizomes and yellow corn seeds suitable for bone formation for children. Potassium is the most abundant mineral in agricultural products (Audu and Aremu, 2011). The results of Ca/P ratio in the studied samples Giza-1, curcumin rhizomes and yellow corn seeds were 1.040, 1.778 and 1.138, respectively. Our results show that lupine seeds, turmeric rhizomes and yellow corn seeds are good sources of many elements when compared with other legumes such as soybean (Abdel-Raheem *et al.*, 2016). Results of elementary analysis of three tercumin capsules are given in Table (2). Results show that the tercumin capsule-2 is higher in the following elements Cu, Fe, Mn, Mg, K, Na, Ca and P% than those reported the capsule-1 and capsule-3. These results show that Potassium (K^+) contents in tercumin capsule-2 (1.05%) are higher than those determined in tercumin capsule-1 (0.89%), tercumin capsule-3 (0.85%).These results showed that phosphorus percent (P%) in tercumin capsule-2 (0.94%) are higher than those found in both tercumin capsule-1(0.89%) and much higher than those found in tercumin capsule-3 (0.62%). Results showed that Ca/P ratio in tercumin capsule-2 (1.15%) are higher than those determined in tercumin capsule-1 and tercumin capsule-3. The Ca/P ratio in tercumin capsules and the results are given in Table (2). The Ca/P ratio concentrations ranged from 1.03 % to 1.15% and the highest concentration was determined in tercumin capsule-2 and the lowest one in tercumin capsule-3.

3.2 Biochemical evaluation of tercumin capsules

The biochemical evaluation of three tercumin capsules was determined and the results are given in Table (3). These results revealed that tercumin capsule-1 is higher in crude fiber (7.85%), crude lipid (8.09%), total nitrogen (3.09%), crude protein (19.31%), and vitamin C (8.02 mg /100g) than those reported for tercumin capsule-2 and capsule-3.

Table (3): Analytical data for proximate composition of tercumin capsules.

Constituents	Capsule-1 (½ FPLS + ¼ TP + ¼ GHYC)	Capsule-2 (¼ FPLS + ½ TP + ¼ GHY)	Capsule-3 (⅓ FPLS + ⅓ TP + ⅓ GHYC)
Dry matter	91.57±0.84	90.43±0.96	87.27±1.27
Total ash content	2.92±0.30	3.04±0.30	3.51±0.35
Crude fiber	7.85±0.79	6.42±0.64	3.89±0.39
Crude lipid	8.09±0.81	6.53±0.65	5.92±0.59
Total nitrogen	3.09±0.31	2.58±0.26	2.34±0.23
Crude protein	19.31±1.93	16.13±1.61	14.63±1.46
Total soluble sugars	12.26±1.24	12.24±1.24	7.26±0.73
Total reducing sugars	5.65±1.23	11.76±1.18	3.82±0.38
Total non-reducing sugars	6.61±1.23	13.06±1.31	3.44±0.34
Vitamin C mg /100g	8.02±0.8	4.83±0.48	6.09±0.61

*Total non-reducing sugars TNRS was calculated by differences between TSS- TRS, Value± SD.

The results given in Table (3) indicated that the highest level of total soluble sugars (TSS) was found in tercumin capsule-2 (24.82%) and the lowest (22.37%) was determined in tercumin capsule-3. Results also, showed that the tercumin capsules could be ordered according to total ash content (TAC) levels as follows: tercumin capsule-3 (3.51%) > tercumin capsule-2 (3.04%) > tercumin capsule -1 (2.92%). Data showed that whole tercumin capsules are a rich source of macronutrients (i.e., Total soluble sugars, protein, crude lipid, and crude fiber), micronutrients (i.e., total ash and vitamin C). Deficiency of vitamin C results in pain in the joints, fatigue, muscle weakness, bleeding of gum, leg rashes, anaemia, haemorrhage, muscle ache, defective skeletal calcification which results in scurvy when prolonged. Turmeric could be a good source of vitamin C as shown in the analysis. It is obtained from dietary sources or food supplements, particularly fruits and vegetables (Vasudevan *et. al.*, 2011).

