Journal of Nutrition & Food Sciences
ISSN: 2155-9600
Barakat, J Nutr Food Sci 2014, 4:5
DOI: 10.4172/2155-9600.1000302
Research Article
Open Access

Fate of Nutritional and Bioactive Compounds of Innovative Chickpeas-Based Vegan Diets Incorporating Different Vegetables

Hassan Barakat*

Department of Food Science, Faculty of Agriculture, Benha University, 13736 Moshtohor, Kaliuobia, Egypt

Abstract

Advances in nutrition research during the past few decades recommended the contribution of vegetarian diets for improving human health and reducing risk diseases. In current study, six innovative ready-to-use and ready-to-eat chickpea-based vegan diets (CVDs) incorporating different vegetables (cauliflower, taro, green zucchini, pea, bean and spinach) at 20% were prepared. These formulated CVDs with 30% chickpea were supplemented by additional edible ingredients. Herein, fate of nutritional and bioactive compounds of those CVDs was investigated. Chemical composition, minerals content, bioactive compounds and antioxidant activity of CVDs before and after cooking were determined. Ready-to-eat CVDs were organoleptically evaluated after frying cooking. Results of composite analysis indicated 67.13 to 71.65, 25.02 to 33.96, 1.87 to 2.36, 7.83 to 9.15, 8.14 to 8.84 and 46.79 to 56.16% for moisture, crude protein, lipids, ash, fiber, and carbohydrates contents in ready-to-use CVDs, respectively. Significant differences ($p<0.05$) were found between macro- and micro-nutrients content of ready-to-use and ready-to-eat as well as caloric value of CVDs. The ready-to-use CVDs exhibit appropriate content of ascorbic acid, chlorophylls, carotenoids, flavonoids, and flavonols which basically depends on their ingredients. Frying process dramatically reduced the ascorbic acid, chlorophylls, carotenoids, flavonoids, and flavonols contents. High organoleptic acceptability of ready-to-eat CVDs was noticed to confirm the consumer attractiveness further. In conclusion, the possibility of healthy ready-to-eat and ready-to-use CVDs incorporated with common consumed vegetables manufacturing could provide a promising approach for improving the human health and dietary pattern practices.

Keywords: Bioactive compounds; Chemical composition; Cooking; Antioxidant activity; Vegan diets; Health benefits

Introduction

Recently, there has been a renewed interest in vegetarian diets. Vegetarian diets are often diverse formulated in composition and shape, comprising a wide range of dietary sources for numerous and individual dietary requirments. Practically, adopting a vegetarian dietary pattern is traditionally interpreted to mean an absence of meat [1,2]. Basically, the vegetarian diets were classified into (i) lacto-ovo-vegetarians (includes dairy and eggs), (ii) lacto-vegetarians (includes dairy), (iii) ovo-vegetarians (includes eggs), and (iv) vegan which have further restrictions imposed and exclude all animal origin foods. Additionally, vegetarians are distinguished by high consumption of fruit, vegetables, legumes, nuts, grains and soy protein-food components, and each of these may independently be associated with positive health impacts [2-5]. Particularly, the meat substituting industry was highly encouraged to reduce the meat consumption and thereby reduce the risk of related disease. Obviously, substituting the meat consumption by alternative protein rich products made from plant proteins, so-called Novel Protein Foods, would be an attractive choice [6]. The University of Oxford suggests that vegetarian diets could significantly reduce people's risk of heart disease. It is observed that vegetarians have up to 32% less risk of developing heart disease than non-vegetarians [1,7,8]. This finding could encourage the processed meat consumers to change their nutritional behavior and prevent themselves from 42% higher risk of heart disease, a 19% higher risk of type 2 diabetes and bladder cancer as mentioned previously [4,9].

Expressively, a new study from Harvard School of Public Health (HSPH) researchers has found that red meat consumption is associated with an increased risk of total cardiovascular and cancer mortality. The results also showed that substituting other healthy protein sources such as fish, poultry, nuts, and legumes was associated with a lower risk of mortality [10]. Additionally, vegetarians tend to have lower overall cancer rates, lower body mass index (BMI), adjustable blood pressure by eating diets lower in saturated fats, have higher levels of dietary fiber, magnesium, iron and potassium, vitamins E and folate, carotenoids, flavonoids and other phytochemicals [4,8,9,11,12]. Practically, vegetables are commonly eaten as fresh or cooked for improving its sensory properties. The phytochemicals are not only contributing to the vegetable's color and taste, but also have been described to possess antimutagenic or even anticarcinogenic activity [11,13]. The Egyptian cuisine is notably conducive to ready-to-use and ready-to-eat vegetarian diets, as it rely heavily on vegetable dishes. However, several commonly consumed vegetables such as cauliflower, green pea, green bean, spinach and green zucchini were favorable for Egyptian consumers over the years ago. There are many studies reviews the health benefits of mentioned vegetables considering their phytochemicals content and potential antioxidant, anticarcinogenic, antimicrobial activities [14-21]. Indeed, carefully planned vegetarian and vegan diets can provide adequate nutrients for optimum health [2]. Clearly, evidence suggests that infants and children can be successfully reared on vegan and vegetarian diets [22,23]. However, still the most presented vegetarian diets are lack in vitamin B_{12} and essential amino acids in valuable amounts which could make them not sufficent to provide the all essential nourish requirements [20]. In spite of all dietary practices, including non-vegetarian diets can be deleterious for health when essential nutrients are not consumed. Therefore, vegetarian and vegan diets need to ensure a balance of nutrients from a wide variety of foods, especially for vulnerable groups. Improving dietary habits is a societal, not just an individual problem. Thus it demands a population-based, multisectoral, multidisciplinary, and culturally relevant approach.

***Corresponding author:** Hassan Barakat, Department of Food Science, Faculty of Agriculture, Benha University, Moshtohor, 13736 Kaluiobia, Egypt, Tel: 002 011 6386902; Fax: 0020132246 7786; E-mail: hassan.barakat@fagr.bu.edu.eg

Received June 22, 2014; **Accepted** August 03, 2014; **Published** August 05, 2014

Citation: Barakat H (2014) Fate of Nutritional and Bioactive Compounds of Innovative Chickpeas-Based Vegan Diets Incorporating Different Vegetables. J Nutr Food Sci 4: 302. doi: 10.4172/2155-9600.1000302

Accordingly, the main objectives of this study were to investigate the possibility to prepare innovative CVDs from chickpea as protein source incroporating different vegetables. Studying the effect of frying cooking method could be investigated as well. To achieve this purpose, six vegan diet formulas have been developed by incorporating 6 different vegetables with chickpea as well as some other edible ingredients. Proximate chemical composition, minerals, bioactive compounds and their antioxidant activity as well as the organoleptic properties for prepared diets were carried out.

