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

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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 requirements. 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 B12 and essential amino acids in valuable amounts which could make them not sufficient 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, multisectional, multidisciplinary, and culturally relevant approach.

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Accordingly, the main objectives of this study were to investigate the possibility to prepare innovative CVDs from chickpea as protein source incorporating 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 chilli], 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 1x1x1 cm cubes. The yellow and undesired spinach leaves were removed after removing the pinkrots of green spinach then, rippled by 1-2 cm. All prepared vegetables were washed and blanched for appropriate time (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, rinsed 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 paprika, 10 g dry ginger, and 5 g dry hot chilli] 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.

### Materials and Methods

#### Ingredients

- **Six different vegetables**
  - Cauliflower (Brassica oleracea var. botrytis)
  - Pea (Pisum sativum L.)
  - Green zucchini (Cucurbita pepo L.)
  - Taro corms (Colocasia esculenta L.)
  - Green bean (Phaseolus vulgaris L.)
  - Green spinach (Spinacia oleracea L.)

- **Proximate chemical composition and minerals content**

- **Proximate chemical composition and minerals content**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>CCVD</th>
<th>PCVD</th>
<th>ZCVD</th>
<th>TCVD</th>
<th>BCVD</th>
<th>SCVD</th>
</tr>
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<tr>
<td>Peeled soaked chickpea</td>
<td>30</td>
<td>30</td>
<td>30</td>
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<td>20</td>
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<td>Green pea</td>
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<tr>
<td>Green Zucchini</td>
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</tr>
<tr>
<td>Taro</td>
<td>-</td>
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<td>20</td>
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<tr>
<td>Green bean</td>
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<td>-</td>
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<td>20</td>
<td>-</td>
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<tr>
<td>Green Spinach</td>
<td>-</td>
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<td>-</td>
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<td>20</td>
</tr>
<tr>
<td>Fixed ingredients</td>
<td>50</td>
<td>50</td>
<td>50</td>
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<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

*: 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 (Baharat), 10% dry coriander, 10% sweet paprika, 10% dry ginger and 5% dry chilli).

**Table 1**: Innovative chickpea-based ready-to-use vegan diet recipes.
method was determined according to AOAC [24]. Vitamin C content is expressed as mg 100 g⁻¹ dw. 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 mixtures were shaken vigorously in a dark bottle for 10 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 antioxidative 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 6x10⁻³ 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 vigorous in a dark bottle for 100 min at 100 rpm. After centrifugation 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

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

<table>
<thead>
<tr>
<th>Recipes</th>
<th>Moisture content</th>
<th>Crude protein content</th>
<th>Lipids content</th>
<th>Ash content</th>
<th>Crude fiber content</th>
<th>Carbohydrates content</th>
<th>Caloric value kcal/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVD</td>
<td></td>
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<tr>
<td></td>
<td>RTU</td>
<td>RTE</td>
<td>RTU</td>
<td>RTE</td>
<td>RTU</td>
<td>RTU</td>
<td>RTU</td>
</tr>
<tr>
<td>CCVD</td>
<td>71.39 ± 0.16</td>
<td>42.06 ± 0.67</td>
<td>27.47 ± 1.00</td>
<td>19.04 ± 0.98</td>
<td>2.13 ± 0.36</td>
<td>20.69 ± 0.44</td>
<td>8.15 ± 0.43</td>
</tr>
<tr>
<td>PCVD</td>
<td>67.13 ± 0.14</td>
<td>38.38 ± 0.83</td>
<td>33.67 ± 0.53</td>
<td>28.89 ± 0.73</td>
<td>2.28 ± 0.33</td>
<td>18.73 ± 1.06</td>
<td>8.69 ± 0.43</td>
</tr>
<tr>
<td>ZCVD</td>
<td>71.26 ± 0.06</td>
<td>39.82 ± 1.01</td>
<td>27.35 ± 1.10</td>
<td>20.35 ± 0.93</td>
<td>2.08 ± 0.34</td>
<td>18.42 ± 1.40</td>
<td>8.74 ± 0.07</td>
</tr>
<tr>
<td>TCVD</td>
<td>69.56 ± 0.17</td>
<td>39.82 ± 1.01</td>
<td>29.14 ± 1.17</td>
<td>22.62 ± 1.54</td>
<td>2.22 ± 0.36</td>
<td>18.42 ± 1.41</td>
<td>11.46 ± 0.14</td>
</tr>
<tr>
<td>BCVD</td>
<td>71.65 ± 0.64</td>
<td>37.48 ± 0.96</td>
<td>33.96 ± 1.47</td>
<td>24.88 ± 1.69</td>
<td>1.87 ± 0.30</td>
<td>17.41 ± 0.99</td>
<td>7.83 ± 0.24</td>
</tr>
<tr>
<td>SCVD</td>
<td>70.27 ± 0.05</td>
<td>40.78 ± 1.04</td>
<td>25.02 ± 1.09</td>
<td>18.09 ± 0.93</td>
<td>2.39 ± 0.39</td>
<td>20.47 ± 1.51</td>
<td>9.15 ± 0.45</td>
</tr>
</tbody>
</table>

* 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 raw into each parameter are not significantly different (p>0.05).

a, b, c, ... = means with the same letter in the column are not significantly different (p>0.05).
A, B, C = means with the same letter in the raw into each parameter are not significantly different (p>0.05).
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 BCVD 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 for neither TCVD nor SCVD, which was not similarly found after cooking. As shown, about 43.5% reduction in the moisture content of deep-fried fresh vegeatins 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 from 1.87% in BCVD to 2.36% in SCVD and from 17.41% in BCVD to 26.22% in PCVD for 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 CVDs in range of 67.13% in BCVD to 112.4 kcal 100 g -1 in PCVD and 252.0 kcal 100 g -1 in CCVD calculated on fw in ready-to-use and ready-to-eat CVDs. The caloric value was ranged from 94.8 kcal 100 g -1 in BCVD to 112.4 kcal 100 g -1 in PCVD calculated on fw in ready-to-use and ready-to-eat CVDs. The moisture content varied from 46.79% in BCVD to 56.16% in SCVD for fresh diets while it was ranged from 6.24% in ZCVD to 7.04% in SCVD for fried diets. Moreover, the average levels of vitamin C were 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 formulated diets was higher than the values of TPC of ready-to-use and ready-to-eat CVDs. Formulated dietwith switch of green zucchini seems to be having high antioxidant activity of innovative ready-to-use CVDs. TPC and antioxidant activity of ready-to-use and ready-to-eat CVDs are also presented in Table 4. TPC of fresh formulated diet with switch of green zucchini seems to be having high antioxidant activity of innovative ready-to-use CVDs.
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 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 BCVD and SCVD, respectively. Moreover, the content of chlorophyll a was also 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 flavonoids illustrated that frying had also pernicious effect on total flavonoids content, where 18 and 44% loss was observed in PCVD and BCVD, respectively, (Figure 1d).

**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 flavonoids illustrated that frying had also pernicious effect on total flavonoids 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...
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 had 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 intrinsic 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 dw 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 slow glyemic 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 requirements, 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, potassium, 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 zinc are 400-1250, 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 different 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 diseases. 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 chlorophyll 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, drying led to loss of chlorophyll 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 depend on initial carotenoids, flavonoids and flavonols content, vegetable structure or diet matrix, and leaching of the carotenoids and their 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 trial 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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