3.3 Biochemical evaluation for the carotenoids content in some rhizomes and seeds

Contents of lutein, zeaxanthin, β-cryptoxanthin and β-carotene were determined in lupine seeds, curcumin rhizomes and yellow corn seeds samples and the results are shown in Table (4). From obtained results, curcumin rhizomes contain the highest content of lutein, zeaxanthin, β-cryptoxanthin and β-carotene followed by bitter lupines Giza-1, and yellow corn seeds. In the human diet, carotenoids have been shown to have antioxidant activity which may help to prevent certain kinds of cancers, arthritis and atherosclerosis. β-carotene is a precursor of vitamin A (retinal) which is biosynthesized *via* the action of β-carotene 15,15'-monooxygenase. There are nearly 600 carotenoids in nature. In humans, four carotenoids (β-carotene, α-carotene, γ-carotene, and β-cryptoxanthin) have vitamin A activity, and they can be converted to retinal (Ngkok and Solcha, 1991). Lupine seeds, curcumin rhizomes and yellow corn seeds contain large quantities of carotenoid pigments, which can be used as dietary supplements or as food additives. The reference concentration values for total α-carotene, total lycopene, and total lutein plus zeaxanthin are from the medians of the laboratory means from the interlaboratory comparison exercise (Levenson, *et al.*, 2000).

Table (4): Analytical data for the carotenoid contents (ng) in rhizomes and seeds.

Constituents	Fine powdered of lupine seeds FPLS var. Giza-1	Turmeric powdered	Grain husks of yellow corn GHYC (Giza-368)
Lutein	54387	76092	44402
Zeaxanthin	144252	190335	123053
β-Cryptoxanthin	46095	60924	39273
β-Carotene	153498	202860	130791

Another study reported that yellow corn contains relatively high carotenoid content, ranging from 11 to 20 µg/g (Loy *et al.*, 1987). Carotenoids such as lutein and zeaxanthin content in white corn are not affected by drying and milling (Mamatha *et al.*, 2012). These calibration curves were used for the quantitation of lutein, zeaxanthin, β-cryptoxanthin, and β-carotene in carrot, spinach, and kale and celery, broccoli, and various tomato preparations (flakes, granulate, and powder). Good sources for lutein are spinach, kale, and broccoli, and sources for β-carotene are kale, broccoli, spinach, carrots, and tomatoes. The found values correlated well with those of the Nutrition Table published by (Souci, and Kraut, 1994). It should be noted that the content of particular items may be affected by variety, maturity, growing conditions, the season of the year, and which part of the item is consumed. In general, outer parts of plants contain higher levels than inner parts.

3.5 Biochemical evaluation of carotenoids content in tercumin capsules

Carotenoids levels in three Tercumin capsules were determined and the results are given in Table (5). These results show that Lutein, Zeaxanthin, β-Cryptoxanthin and β-Carotene content in tercumin capsule-2 are higher than those determined in tercumin capsule-3 and tercumin capsule-1. In literature survey, epidemiology studies showed that carotenoids can prevent the development of some chronic diseases in humans, including cancers and cardiovascular diseases, in addition to other biological activities, including antioxidant activity, influences on the immune system, control of cell growth and differentiation and stimulant effects on gap junction communication (Wang *et al*., 2008). Data show that the Tercumin capsules contain diverse carotenoids such as lutein, zeaxanthin, β-cryptoxanthin, and β-carotene in (Table 5).

Table (5): Analytical data for the predominant carotenoid content (ng) in tercumin capsules.

Constituents	Capsule-1 (½ FPLS + ¼ TP + ¼ GHYC)	Capsule-2 (¼ FPLS + ½ TP + ¼ GHYC)	Capsule-3 (⅓ FPLS + ⅓ TP + ⅓ GHYC)
Lutein	22046.94	34635.78	31380.04
Zeaxanthin	75587.57	102316.12	45403.57
β-Cryptoxanthin	23999.97	32600.85	30376.48
β-Carotene	79948.55	108578.67	101174.34

Lutein and zeaxanthin absorb damaging blue light in macular region of the retina, therefore protecting vision and resulting in good eye health and besides, carotenoids have been reported to help improve visual performance, sleep quality, and adverse physical symptoms (Johnson, 2002; Stringham *et al.* 2017). Rios *et al.* (2014) reported that corn grain color was directly influenced by the concentration of carotenoids in different corn varieties, according to their genotype.

