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APPLICATION OF MULTI CRITERIA DECISION TECHNIQUE TO DETERMINE THE BEST CHICKPEA CULTIVARS WITH HIGH ANTIOXIDANT POTENTIAL

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ABSTRACT

In this study, technique for order preference by similarity to ideal solution (TOPSIS) analysis, which is multi criteria decision making method, was firstly applied to rank the most suitable cultivars among 12 registered chickpeas for high antioxidant potentials. Registered chickpea cultivars were grown in trial fields of state research institute in 2015, Adana, Turkey. The cultivars were analyzed for the criteria such as their water-soluble protein content (WSPC), total phenolic content (TPC), free radical scavenging activity (FRSA) and iron chelating activity (ICA) which were related to their antioxidant potentials. However, depending on each criterion, the ranking of the cultivars was completely different so that TOPSIS analysis was applied to the obtained data in six steps. Firstly, the decision matrix was constructed and then each criterion was weighted as respectively 0.40, 0.30, 0.20, 0.10 for FRSA, TPC, ICA, and WSPC by the researchers. After the weighted normalized decision matrix was constructed, the positive ideal and negative ideal solutions were determined. Then the separation measures for each alternative were calculated (Si* and Si- for the separation from positive and negative ideal alternative, respectively). Finally, the relative closeness to ideal solution was calculated (Ci*). The cultivar Seçkin with the highest Ci* value (0.776) was the first rank and followed by Aydın, Azkan, and Çakır. This study showed the usefulness of TOPSIS analysis in the multi criteria decision making process when the presence of different parameters related to same property of sample set such as antioxidant potential of chickpea cultivars.

Keywords: *multi criteria decision technique, TOPSIS, chickpea, antioxidant potential.*

INTRODUCTION

Chickpea is an ancient crop which was domesticated in southeastern Turkey and spread to other parts of the world dominantly in tropical, subtropical, and temperate regions about 45 countries (Atalay and Babaoglu, 2012; Ozkilinc et al., 2011; Özer et al., 2010). The major producer of chickpea is India with 9.9 M tones production and followed by Australia, Myanmar, Ethiopia, and Turkey (FAO, 2014). It is the third most important pulse crop after dry bean and pea and consumed as flour, canned, roasted, boiled, fermented, fried steamed, or eaten as snack food (Bibi et al., 2007; Coşkuner and Karababa, 2004; Çelik et al., 2016; Özer et al., 2010). Chickpea is good source of protein (15-29 %), carbohydrate (41-47 %), dietary fiber (14-18 %), minerals and vitamins (Bibi et al., 2007; Çelik et al., 2016; Mafakheri et al., 2011; Özer et al., 2010; Torutaeva et al., 2014). However, chickpea is cultivated mostly in arid or semiarid Mediterranean environment of West Asia and North Africa, it has been adopted in North America, western Canada, Australia, New Zealand, and Central Europe due to its high nitrogen utilization efficiency and high protein yield under drought conditions (Neugschwandtner et al., 2015; Oweis et al., 2004; Sadras and Dreccer, 2015; Siddique et al., 2012). Biotic factor such as ascochyta blights and abiotic factors such as cold, drought, salinity, and micronutrient deficiencies lower the chickpea yield (Atalay and Babaoglu, 2012; Mafakheri et al., 2011; Siddique et al., 2012). Due to its low genetic polymorphism and limited genetic variation, it is relatively difficult to develop resistant varieties through classical breeding methods to mentioned stress factors (Atalay and Babaoglu, 2012). The studies showed that winter sown chickpea is more tolerant to biotic and abiotic stresses than spring or summer chickpea (Oweis et al., 2004).

Chickpea seeds have many bioactive and functional properties that are important for health-related products and other processed products. Chickpea proteins, hydrolysates, and peptides had considerable phenolic content with important antioxidant activities based on free radical scavenging activities and metal chelating abilities (Kou et al., 2013; Torres-Fuentes et al., 2015; Zhao et al., 2014). Chickpea proteins had also the potential to be used as functional plant based protein source because their functional properties were comparable with or superior than those of soy and animal origin proteins (Aydemir and Yemenicioglu, 2013). Many researchers were also reported the studies related to good functional properties of chickpea flours or proteins (Ghribi et al., 2015; Withana-Gamage et al., 2011; Xu et al., 2017). Processed chickpea products are also suitable as replacement of wheat flour or value-added ingredient for functional food productions such as mayonnaise, muffin batter, gluten-free spaghetti, salad dressing, etc (Alamri et al., 2013; Alu'datt et al., 2017; Alvarez et al., 2017; Demi et al., 2010; Flores-Silva et al., 2014; Ma et al., 2016). In addition to tolerance to stress factors and yield, the bioactive and functional properties of chickpea seed should be considered if value added products formation is aimed. In this study, a comprehensive evaluation of the antioxidant potentials of 12 registered chickpea cultivars, which were developed by breeding methods and grown in 2015, Adana, Turkey, was performed by using Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method which was one of the best and widely used multiple criteria decision making technique to choose the best alternative that had the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution (Kou et al., 2015).