Materials and Methods

Ingredients

Six different vegetables namely, cauliflower (*Brassica oleracea var. botrytis*), pea (*Pisum sativum* L.), green zucchini *(Cucurbita pepo* L.), taro corms (*Colocasia esculenta* L.), green bean (*Phaseolus vulgaris* L.) and green spinach (*Spinacia oleracea* L.) were obtained in fresh status from the central local vegetable market at El-Obour City, Egypt. Dry edible chickpea (*Cicer arietinum* L.), sweet potato (*Ipomoea batatas* L.), whole barley, carrot (*Daucus carota* L.), green leafy herbs mix [fresh coriander leaves (*Coriandrum sativum* L.), dill (*Anethum graveolens* L.), parsley (*Petroselinum crispum* L.)], red pepper (*Capsicum annuum* L.), onion (*Allium cepa* L.), garlic (*Allium sativum* L.) and edible salt were obtained from local supermarket, Egypt. In addition, traditional spices mixture was formulated as [25% black pepper, 20% cumin, 20% relish "Baharat; ready-mix of specific spices", 10% dry coriander seed, 10% dry sweet paprika, 10% dry ginger and 5% dry chili], which were brought from Ragab El-Attar's local spices supermarket, Egypt.

Ingredients preparation

All mentioned vegetables were washed, sorted and prepared as follow: green leaves of cauliflower were removed then edible part was cut into 1-1.5 cm, green pea was peeled and the end parties of green zucchini and green beans were removed then chopped in 2 cm pieces. The taro corms were peeled manually by sharp knife then chopped into 1x1x1cm cubes. The yellow and undesired spinach leaves were removes after removing the pink rots of green spinach then, ripped by 1-2 cm. All prepared vegetables were washed and blanched for appropriate time (3, 3, 3.5, 4, 5 and 2.5 min, respectively) using live steam blancher then cooled down and shortly kept until use under freezing conditions (-18 ± 1°C).

Unpeeled chickpeas were washed and soaked in water for 12 h. Then excessive water was drained and chickpeas were peeled manually and ground for 3 min using a conventional kitchen machine. Sweet potato and carrots were peeled, washed, chopped in 1 cm slices, and blanched using live steam blancher for 6 and 4 min, respectively. Subsequently, the blanched materials were immediately cooled down and homogenized to a homogeneous puree. The whole naked barley kernels were milled twice to obtain homogeneous and fine barley flour. Sweet red pepper was washed and chopped in small cubes after removing the internal seeds. Further ingredients such as fresh onion and garlic were peeled, washed and then chopped immediately before preparing the vegan diets. To prepare the green leafy herbs mix, fresh coriander, dill and parsley were washed, ripped then mixed as (2:1:1) respectively. The dried spices mix were formulated as [25 g black pepper, 20 g cumin, 20 g relish ('Baharat'), 10 g dry coriander, 10 g dry sweet aparika, 10 g dry ginger, and 5 g dry hot chili] to prepare 100 g spices mix and used immediately.

Different innovative ready-to-use CVDs preparation

Six vegan diet formulas were prepared from the previously prepared ingredients according to recipes in Table 1. Tow kilograms from each formula were prepared using a kitchen machine. Each ready-to-use vegan diet formula was filled in 2 polyethylene bags as 0.3 kg for chemical analysis of fresh diet and 1.7 kg for frying process and chemical analysis of fried diets. Before the sensory evaluation, the vegan diet were kept for the homogeneity of all ingredients for 12-18 hr under cooling conditions then fried, while small diet bags were subjected immediately for analysis. The whole experiment and analysis were done in triplicates.

Different innovative ready-to-eat CVDs preparation

Ready-to-eat CVDs were left at room temperature for 5 min then mixed with 0.1% sodium bicarbonate amount immediately before frying [carbon dioxide producer, making the CVDs more porous and puffy during frying]. The vegan diet mixture was shaped using a frame and wide knife which were designed especially for this purpose. Appropriate amounts of each prepared vegan mixture was put into the frame, and then cut with the knife as symmetrical bars as (10×0.8×0.6 cm: L×W×T) prior to frying. The vegan bars were stir-fried at 180-190°C for 3-5 min in preheated sun flower oil. The CVDs were served immediately after frying for the panelists to evaluate its organoleptic characteristics. However, appropriate samples have been taken off for chemical and phytochemicals analysis.

Proximate chemical composition and minerals content

Ready-to-use and ready-to-eat CVDs were subjected to chemical analysis (moisture, crude protein, crude lipids, ash, crude fibre according to methods of AOAC [24]. However, the carbohyrates content was determined by defference according to Merrill and Watt [25]. The minerals content including sodium, potassium, calcium was determined in both prepared fresh and fried vegan diets using flame photometry while magnesium, iron, copper, manganese and zinc contents were determined by atomic absorption spectroscopy according to AOAC [24]. A standard colorimetric method was employed for phosphorus as mentioned by Borah et al. [26].

Ascorbic acid determination

The ascorbic acid content in various CVDs either ready-to-use and ready-to-eat applying the 2,6-dichloroin-dophenol titrimetric

Ingredients [a]	Ready-to-use CVD recipes (%)					
	CCVD	PCVD	ZCVD	TCVD	BCVD	SCVD
Peeled soaked chickpea	30	30	30	30	30	30
Cauliflower	20	–	–	–	–	–
Green pea	–	20	–	–	–	–
Green Zucchini	–	–	20	–	–	–
Taro	–	–	–	20	–	–
Green bean	–	–	–	–	20	–
Green Spinach	–	–	–	–	–	20
Fixed ingredients [b]	50	50	50	50	50	50

[a] : All mentioned ingredients were obtained on fresh status from the different local markets in Egypt (see materials),

[b]: Fixed ingredients were mixed as [24% blanched sweet potato, 20% whole barley flour, 14% blanched carrot puree, 14% green leafy herbs mix (coriander: dill: parsley; 2:1:1), 12% red pepper paste, 10% fresh onion, 2.5% salt, 1.5% fresh garlic and 2% dried spices mixed as (25% pepper, 20% cumin, 20% relish (Boharat), 10% dry coriander, 10% sweet paprika, 10% dry ginger and 5% dry chili)].