3.6 Levels of secondary metabolites in tercumin capsules and their sources

3.6.1 Total phenolic compounds TPCs

Results showed that TPCs in both tercumin capsules and their sources tercumin capsules ranged from 2.18 to 29.48 mg/100g (Table 6). TPCs in the yellow corn grains are higher than those found in the bitter lupine seeds Giza-1 (2.185 mg/100g) and turmeric rhizomes. Turmeric is an excellent source of phenolic compounds, ascorbic acid and carotenoids which have been reported to show good antioxidant activity (Zhang and Wang 2001). Kuhnen (2007) found about 32 to 114 mg/ 100 g of total phenols in samples of different varieties of local and commercial corn, showing that this parameter may fluctuate greatly between the analyzed corn seeds. Bacchett *et al*. (2013), for example, found total phenolic content around 115 to 175 mg/ 100 g for different Italian local corn varieties. In the present study, we found results from 109 to 180 mg/ 100 g of total phenolic compounds in the varieties evaluated. In this study, it seemed that, the higher total phenolic content of plants resulted in higher antioxidant activity as reported by Shan *et al*. (2005) and Wong *et al*., (2006). In the present study the mixture of results of TPCs determined in three different tercumin capsules are given in Table (6). These results show that TPCs concentrations in the tercumin capsules-3 are higher than those found in the tercumin capsules-1 and tercumin capsules-2. The levels of TPCs in the tercumin capsules-1 (20.1 mg /100g) and tercumin capsules-2 (25.63 mg /100g) and tercumin capsules-3 (29.480 mg /100g). Phenolic compounds are commonly found in both edible and non-edible plants, and they have been reported to have multiple biological effects. Crude extracts of vegetables such as potato and tomato rich in phenolics are increasingly of interest in the food industry because they retard oxidative degradation of lipids and thereby improve the quality and nutritional value of food (Kahkonen *et al*., 1999; Loliger, 1991). It has been determined that the chemical structure of curcumin, had showed antioxidant, antimicrobial, anti-inflammatory, anti-angiogenic, anti-mutagenic, and antiplatelet aggregation properties (Deogade and Ghate, 2015).

3.6.2 The total flavonoid content in the capsules and their sources

The total flavonoid content in the capsules and its own sources was determined as catechin equivalent (CE) and was expressed as mg CE/100 g DW. Total flavonoid contents in tercumin capsules and their sources were assayed and the results indicated that turmeric powdered contained the highest level 4.97 mg CE /100 g DW followed by grain husks of yellow corn (GHYC) and the lowest level (1.396 mg/100g) was found in the powder of lupine seed Giza-1.The results also show that tercumin capsule-3 contain the highest concentration (5.142 mg CE /100 g DW) of TFs followed by tercumin capsule-1and tercumin capsule-2 contain the lowest concentration. Corn husks are most commonly used to encase foods to be steamed or baked, imparting a very light corn flavor. Corn husks can be used in the presentation of a dish, but are not edible and should be discarded after use. The color of seed coats of lupine samples is a result of TF existence and the roles of their fractions are antioxidants, defensive compounds and source of some glycosides (Duenas *et al*., 2009). The higher levels of flavonoids are a positive indication of plant extracts because the higher flavonoid content is the higher antioxidant potential and higher cancer preventive function (Duenas *et al*., 2009; Zhishen *et al*., 1999). Phuyal *et al*.

(2020) reported that the plants contain polyphenols and flavonoids that act as free radical scavengers and reduce oxidative stress and may be an alternative remedy to cure various harmful human diseases.

3.6.3 Total alkaloids

Total alkaloids (TAs) in samples of lupine seed, were determined and the results are given in Table (6). These results showed that total alkaloids in curcumin rhizomes (1.82%) are higher than those determined in yellow corn seeds (1.203%). The levels of TAs in turmeric rhizomes are always higher than those determined in yellow corn grains.

Results also showed those curcumin rhizomes always the highest contents of the determined secondary metabolites. One major safety issues of lupines-based foods is the presence of (QAs), bitter compounds produced by lupines plants as a defense mechanism against predators. In mammals, quinolizidine alkaloids intoxication is characterized by trembling, shaking, excitation, and convulsion (Zamora *et al*., 2008).

Table (6): Levels of TPCs (mg/100g), TAs % and TFs in tercumin capsules and their sources.

Constituents	Total phenolic compounds TPCs (mg/100g)	Total alkaloids TAs (%)	Total flavonoids (mg CE /100 g)
Fine powdered of lupine seeds FPLS Giza-1	2.185±0.11	1.379±0.05	1.396±0.05
Turmeric powdered	13.83±1.3	1.820±0.20	4.975±0.44
Grain husks of yellow corn GHYC (Giza-368)	28.520±2.51	1.203±0.03	2.225±0.20
Capsule-1 ½ FPLS + ¼ TP + ¼ GHYC	20.095±2.01	1.528±0.08	2.747±030
Capsule-2 ¼ FPLS + ½ TP + ¼ GHYC	25.631±2.3	1.793±0.30	2.492±0.29
Capsule-3. ⅓ FPLS + ⅓ TP + ⅓ GHYC	29.480±2.59	1.482±0.20	5.142±0.32

Value± SD

Lupanine and sparteine, the most common quinolizidine alkaloids, show acute oral toxicity due to neurological effects leading to the loss of motor co-ordination and muscular control. Lupanine and lupine alkaloid extracts have shown to have herbicidal activity, and the capacity to inhibit the growth of *Fusarium avenaceum*, *Fusarium solani*, *Botrytis cinerea*, *Rhizoctonia solani*, and *Fusarium oxysporum.* Lupine alkaloids also have feeding deterrence effects on the red legged earth mite *Halotydeus destructor* (Zamora *et al*., 2008; Zamora *et al*., 2005). Alkaloids have potent pharmacological effects, such as antimalarial, antispasmodic, and analgesic, as well as facilitate the treatment of hypertension and mental disorders, and have antitumor effects (Badami, *et al*., 2003 and Zhang, *et al*., 2008). The concentrations of total alkaloids in tercumin capsules were determined and the results are given in Table (6). These results showed that total alkaloids in tercumin capsule-2 (1.793%) are higher than those found in both tercumin capsule-1(1. 528%) and tercumin capsule-3 (1. 482%). Some alkaloids might be toxic, but they have been widely applied in pharmaceutical areas as medication. The biochemical and pharmacological properties of quinolizidine alkaloids (QAs) have a wide variety of biological activities. They are toxic or inhibitory for most organisms (García-López *et al*., 2004; Kubo *et al*., 2006). Alkaloids have been known to be the largest groups of secondary metabolites in plants. The claimed to have powerful effects on humans and could be used as pain killers. Oghenejobo *et al*. (2014) reported that alkaloids are very efficient therapeutically among the plant phytochemicals. In the present work, three different capsules were biochemically evaluated and the results indicated that tercumin capsules are good sources of crude protein, crude lipids, sugars, L-ascorbic acid. The concentrations of carotenoids pigments, TPCs, TFs and TAs are high and enough to as potential protection of human body. We suggest use tercumin capsules to reduce eye diseases such as age-related macular degeneration. The human macula uniquely concentrates three carotenoids: lutein, zeaxanthin, and *meso*-zeaxanthin. Lutein and zeaxanthin must be obtained from dietary sources such as corn, turmeric and green leafy vegetables, and orange and yellow fruits and vegetables, while *meso*-zeaxanthin is rarely found in diet and is believed to be formed at the macula by metabolic transformations of ingested carotenoids.

5. Conclusions

It could be concluded that legumes especially lupine seeds, turmeric rhizomes and yellow corn grains are good sources of crude protein, carbohydrates, higher soluble dietary fiber and the consumption of these seeds has many health benefits such as antioxidant activities and anti-mutagenic effects of natural phenolic compounds and total alkaloid concentrated in seed and rhizomes. We suggest use tercumin capsules as alternative solution to reduce the side effects of malnutrition and supplemented feed. The tercumin capsules need more studies especially on eye diseases such as age-related macular degeneration and retinopathy

References

Abdel-Raheem, S .A., Abdel-Naem, G. F., Azazz, N. A., Abdel-Monem, A. M. and Talat, M. (2016), "Chemical evaluation and levels of secondary metabolites in some local varieties of some soy bean (*Glycin max*, L.) seeds", *Journal of biochemical and Environment sciences,* Vol. 1 No. 11, pp. 1–24.

Al-Saud, N. B. S. (2020), "Impact of curcumin treatment on diabetic albino rats", *Saudi Journal of Biological Sciences*, Vol. 27, pp. 689–694.