Table 1: Innovative chickpea-based ready-to-use vegan diet recipes.

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method was determined according to AOAC [24]. Vitamin C content is expressed as mg 100 g^{-1} fw. A pure ascorbic acid (Sigma) was used to prepare a standard solution as (1 mg ml^{-1}).

Total phenolic content (TPC) determination

One g of freeze-dried ready-to-use and ready-to-eat CVDs was mixed with 25 ml of 70% methanol (v/v). The mixes were shaken vigorously in a dark bottle for 100 min at 100 rpm. After centrifugation at 3,225 xg for 10 min, the supernatant was collected and the residue was re-extracted twice with 15 ml 70% methanol for total phenolic content and antioxidant activity determination. To avoid oxidation, all extracts were stored in the dark at -18 ± 1 °C and analyses were performed within 48 h. The TPC of ready-to-use CVDs as well as ready-to-eat CVDs was determined according to Folin-Ciocalteu spectrophotometric method [27]. The measurements were compared to a standard curve of prepared gallic acid (GA) solution, and the total phenolic content was expressed as milligrams of gallic acid equivalents (GAE) per gram of dried sample (mg of GAE g^{-1} dw).

Determination of antioxidant activity

The radical scavenging activity using DPPH reagent (1,1-Diphenyl-2-picrylhydrazyl) for ready-to-use and ready-to-eat CVD extracts have been carried out using modified method by Lu et al. [27]. Each extract from fresh and fried diets (0.1 ml) was added to 2.9 ml of 6×10^{-5} mol methanolic solution of DPPH. The absorbance at 517 nm was measured after the solution had been allowed to stand in the dark for 60 min. The Trolox calibration curve was plotted as a function of the percentage of DPPH radical scavenging activity. The final results were expressed as micromoles of Trolox equivalent (TE) per gram (μmol TE g^{-1} dw).

Analysis of phytochemicals

Total carotenoids determination: According to Yuan et al. [28], 5 g of each freeze-dried CVDs were extracted with a mixture of acetone and petroleum ether (1:1, v/v) repeatedly using the mortar and pestle until a colorless residue was obtained. The upper phase was collected and combined with crude extracts after washed for several times with water. The extracts were made up to a known volume with petroleum ether. Total carotenoids content was determined by recording the absorbance at 451 nm with a spectrophotometer. Total carotenoids were estimated as mg g^{-1} dw.

Flavonoids and flavonols determination: The total flavonoids content of ready-to-use and ready-to-eat CVDs were determined according to the method of Mohdaly et al. [29]. A 0.5 ml aliquot of 2% $AlCl_3$ ethanolic solution was added to 0.5 ml of the extracts and mixed well. After keeping for 1 h at room temperature, the absorbance at 420 nm was measured. A yellow color indicates the presence of flavonoids. The total flavonoids content were expressed as mg quercetin equivalent (QE) per 100 g dw. The total flavonols content were determined according to Kumaran and Karunakaran [12]. A 0.6 ml aliquot of 2% $AlCl_3$ ethanolic solution was added to 0.6 ml of each extract and 0.8 ml of a 5% aqueous sodium acetate solution were added. After mixing and keeping for 2.5 h at room temperature, the absorbance at 440 nm was measured. Total flavonols content were expressed as mg quercetin equivalent (QE) per 100 g dw.

Sensory evaluation: Sensory evaluation of the ready-to-eat CVDs immediately after preparation of the six CVDs incorporating different vegetables was carried out. Thirty panelists of the staff members and students from the Food Science Department, Faculty of Agriculture, Benha University, in the age range of 20 to 57 years were asked to evaluate the fried CVD bars towards appearance, color, taste, odor, texture, oiliness, and overall acceptability. A 7-point hedonic scale (7 being like extremely, 4 like accepted and 1 dislike extremely) was used to select the best recipe for a wide scale production. Results were subjected to analysis of variance and average of the mean values of the aforementioned attributes and their standard error were calculated according to Wilson et al. [30].

Statistical analysis: The statistical analysis was carried out using SPSS program with multi-function utility regarding to the experimental design under significance level of 0.05 for the whole results. Multiple comparisons applying LSD with Duncana,B were carried out according to Steel et al. [31].