Akbik, D., Ghadiri, M., Chrzanowski, W. and Rohanizadeh, R. (2014), "Curcumin as a wound healing agent", *Life of sciences,* Vol. 116 No. 1, pp. 1–7.

AOAC (1984), *Official methods of analysis,* 14th ed., Association of Official Analytical Chemists, Washington, C.D., USA.

AOAC (2000), *Official methods of analysis*, 20th ed., Association of Official Analytical Chemists, Washington, C.D.,USA.

Ascheri, J. R. and Germani, R. (2004), *Corn quality protocol*, Embrapa Food Agroindustry, Rio de Janeiro, Argentina, pp. 23.

Audu, A. and Aremu, U. (2011), "Effect of processing on chemical composition of red kidney bean (*Phaseolus vulgaris* L.) flour", *Pakistan Journal of Nutrition*, Vol. 13, pp. 1069–1075.

Badami, S., Manohara, R. S. A., Kumar, E. P., Vijayan, P. and Suresh, B. (2003), "Antitumor activity of total alkaloid fraction of solanum pseudocapsicum leaves", *Phytotherapy of research*, Vol. 17, pp. 1001–1004.

Bjarnason, M. and Vasal, S. K. (1992), "Breeding of Quality Protein Maize (QPM)", *Plant Breeding Reviews*, John Wiley and Sons, Oxford, UK, Vol. 9, pp. 181–216.

Cheng, A. L., Hsu, C. H ., Lin, J. K., Hsu, M. M., Ho, Y. F., Shen, T. S., Ko, J. Y., Lin, J. T., Lin, B. R., Ming-Shiang, W., Yu, H. S., Jee, S. H., Chen, G. S., Chen, T. M., Chen, C. A., Lai. M. K., Pu, Y. S., Pan, M. H., Wang, Y. J., Tsai, C. C. and Hsieh, C. Y. (2001), "Phase I clinical trial of curcumin, a chemopreventive agent, in patients with high-risk or pre-malignant lesions", *Anticancer Research*, Vol. 21, pp. 2895–2900.

Cortes-Gomez, A., San Martın-Martınez, E., Martınez-Bustos, F. and Vazquez-Carrillo, G. M. (2005), "Tortillas of blue maize (*Zea mays* L.) prepared by a fractionated process of nixtamalization: analysis using response surface methodology", *Journal of Food Engineering*, Vol. 66, pp. 273–281.

Deogade, S. and Ghate, S. (2015). "Curcumın: Therapeutıc applıcatıons in systemıc and oral health", *International journal of biological Pharmacology of Research*, Vol. 6 No. 4, pp. 281–290.

Dubois, M., Gilles, R. A., Hamilton, J. K., Rebers, P. A. and Smith, F. (1956), "Colorimetric method for determination of sugars and related substances", *Analytical Chemists*, Vol. 28, pp. 350–358.

Duenas, M., Hernandez, T., Estrella, I. and Fernandez, D. (2009), "Germination as a process to increase the polyphenol content and antioxidant activity of lupine seeds (*Lupinus angustifolius* L.)", *Food Chemistry*, Vol. 117, pp. 599–607.

García-Lopez, P. M., Garzon, P. M., Wysocka, W., Maiztegui, B., Alzugaray, M. E., Del Zotto, H. and Borelli, M. I. (2004), "Quinolizidine alkaloids isolated from *Lupinus* enhance insulin secretion", *European Journal of*

Pharmacology, Vol. 504, pp. 139–142.

Gomez, K. A. and Gomez, A. A. (1984), *Statistical procedures for agricultural research*, John Willy and Sons Inc., New York, USA.

Hao, Z., Parker, B., Knapp, M. and Yu, L. (2005), "Simultaneous quantification of a-tocopherol and four major carotenoids in botanical materials by normal phase liquid chromatography-atmospheric pressure chemical ionization-tandem mass spectrometry", *Journal Chromatogr A*, Vol. 1094, pp. 83–90.

Harborne, J. B. (1973), "Phytochemical methods", *A guide to modern techniques of plant analysis*, Chapman and Hall, New York, USA.

Humphries, J. M. and Khachik, F. (2003), "Distribution of lutein, zeaxanthin, and related geometrical isomers of fruit, vegetables, wheat, and pasta products", *Journal of Agricultural and Food Chemistry*, Vol. 51, pp. 1322–1327.