Results

Proximate chemical composition of innovative ready-to-use and ready-to-eat CVDs

Proximate chemical composition and caloric value of six ready-

Recipes[¥]	Chemical composition (%)												Caloric value kcal/100 g [fw]	
	Moisture content		Crude protein content [dw]		Lipids content [dw]		Ash content [dw]		Crude fiber content [dw]		Carbohydrates content [dw]			
	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE
CCVD	71.39^{aA} ± 0.16	42.06^{aB} ± 0.67	27.47^{cA} ± 1.00	19.04^{deB} ± 0.98	2.13^{aB} ± 0.36	20.69^{aA} ± 0.44	8.15^{bA} ± 0.43	7.02^{aB} ± 0.11	8.33^{aA} ± 0.31	7.89^{aB} ± 0.29	54.45^{abA} ± 1.25	44.48^{aB} ± 0.28	97.35^{aB} ± 1.44	252.01^{bA} ± 2.08
PCVD	67.13^{bA} ± 0.14	38.38^{abB} ± 0.83	33.67^{aA} ± 0.53	26.89^{aB} ± 1.33	2.28^{aB} ± 0.3	18.73^{bA} ± 1.06	8.69^{bA} ± 1.98	6.93^{aB} ± 0.36	8.20^{aA} ± 0.81	8.05^{aA} ± 0.71	48.09^{cA} ± 1.19	38.51^{bB} ± 1.34	112.41^{aB} ± 0.64	262.28^{aA} ± 2.35
ZCVD	71.29^{aA} ± 0.06	39.82^{abB} ± 1.01	27.35^{cA} ± 1.04	20.35^{dB} ± 1.38	2.08^{aB} ± 0.34	18.42^{bA} ± 1.40	8.74^{bA} ± 0.07	6.24^{aB} ± 0.23	8.14^{aA} ± 0.86	7.18^{bB} ± 0.71	54.57^{abA} ± 1.14	46.01^{aB} ± 1.07	97.59^{aB} ± 2.34	256.21^{abA} ± 3.07
TCVD	69.56^{abA} ± 1.17	39.82^{abB} ± 1.01	29.14^{bA} ± 1.17	22.62^{cB} ± 1.54	2.22^{aB} ± 0.36	18.42^{bA} ± 1.41	11.46^{aA} ± 1.14	6.93^{aB} ± 0.26	8.64^{aA} ± 0.86	8.08^{aB} ± 0.80	51.85^{bcA} ± 0.44	43.05^{aB} ± 1.24	102.82^{aB} ± 2.96	254.80^{abA} ± 2.08
BCVD	71.65^{aA} ± 0.64	37.48^{bB} ± 0.96	33.96^{aA} ± 1.47	24.88^{bB} ± 1.69	1.87^{aB} ± 0.30	17.41^{bA} ± 0.32	7.83^{bA} ± 0.99	6.67^{aB} ± 0.24	8.34^{aA} ± 0.86	7.63^{bB} ± 0.76	46.79^{cA} ± 1.25	42.08^{aB} ± 1.32	94.84^{aB} ± 2.81	262.27^{aA} ± 3.90
SCVD	70.27^{abA} ± 0.05	40.76^{abB} ± 1.04	25.02^{dA} ± 1.81	18.09^{eB} ± 1.23	2.36^{aB} ± 0.39	20.47^{aA} ± 1.55	9.15^{bA} ± 1.31	7.04^{aB} ± 0.27	8.84^{aA} ± 0.86	7.90^{abB} ± 0.79	56.16^{aA} ± 1.56	45.42^{aB} ± 1.08	100.83^{aB} ± 0.49	256.40^{abA} ± 2.49

[¥]: see materials and methods, table 1,
[dw]: values were calculated on dry weight basis,
[fw]: values were calculated on fresh weight basis,
RTU: ready-to-use, RTE: ready-to-eat,
[a, b, c, ...]: means with the same letter in the same column are not significantly different (p>0.05),
[A, B, C, ...]: means with the same letter in the same raw into each parameter are not significantly different (p>0.05).

Table 2: Chemical composition of innovative read-to-use and read-to-eat chickpea-based vegan diets incorporating different vegetables (mean ± SE).

to-use and ready-to-eat CVDs prepared from different vegetables are presented in Table 2. A significant difference (p<0.05) was found between both ready-to-use and both ready-to-eat CVDs in all chemical composition parameters and caloric value. The moisture content of ready-to-use CVDs was in range of 67.13% in PCVD to a high of 71.65% in BCVD, while a low of 38.38% in PCVD to a high of 42.06% in CCVD for ready-to-eat CVDs was recorded. A significant difference (p<0.05) was found between (CCVD, ZCVD and BCVD) and PCVD neither TCVD nor SCVD, which was not similarly found after cooking. As shown, about 43.5% reduction in the moisture content of deep-fried vegan diets was recorded when calculated on means average of fresh and cooked diets. The crude protein content of the six CVDs varied from 25.02% in SCVD to 33.96% in BCVD and from 18.09% in SCVD to 26.89% in PCVD for ready-to-use and ready-to-eat CVDs, respectively. The protein content in fresh PCVD and BCVD was significantly higher than other formulated CVDs, which was similarly observed after cooking, Table 2. In the same context, crude lipid content was varied from 1.87% in BCVD to 2.36% in SCVD and from 17.41% in BCVD to 20.69% in CCVD for ready-to-use and ready-to-eat CVDs, respectively. Frying cooking increased the lipid content in all CVDs by 8.8-times when compared to fresh diets. Data presented in Table 2 showed that ash content was ranged from 7.83% in BCVD to 11.46% in TCVD for fresh diets while it was ranged from 6.24% in ZCVD to 7.04% in SCVD for fried diets. However, no significant difference (p>0.05) has been found between formulated diets after frying in ash contents. All formulated diets seem to have adequate fiber content which was not significantly different in the most of prepared diets. The carbohydrates content varied from 46.79% in BCVD to 56.16% in SCVD for fresh diets while they varied from 38.51% in PCVD to 46.01% for ZCVD for fried diets, Table 2. The caloric value was ranged from 94.8 kcal 100 g^{-1} in BCVD to 112.4 kcal 100 g^{-1} in PCVD and 252.0 kcal 100 g^{-1} in CCVD to 262.2 kcal 100 g^{-1} in PCVD calculated on fw in ready-to-use and ready-to-eat CVDs, respectively.

Minerals content of innovative ready-to-use and ready-to-eat CVDs

The minerals content (sodium, potassium, calcium, phosphorus, magnesium, iron, copper, manganese and zinc) in ppm of ready-to-use and ready-to-eat CVDs are given in Table 3. Generally, minerals content was changed after frying with different reduction rates. A significant difference (p<0.05) was found between both ready-to-use and ready-to-eat CVDs in all measured minerals. Formulated vegan diet with taro (TCVD) showed highest sodium content while the lowest content was recorded in formulated vegetarian diet with green bean (ZCVD). No significant difference (P>0.05) was found among ready-to-use or ready-to-eat CVDs. After frying, the sodium content was ranged from 503 ppm in CCVD to 644 ppm in SCVD. Potassium content in formulated CVDs with different vegetables was ranged from a low of 465 ppm in SCVD to a high of 760 ppm in TCVD. In ready-to-eat CVDs, potassium content was changed with different reduction levels to a low of 525 ppm in SCVD to a high of 680 ppm in BCVD. The BCVD showed the highest calcium content in both ready-to-use and ready-to-eat CVDs, while the lowest calcium content was recorded in both fresh and fried PCVD. Phosphorus was also determined in both ready-to-use and ready-to-eat CVDs, results were tabulated in Table 3. Formulated chickpeas with green zucchini seems to be having high phosphorus content than other formulated vegetables with same protein source while the lowest phosphorus content had been recorded in both fresh and fried BCVD. Magnesium content of 6 CVDs was assayed before and after frying cooking (Table 3). High magnesium content was found in fresh and fried SCVD followed by ZCVD diets. Iron content in different formulated vegan diets is given in the same table, which was ranged from 2.1 ppm in PCVD to 2.7 ppm in SCVD while, it was ranged from 1.9 ppm in PCVD and TCVD to 2.3 ppm in SCVD fried CVDs. Formulated chickpea with spinach (SCVD) exhibit high copper content while formulated chickpea with taro (TCVD) exhibit lower content in both ready-to-use and ready-to-eat CVDs (Table 3). The highest manganese and zinc contents were obserevd in CCVD while the low manganese and zinc contents were observed in BCVD and TCVD, respectively (Table 3).

Ascorbic acid, total phenolic compounds (TPC) and antioxidant activity of innovative ready-to-use and ready-to-eat CVDs

Data in Table 4 shows the content of vitamin C [mg 100 g^{-1} fw], TPC [mg g^{-1} dw] and antioxidant activity [μmol TE g^{-1} dw] of various innovative ready-to-use and ready-to-eat CVDs. All fresh diets demonstrated appropriate content of vitamin C which basically depends on the initial ingredients. However, the average levels of vitamin C were dramatically decreased in ready-to-eat CVDs which were influenced by frying cooking. Moreover, TPC and antioxidant activity of ready-to-use and ready-to-eat CVDs are also presented in Table 4. TPC of fresh

Recipes¥	Minerals content (ppm ^{dw})																	
	Sodium		Potassium		Calcium		Phosphorus		Magnesium		Iron		Copper		Manganese		Zinc	
	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE	RTU	RTE
CCVD	756.9^{aA} ± 21.8	503.3^{aB} ± 14.9	570.2^{bA} ± 14.6	518.9^{bB} ± 11.7	52.6^{cA} ± 2.42	57.9^{bA} ± 1.9	122.4^{cA} ± 2.9	114.9^{cB} ± 1.5	62.1^{bA} ± 2.6	58.4^{aB} ± 1.8	2.6^{aA} ± 0.2	2.3^{aB} ± 0.1	0.4^{dA} ± 0.02	0.3^{bB} ± 0.02	0.9^{aA} ± 0.05	0.8^{aB} ± 0.07	1.5^{aA} ± 0.10	1.3^{aB} ± 0.11
PCVD	721.4^{aA} ± 18.9	634.1^{aA} ± 13.5	622.8^{bA} ± 15.2	554.6^{bB} ± 12.5	41.5^{dA} ± 1.8	37.1^{cA} ± 2.5	95.9^{dA} ± 2.8	87.2d^{eA} ± 2.2	55.4^{cA} ± 2.9	49.1^{bB} ± 2.8	2.1^{aA} ± 0.2	1.9^{bB} ± 0.2	0.5^{cA} ± 0.03	0.4^{bB} ± 0.03	0.7^{bA} ± 0.05	0.6^{cB} ± 0.04	1.4^{aA} ± 0.17	1.3^{aB} ± 0.09
ZCVD	670.1^{aA} ± 16.2	589.6^{aA} ± 12.7	587.2^{bA} ± 13.7	529.1^{bB} ± 11.0	63.8^{bA} ± 2.2	51.6^{bB} ± 2.6	196.5^{aA} ± 4.6	177.2^{aB} ± 4.8	66.2^{bA} ± 3.6	54.5^{abB} ± 2.4	2.4^{aA} ± 0.2	2.1^{aB} ± 0.1	0.8^{bA} ± 0.05	0.7^{aB} ± 0.04	0.7^{bA} ± 0.05	0.6^{cB} ± 0.04	1.3^{bA} ± 0.17	1.2^{bB} ± 0.06
TCVD	792.7^{aA} ± 12.8	610.7^{aB} ± 11.6	759.1^{aA} ± 10.9	656.5^{aB} ± 12.2	78.7^{aA} ± 2.2	70.9^{aB} ± 1.8	123.3^{cA} ± 2.8	99.6^{dB} ± 3.2	53.7^{cA} ± 2.1	45.2^{bB} ± 2.0	2.4^{aA} ± 0.2	1.9^{bB} ± 0.1	0.3^{eA} ± 0.03	0.3^{bA} ± 0.03	0.8^{bA} ± 0.07	0.6^{cB} ± 0.06	1.3^{bcA} ± 0.19	1.0^{bB} ± 0.08
BCVD	705.9^{aA} ± 19.1	608.7^{aB} ± 15.2	754.7^{aA} ± 13.1	679.7^{aB} ± 11.5	78.9^{aA} ± 1.9	74.2^{aA} ± 1.8	83.3^{dA} ± 3.9	73.7^{eB} ± 2.7	53.8^{cA} ± 2.4	46.9^{bB} ± 2.8	2.5^{aA} ± 0.2	2.2^{aB} ± 0.2	0.4^{dA} ± 0.03	0.4^{bA} ± 0.02	0.7^{bA} ± 0.05	0.6^{cB} ± 0.04	1.3^{bcA} ± 0.14	1.1^{bB} ± 0.09
SCVD	678.5^{aA} ± 16.1	643.9^{aA} ± 14.6	465.3^{cB} ± 11.8	525.4^{bA} ± 14.0	78.1^{aA} ± 1.7	72.6^{aB} ± 2.7	178.1^{bA} ± 4.6	147.5^{bB} ± 4.8	74.2^{aA} ± 2.9	59.8^{aB} ± 1.9	2.7^{aA} ± 0.1	2.3^{aB} ± 0.1	1.1^{aA} ± 0.05	0.8^{aB} ± 0.04	0.9^{aA} ± 0.05	0.8^{bB} ± 0.04	1.2^{cA} ± 0.21	1.1^{bB} ± 0.06

¥: see materials and methods, table 1,
dw: values were calculated on dry weight basis,
RTU: ready-to-use, RTE: ready-to-eat,
a, b, c, ...: means with the same letter in the same column are not significantly different (*p*>0.05),
A, B, C, ...: means with the same letter in the same raw into each parameter are not significantly different (*p*>0.05).

Table 3: Minerals content of innovative read-to-use and read-to-eat chickpea-based vegan diets incorporating different vegetables (mean ± SE).