Johnson, E. J. (2002), "The role of carotenoids in human health", *Nutrition Clinical Care*, Vol. 5, pp. 56–65.

Kahkonen, M. P., Hopia, A. I., Vuorela, H. J., Rauha, J. P., Pihlaja, K., Kujala, T. S. and Heinonen, M. (1999), "Antioxidant activity of plant extracts containing phenolic compounds", *Journal of Agricultural and Food Chemistry*, Vol. 47 No. 10, pp. 3954–3962.

Kocaadam, B. and Sanlier, N. (2017), "Curcumin, an active component of turmeric (*Curcuma longa*), and its effects on health", *Critical Reviews in Food Science and Nutrition*, Vol. 57 No. 13, pp. 2889–2895.

Kubo, H., Inoue, M., Kamei, J. and Higashiyama, K. (2006), "Hypoglycemic effect of multiflorine derivatives in normal mice", *Biological Pharmacology Bulletin*, Vol. 29, pp. 2046–2050.

Kuhnen, S. (2007), *Metabolômica e Bioprospecção de Variedades Crioulas e Locais de Milho (Zea mays L.)*, PhD in Plant Genetic Resources, Department of Phytotechny, Federal University of Santa Catarina, Florianópolis, Brazil.

Levenson, M. S., Banks D. L., Eberhardt, K. R., Gill, L. M., Guthrie, W. F., Liu, H. K., Vangel, M. G., Yen, J. H. and Zhang, N. F. (2000), "An Approach to Combining Results From Multiple Methods Motivated by the ISO GUM", *Journal of Research of Natural and Institute of Standards Technology*, Vol. 105, pp. 571–579.

Loliger, J. (1991), "The use of antioxidants in food", *Free radicals and food additives*, Aruoma, O. I., Halliwell, B., Eds., Taylor and Francis, London, United Kingdom, pp. 129–150.

Lopez-Martinez, L. X., Oliart-Ros, R. M., Valerio-Alfaro, G., Lee, C. H. and Parkin, H. G. (2009), "Antioxidant activity, phenolic compounds and anthocyanins content of eighteen strains of Mexican maize", *LWT- Food Science and Technology*, Vol. 42 No. 6, pp.1187–1192.

Loy, D. D., Wright, K. N., White, P. J. and Johnson, L. A. (1987), *Nutritional properties and feeding value of corn and its by-products*, American Association of Cereal Chemists, Inc., USA.

Lucas, M. M., Stoddard, F. L., Annicchiarico, P., Frías, J., Martínez-Villaluenga, C. and Sussmann, D. (2015), "The future of lupin as a protein crop in Europe", *Front Plant of Science*, Vol. 8, pp. 705.

Mahmoud, I. H., Azzaz, N. A., Khalifa, Y. A. M., Mahmoud, M. A. and Fakhry, G. (2016), "Effect of foliar application with active yeast extract and benzyladenine on some vegetative growth criteria and chemical composition of lupine (*Lupinus Termis, L.*) plants", *Minia Journal of Agricultural Research & Development*, Vol. 36 No. 2, pp. 193–214.

Mamatha, B. S., Arunkumar, R. and Baskaran, V. (2012), "Effect of processing on major carotenoid levels in corn (*Zea mays*) and selected vegetables: bioavailability of lutein and Zeaxanthin from processed corn in mice", *Food Bioprocess and Technology*, Vol. 5, pp. 1355–1363.

Miller, G. L. (1959), "Use of 3,5-dinitrosalicylic acid reagent for determination of reducing sugars", *Analytical Chemists*,Vol. 31, pp. 426–428.

Mittelmann, A., Filho, J. M., Monteiro de Lima, J. M., Hara-Klein, C., Machado da Silva, R. and Tanaka, R. T. (2006), "Diallel Analysis of Oil Content in Maize", *Revista Brasileira Agrociência*, Vol. 12 No. 2, pp. 139–143.

Mondy, N. I. and Ponnampalam, R. (1986), "Potato quality as affected by source of magnesium fertilizer: Nitrogen, minerals and ascorbic acid", *Journal of Food Sciences*, Vol. 51, pp. 352–357.