Citation: Barakat H (2014) Fate of Nutritional and Bioactive Compounds of Innovative Chickpeas-Based Vegan Diets Incorporating Different Vegetables. J Nutr Food Sci 4: 302. doi: 10.4172/2155-9600.1000302

prepared CVDs was ranged from a low of 66.7 mg GAE g^{-1} for ZCVD to a high of 80.3 mg GAE g^{-1} for SCVD, whereas a low of 53.3 mg GAE g^{-1} for TCVD to a high of 72.0 mg GAE g^{-1} for CCVD for fried diets were noticed. The evolution of DPPH radical scavenging activity of various CVDs was assayed using the common DPPH assay before and after frying and results are referred to Trolox equivalent g^{-1} [μmol TE g^{-1}], given in Table 4. The antioxidant activity ranged from low of 122.0 μmol TE g^{-1} in ZCVD to high of 151.9 μmol TE g^{-1} in SCVD for ready-to-use CVDs. The antioxidant activity slightly decreased after frying to be in range of 108.1 μmol TE g^{-1} in ZCVD to 147.0 μmol TE g^{-1} in CCVD for ready-to-eat CVDs. The content of TPC and related antioxidant activity in different CVDs showd different significances Patterns in both ready-to-use and ready-to-eat CVDs owing to a result of cooking method impact.

Recipes[¥]	Ascorbic acid [mg 100 $g^{-1\ fw}$]		TPC [mg $g^{-1\ dw}$]		Antioxidant activity [μmol TE $g^{-1\ dw}$]	
	RTU	RTE	RTU	RTE	RTU	RTE
CCVD	50.47^{aA} ± 1.46	14.55^{Ab} ± 0.17	76.98^{aA} ± 2.41	72.03^{aA} ± 1.19	151.37^{aA} ± 0.85	146.96^{aA} ± 2.43
PCVD	46.59^{abA} ± 2.36	14.37^{Ab} ± 0.20	68.39^{bA} ± 0.30	64.26^{abA} ± 1.89	112.83^{cA} ± 0.49	107.95^{cA} ± 1.59
ZCVD	48.28^{abA} ± 2.91	15.96^{aB} ± 0.27	66.67^{bA} ± 0.14	55.41^{bB} ± 1.77	122.03^{bA} ± 0.90	108.10^{cA} ± 2.25
TCVD	45.75^{bA} ± 1.33	15.96^{aB} ± 0.27	69.24^{bA} ± 2.60	55.41^{bB} ± 1.77	135.14^{bA} ± 1.06	122.84^{bB} ± 1.64
BCVD	50.95^{aA} ± 1.79	15.36^{aB} ± 0.23	68.93^{bA} ± 1.58	53.33^{bB} ± 1.65	145.15^{aA} ± 1.2	118.23^{bcB} ± 2.34
SCVD	50.67^{aA} ± 1.28	14.41^{aB} ± 0.25	80.34^{aA} ± 0.13	61.92^{bB} ± 2.01	151.88^{aA} ± 0.27	124.79^{bB} ± 1.77

¥: see materials and methods, table 1,
dw: values were calculated on dry weight basis,
fw: values were calculated on fresh weight basis,
RTU: ready-to-use, RTE: ready-to-eat,
a, b, c, ...: means with the same letter in the same column are not significantly different (*p*>0.05),
A, B, C, ...: means with the same letter in the same raw into each parameter are not significantly different (*p*>0.05).

Table 4: Ascorbic acid, total phenolic compounds and antioxidant activity of innovative read-to-use and read-to-eat chickpea-based vegan diets incorporating different vegetables (mean ± SE).

Phytochemicals of innovative ready-to-use and ready-to-eat CVDs

The phytochemicals such as chlorophylls, carotenoids, flavonoids, and flavonols of ready-to-use and ready-to-eat CVDs have been investigated and data are given in Figure 1 (a, b, c, and d). The frying cooking treatment caused a significant loss of chlorophyll *a* and *b* significantly ($p<0.05$). The content of chlorophyll *a* in ready-to-eat CVDs was significantly reduced by 49, 47, 53, 57, 48 and 70% for CCVD, PCVD, ZCVD, TCVD, BCVD, and SCVD, respectively. Moreover, the content of chlorophyll *b* was also significantly reduced by 40, 52, 29, 35, 36 and 49% for CCVD, PCVD, ZCVD, TCVD, BCVD, and SCVD, respectively, (Figure 1a). The frying cooking of innovate CVDs caused a loss of total carotenoids which ranged from 27% in SCVD to 39% in BCVD, (Figure 1b). A significant loss of flavonoids content was observed in ready-to-eat CVDs when compared to ready-to-use ones. The total flavonoids loss was ranged from 12 to 40% in PCVD and BCVD, respectively, (Figure 1c). The results for total flavonols illustrated that frying had also pernicious effect on total flavonols content, where 18 and 44% loss was observed in PCVD and BCVD, respectively (Figure 1d).

Organoleptic properties of innovative ready-to-eat chickpea-based CVDs

Sensory evaluation of food products is an important criterion by which its consumer acceptability can be assessed. The sensory evaluation

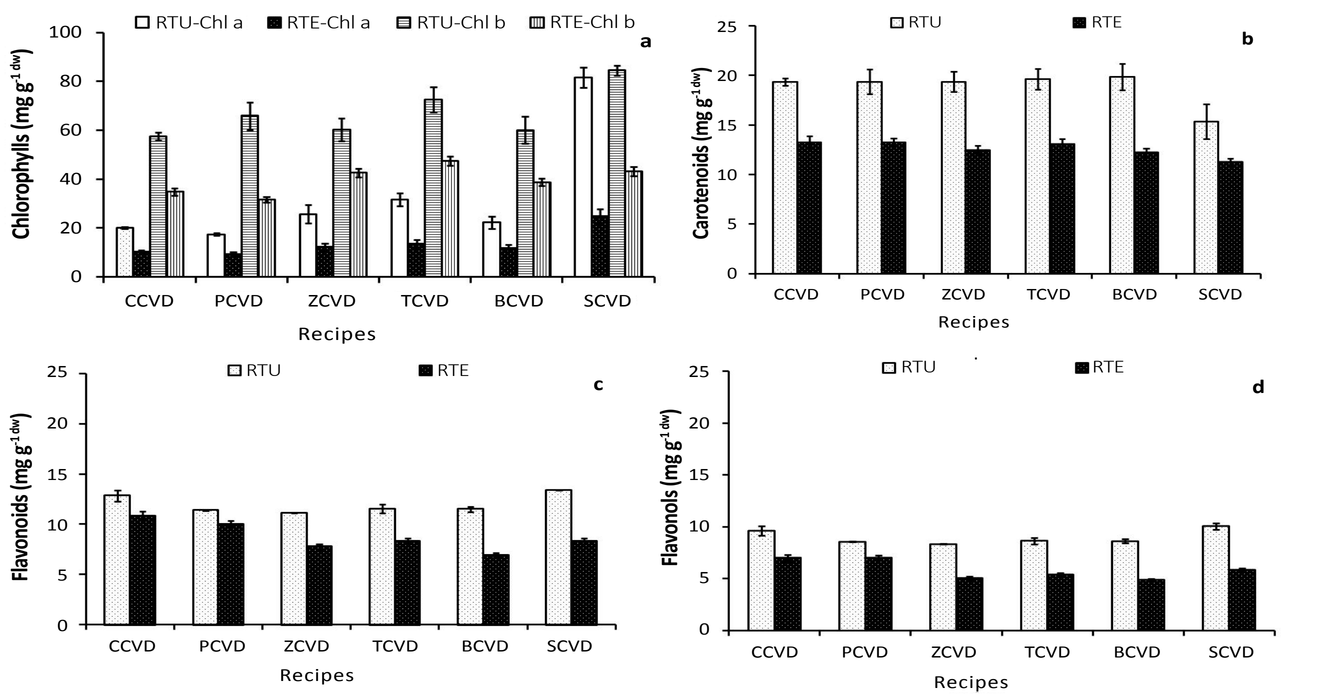

Figure 1: Phytochemicals profile of innovative chickpea-based vegan diets incorporating different vegetables, RTU: read-to-use, RTE: read-to-eat. Recipes; CCVD: caluiflower chickpea-based vegan diet, PCVD: pea chickpea-based vegan diet, ZCVD: zucchini chickpea-based vegan diet, TCVD: taro chickpea-based vegan diet, BCVD: bean chickpea-based vegan diet and SCVD: spinash chickpea-based vegan diet (see table 1, material and methods).

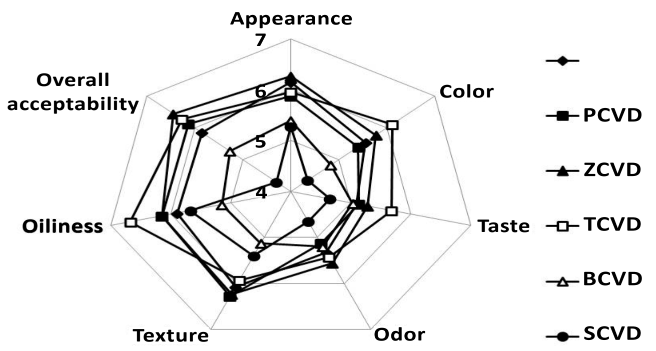

Figure 2: Organoleptic properties of innovative read-to-eat chickpea-based vegan diets incorporating different vegetables. Recipes; CCVD: caluiflower chickpea-based vegan diet (-♦-), PCVD: pea chickpea-based vegan diet (-■-), ZCVD: zucchini chickpea-based vegan diet (-▲-), TCVD: taro chickpea-based vegan diet (-□-), BCVD: bean chickpea-based vegan diet and SCVD (-Δ-): spinash chickpea-based vegan diet (-●-), see Table 1, material and methods.

of ready-to-eat CVDs based on a seven-point hedonic scale showed that all fried diets recorded mean scores higher than 4 (acceptable score) for all tested parameters, (Figure 2). The appearance of ready-to-eat CVDs showed high mean scores for CCVD, ZCVD and TCVD. The most preferable color for the panelists was recorded for TCVD diets while lowest score was recorded for SCVD. Results for taste, as the most important organoleptic property showed that TCVD and ZCVD were the best preferred significantly. Odor attracts the consumer and is able to increase his appetite. The highest score was recorded for CCVD, ZCVD and TCVD. The cooking method affected the texture of those innovative diets, where the texture of ZCVD, PCVD, and CCVD was significantly preferred while the lowest texture score was recorded for BCVD. Oiliness reflects the oil retaining after cooking and panelists were asked to give higher score for lower oil content after pressing the vegan bars between their fingers. The lowest retaining oil level had been recorded for TCVD while the highest retaining oil level bad been recorded for BCVD, significantly. The statistical analysis had been classified the diets in four groups significantly according to the overall acceptability, (Figure 2). Moreover, the overall acceptability scores indicated that the different diets could be arranged as ZCVD > TCVD > PCVD > CCVD > BCVD > SCVD.

Discussion

The present study firstly aimed to formulate CVDs incorporating different vegetables with other ingredients to serve a balanced diet for consumers as ready-to-use and ready-to-eat CVDs. Practically, obtained results of proximate chemical composition concluded that prepared diets are considered as valuable source of crude protein, lipid, fiber and carbohydrates both ready-to-use and ready-to-eat CVDs which may have appropriate health benefits [1,4,14,32-34]. Formulated diets with legume vegetables such as green pea and bean increased the crude protein content as a result of its initial protein content as mentioned before [6,17]. However, applying the deep frying cooking method increased the lipid content which influenced the nutritional composition to be in agree with Barakat [35]. Thus, deep-frying can be changed to microwaving, steaming or baking which may lead to drastic reduction in lipid content in the diets (further study). Also, ready-to-eat CVDs exhibited valuable lipid content which increased the caloric value of the prepared diets. According to Dietary Reference Intakes [36], the Recommended Dietary Allowances (RDA) of protein is ranged from 34-56 g d^{-1} for age ranging from 9-70 years of both genders, which increased to 71 g d^{-1} for females in pregnancy and lactation. The formulated CVD, 100 g dw could provide at least 45% of the RDA for adults and at least 40% of the RDA for pregnant and lactating womens daily. In context, Adequate Intake (AI) of dietary fiber could be compensated by at least 35% when consuming 100 g dw of CVD daily. Moreover, RDA of carbohydrates is 130 g d^{-1} for age ranging from 9-70 years of both genders, which increased to 210 g d^{-1} for females in pregnancy and lactation. Consuming about 100 g dw of CVD could provide at least 28% of the RDA for adults and at least 21% of the RDA for pregnant and lactating women (about 90% absorbance efficiency). Accordingly as shown, 100 g of ready-to-eat CVDs fw could provide about 252-262 kcal which is cover the requirements of adult person (70 kg) for about 3 - 4 hrs [36,37].