Moros, E. E., Darnako, D., Cheryan, M., Perkins, E. G. and Jerrell, J. (2002), "Analysis of xanthophylls in corn by HPLC", *Journal of Agricultural and Food Chemistry*, Vol. 50, pp. 5787–5790

Mozaffarieh, M., Sacu, S. and Wedrich, A. (2003), "The role of carotenoids, lutein, and Zeaxanthin, in protecting against age-related macular degeneration: a review based on controversial evidence", *Journal of Nutrition*, Vol. 2, pp. 1–8.

Newairy, A. A., Mansour, H. A.,

Youssef, M. I. and Sheweita, S. A. (2002), "Alterations of lipid profile in plasma and liver of diabetic rats: effect of hypoglycemic herbs", *Journal of Environmental Science and Health* B, Vol. 37, pp. 475–484.

Ngkok, S. and Solcha, I. (1991), "Carotenoid and contents of papaya and pineapple: Influence of hanching and predrying treatment", *Food Chemistry*, Vol. 39, pp. 175–179.

Nile, S. H. and Park, S. W. (2014), "Antioxidant, a-glucosidase and xanthine oxidase inhibitory activity of bioactive compounds from Maize (*Zea mays* L.)", *Chemical Biology & Drug Design*, Vol. 83, pp. 119–125.

Oghenejobo, M., Oghenejobo, B. U. S. and Uvieghara, K. E. (2014), "Phytochemical screening and antimicrobial activities of fractionated leaf extract of *Combretum racemosum*", *Schaeffer Academy of Journal Pharmacology*, Vol. 3 No. 6, pp. 455–462.

Olojede, A. O., Nwokocha, C. C., Akinpelu, A. O. and Dalyop, T. (2009), "Effect of variety, rhizome and seed bed types on yield of turmeric (*Curcuma longa* L.) under a humid tropical agro-ecology", *Advances in Biological Research*, Vol. 3, pp. 40–42.

Paes, M. C. D. (2008), "Physical, chemical and technological aspects of corn grain (In Portuguese)". *The Corn Culture*, Embrapa Corn and Sorghum, Sete Lagoas, Brazil, pp. 47–60.

Phuyal, N., Jha, P. K., Prasad Raturi, P. and Rajbhandary, S. (2020), "Total phenolic, flavonoid contents, and antioxidant activities of fruit, seed, and bark extracts of *Zanthoxylum armatum* DC", *The Scientific World Journal*, Vol. 2020, p. 1-7.

Pisarikova, B. and Zraly, Z. (2009), "Nutritional value of lupine in the diets for pigs (a review)", *Acta Veterinaria Brunensis*, Vol. 78, pp. 399–409.

Prasad, S., Gupta, S., Tyagi, A. and Aggarwal, B. (2014), "Curcumin, a component of golden spice: From bedside to bench and back", *Biotechnology Advances*, Vol. 32 No. 6, pp. 1053–1064.

Rios, S. A., Paes, M. D., Cardoso, W. S., Borém, A. and Teixeira, F. F. (2014), "Color of corn grains and carotenoid profile of importance for human health", *American Journal of Plant Sciences*, Vol. 5, pp. 857–862.

Salimifar, M., Hassan. Z. F. and Fatehi, M. (2013), "A review on natural products for controlling type-2 diabetes with an emphasis on their mechanisms of actions", *Current Diabetes of Reviews*, Vol. 9, pp. 402–411, 2013.

Saric, M., Kastrori, R., Curic, R., Cupina, T. and Geric, L. (1967), "Chlorophyll determination", *Practicum for Plant Physiology (In*

Serbian), Scientific Book, University of Novi Sad, Belgrade, Serbia, pp. 215

Shan, B., Cai, Y. Z., Sun, M. and Corke, H. (2005), "Antioxidant capacity of 26 spice extracts and characterization of their phenolic constituents", *Journal of the Agricultural and Food Chemistry*, Vol. 53, pp. 7749–7759.

Shishir, S., Gautam. S. and Bharat, B. A. G. (2005), "Curcumin: getting back to the roots", *Academy of Science*, Vol. 1056, pp. 206–217.

Silva, J. S., Bebert, P. A., Afonso, A. L. and Rufato, S. (2000), " Quality of grains", *Drying and storage of agricultural products (In Portuguese)*, Learn Easy, Viçosa, Brazil, pp. 71.