Formulated diets with chickpea and different vegetables demonstrated appropriate minerals content, (Table 3). This result may be basically depends on depression or increase of these minerals content in used vegetables or protein sources as main ingredients in formulated diets. However, the minerals content had minus changes after frying in the different vegan diets. This may be due to the influence of frying method which increasing the absorbed oil and consequently increasing the lipids content. These results were in agreement with [5,26,35,38-40]. Furthermore, studies have been concluded that chickpea contain various minerals and could be efficiently successful to slows glycemic response and to combat global micronutrient malnutrition [36,41-43]. Our presented results of minerals composition may compatible with vegetables and legumes minerals content which were reviewed by Gebhardt and Thomas [37]. For human requirments, the presented minerals content in 100 g dw of prepared CVDs could provide 48, 14, 7, 9, 22, 12, 48, 52 and 15% from the the daily AI and RDA. As mentioned in Dietary Reference Intakes [36]. The AIs for sodium, potasium, calcium, and manganese are 1000-1500, 3000-5100, 500-1300, and 1.2-1.3 mg d^{-1}, whereas the RDAs for phosphorus, magnesium, iron, copper, and zince are 460-1250, 80-420, 8-27, 0.34-1.3, and 3-13 mg d^{-1}. The presented CVDs seem to be low in some minerals content and supplementing experiment is needed further.

Recently, research has confirmed a strong relationship between the amount of available biologically active compounds in vegetables and their antioxidant properties [44-52]. A drastic reduction of vitamin C was remarked after frying cooking of all diets as influenced by cooking temperature to be in agreement with Francisco et al. [53]. In the present study, the effect of frying cooking on TPC of CVDs and their antioxidant properties have been determined (Table 4). Appropriate data of TPC for many vegetables are available but a few are available on similar vegan diets [35,54] which more or less confirmed the results of the present study. The antioxidant activity of vegan diets correlates with the TPC. However, it is known that phenolic compounds are not stable under thermal conditions and may be transformed into other compounds. Obtained results illustrated that scavenging activity was decreased upon the effect of frying process [44,54]. Indeed, studying the effect of diffrent cooking method on such prepared CVDs will guide the food producers to select the best cooking method for nutritional and organoleptic characteristics (further study).

Phytochemicals are found virtually in plant-based foods and promoted to prevent and treat many related health dieases. In present study, chlorophylls, carotenoids, flavonoids, and flavonols contents of ready-to-use vegan could provide rich phytochemicals content (Figure 1). The applied cooking method was drastically affected the phytochemicals content in fried diets. The chlorophyll's content is responsible for the degree of greenness and is important for the determination of a vegetable's quality [55]. Further, it was reported that chlorophylls and its derivatives exert beneficial effects such as anticarcinogenic and antimutagenic activities [56]. However, green vegetables exhibit poor color quality and the chlorophyll's content decreases after being thermally processed [57]. In the present study, frying led to loss of chlorophylls significantly. This result is in agreement with a study described by Yuan et al. [28] and Barakat [35]. Chlorophyll *b* exhibits more heat resistance compared with chlorophyll *a*. The chlorophyll *a* and *b* were retained by 30-53% and 48-71% in ready-to-eat CVDs, respectively. In contrast, Turkmen et al. [56] observed that chlorophyll *a* is more heat resistant compared with chlorophyll *b* in five of six vegetables. Carotenoids have been extensively studied for their potential protection against numerous cancer diseases. In recent years, several reports on the retention of total carotenoids in cooked vegetables are available [28,52,58]. In all diets, formulation of CVDs incorporating different vegetables exhibit rich carotenoids content, a result of increasing the carotenoids content in chickpeas grains, carrot and sweet potato [59]. It is presented herein that, total carotenoids, flavonoids and flavonols were retained by 61-73, 60-88, and 56-79%, respectively. The retained content may depends on initial carotenoids, flavonoids and flavonols content, vegetable structure or diet matrix, and leaching of the carotenoids and its derivatives into the oil followed by thermal degradation during frying cooking, being similar to reports by [28,35,52,60].

In our previous study, the given organoleptic data by most panelists confirmed that chickpea could be the best protein source for preparing CVDs when compared statistically with soy and faba bean [35]. Thus, the chickpea was used as main protein source in formulated vegan diet in present study. Regarding to the organoleptic properties, the panelists provided high scores for all prepared diets especially for TCVD and ZCVD. This may be due to the reflected organoleptic characteristics of those diets which might be the most preferred. In contrary, low score has been obtained in SCVD which might be due to the effect of thermal processing on green color of spinach and its disproportionate structure [61]. Reducing the water content with a corresponding denaturation of proteins and browning reactions are reasons for a good texture [30,62]. Therefore, formulation of chickpea and different vegetables in combination with rich bioactive ingredients is hereby recommended as edible vegan diet, particularly during off-seasons when other conventional vegetables are scarce, expensive or not available. It is recognized that over-reliance on one single food, or food group, will not provide the range of nutrients required for optimum health and well-being. Thus, the prepared CVDs could be a considerable trail to improve the dietary practices and general health in low income countries. Therefore, new Egyptian Standards for regulation of ready-to-use and ready-to-eat CVDs could be required.

Conclusion

Vegan diets are associated with reduced risk of many diseases in health-conscious individuals. Accordingly, moderation and variety in individual diets is recommended. The current study concluded the potential applicability of different innovative chickpea-based CVDs incorporating different vegetables. Obtained results could provide sufficient information about macro- and micronutrients, phytochemicals content and their antioxidant activity as well as sensory attractiveness of prepared CVDs. Highly consumer acceptability could be an encourage motive for large scale applications. However, studies about formulating different functional diets as well as shelf-life stability should be investigated further. The current study could also provide valuable impact of thermal treatment for optimizing the cooking conditions as well as for designing new functional foods. Expressively, the lack and deficiency of some vitamins and minerals should be concerned further.

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Citation: Barakat H (2014) Fate of Nutritional and Bioactive Compounds of Innovative Chickpeas-Based Vegan Diets Incorporating Different Vegetables. J Nutr Food Sci 4: 302. doi: 10.4172/2155-9600.1000302