Singleton, V. L. and Rossi, J. A. (1965), "Colorimetry of total phenolics with phosphomolybdic- phosphotungstic acid reagents", *American Journal of Enology and Viticulture*, Vol. 16, pp. 144–158.

Souci, S. W., Fachmann, W. and Kraut, H. (1994), *Food Composition and Nutrition Tables*, 5th edition, Medpharm Scientific Publishers, Stuttgart, Germany, 1994.

Stringham, J. M., Stringham, N. T. and O'Brien, K. J. (2017), "Macular carotenoid supplementation improves visual performance, sleep quality, and adverse physical symptoms in those with high screen time exposure", *Foods*, Vol. 6, pp. 47.

Thiraphatthanavong, P., Wattanathorn. J., Muchimapura, S., Thukham-mee, W., Wannanon, P., Tong-un, T., Suriharn, B. and Lertrat, K. (2014), "Preventive effect of *Zea mays* L. (Purple Waxy Corn) on experimental diabetic cataract", *BioMed Research International*, Vol. 2014, pp. 1–8.

Vasudevan, D. M., Sreekumari, S. and Vaidyanathan, K. (2011), *Text book of Biochemistry for medical students*, 6th ed., JAYPEE Brothers medical publishers (P) Ltd, India, pp. 406–407.

Wang, S., Errington. S. and Yap, H. H. (2008), *Studies on carotenoids from lupine seeds*, Lupines for Health and Wealth, Proceedings of the 12th International Lupine Conference, Canterbury, New Zealand, pp. 198–202.

Wickenberg, J., Ingemansson, S. L. and Hlebowicz, J. (2010), "Effects of *Curcuma longa* (turmeric) on postprandial plasma glucose and insulin in healthy subjects", *Journal of Nutrition*, Vol. 9 No. 43, pp. 1–5.

William, P. (2000), *New potential dry land crops in northeastern oregon*, Columbia Basin Agricultural Research Center, Oregon state University Agronomist, Pendleton, Oregon, USA.

Wong, C., Li, H., Cheng, K. and Chen, F.

(2006), "A systematic survey of antioxidant activity of 30 Chinese medicinal plants using the ferric reducing antioxidant power assay", *Food Chemistry*, Vol. 97, pp. 705–711.

Yue, G. G., Chan, B. C., Hon, P. M., Kennelly, E. J., Yeung S. K., Cassileth, B. R. and Lau, C. B. (2010), "Immunostimulatory activities of polysaccharide extract isolated from *Curcuma longa*", *International Journal of Biological Macromolecules*, Vol. 47 No. 3, pp. 342–347.

Zamora, N. F., Bernal, A. A., Ruiz-López, M. A., Soto-Hernandez, M. and Escalante, A. E. (2005), "Inhibición del crecimiento micelial de hongos fi topatogenos *in vitro* con lupanina y un extracto alcaloideo obtenido de semillas de *Lupinus exaltatus* Zucc. (Fabacea)", *Reviews Mexican of Fitopatol*, Vol. 23 No. 2, pp.124–129.

Zamora, N. F., García, P. M. L., Ruiz-López, M. A. and Salcedo, E. P. (2008), "Composición de alcaloides en semillas de *Lupinus mexicanus* (Fabaceae) y evaluación antifungica y alelopática del extracto alcaloideo", *Agrociencia*, Vol. 42, pp. 185–192.

Zhang, W. and Wang, S. (2001), "Antioxidant activity and phenolic composition in selected herbs", *Journal of Agricultural and Food Chemistry*, Vol. 49, pp.5165–5170.

Zhang, Y., Li, X., Zou, D., Liu, W., Yang J. and Zhu, N. (2008), "Treatment of type-2 diabetes and dyslipidemia with the natural plant alkaloid berberine", *Journal of Clinical Endocrinology and metabolic*, Vol. 93, pp. 2559–2565.

Zhishen, J., Mengcheng, T. and Jianming, W. (1999), "The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals", *Food Chemistry*, Vol. 64, pp. 555–559.

Zilic, S., Serpen, A., Akillioglu, G., Gokmen, V. and Vancetovic, J. (2012), "Phenolic Compounds, carotenoids, anthocyanins, and antioxidant capacity of colored maize (*Zea mays*, L.) Kernels", *Journal of Agricultural and Food Chemistry*, Vol. 60 No. 5, pp.1224–1231.