MATERIALS AND METHODS

Materials: 12 registered chickpea cultivars were kindly donated by Dr. Dürdane Mart from Eastern Mediterranean Agricultural Research Institute. *Preparation of chickpea extracts*: Chickpea seeds were firstly grounded to obtain chickpea flour and extracted in deionized water as 500 mg chickpea flour in 5 ml deionized water stirring overnight. Then the suspensions were centrifuged (15000×rcf, 25˚C, 30 min) and supernatant were collected and named as chickpea extract. Total moisture content of chickpea flours was measured with moisture analyzer (Ohaus MB 45, Switzerland).

Antioxidant potentials of chickpea extracts: Total phenolic content (TPC) of extracts were spectrophotometrically determined by using Folin-Ciocalteu's reagent. The absorbances were measured at 765 nm as 3 replicates and results were expressed as mg gallic acid/g dry weight basis (dwb). Free radical scavenging activity (FRSA) of extracts were determined spectrophotometrically at 734 nm. The inhibition of ABTS free radical solution by antioxidants in cickpea extract was measured as three replicates and the results were expressed as µmol Trolox/g dwb. Iron chelating activity (ICA) of extracts were spectrophotometrically determined at 562 nm by measuring the binding of Fe^{2+} (formed by reaction of $FeCl_2.4H_2O$ and ferrozine) with the groups in chickpea extract as three replicate sand the results were expressed as µmol EDTA/g dwb (Aydemir et al., 2014). Water soluble protein content (WSPC) of chickpea extracts were determined by Lowry method as three replicates and the results were expressed as mg casein / g dwb.

TOPSIS comprehensive evaluation method: TOPSIS method was developed to overcome rank problems in multiple criteria decision making (Hwang and Yoon, 1981). The details of the steps of TOPSIS method were expressed as follow: In step 1, decision matrix was established. In step 2, normalized decision matrix was calculated. In step 3, the weighted normalized decision matrix was calculated. In step 4, positive and negative ideal solutions were determined. In step 5, the distance of each alternative from positive and negative ideal solution was determined. In step 6, the closeness coefficient of each alternative was determined (Kou et al., 2015).

RESULTS AND DISCUSSIONS

Antioxidant potential of chickpea extracts: Phenolic compounds were related to antioxidant activity of plant extracts due to their free radical scavenging activities and metal chelating activities. In this study, water extracts of registered chickpea flours had significantly varied TPC between 1471 - 2152 µg gallic acid / g (Table 1). While their FRSA changed from 1544 to 2514 µmol Trolox / g, ICA values were between 1.1 and 17.7 µmol EDTA / g. Their WSPC was similar to each other and varied from 48 to 77 mg casein / g.

Table 1. Antioxidant parameters of registered chickpea cultivars (dry weight basis)

Registered Cultivar	**FRSA (µmol Trolox/g)**	**ICA (µmol EDTA/g)**	**TPC (µg GA/g)**	**WSPC (mg casein/g)**
Aksu	15.44±0.8	4.5±0.7	1474±73	57±1.4
Arda	23.08±0.4	10.8±1.0	2060±14	48±2.8
Aydin	21.18±0.1	15.9±2.0	1782±71	68±5.0
Azkan	18.97±0.9	17.7±0.3	1559±521	52±6.4
Çakir	25.14±1.7	14.4±0.7	2152±20	62±4.8
Diyar	20.96±1.9	4.8±2.5	1995±114	65±7.1
Gülümser	21.04±1.7	1.1±0.3	2080±72	55±4.6
Hasanbey	21.83±0.9	8.7±0.4	1993±136	51±2.9
Ilgaz	19.43±0.7	8.2±1.1	1785±161	68±5.9
İnci	20.45±1.5	3.1±1.4	1983±128	61±4.2
İzmir	18.45±0.5	10.3±0.6	1655±49	66±4.7
Seçkin	23.15±1.5	14.3±0.8	1984±78	77±5.5

TOPSIS method: When all the measured parameters were evaluated it is hard to decide which cultivar is the best in terms of antioxidant potential. Because in each criterion, the ranking is different. Therefore, in order to rank the cultivars that fits more to the desired purpose, TOPSIS was applied. In TOPSIS method, the researchers joined the study assigned different weights to the measured parameters subjectively. The attributed weights were 0.40 for FRSA, 0.30 for TPC, 0.20 for ICA, and 0.10 for WSPC. After the normalized decision matrix was established, the weighted normalized matrices were established (Table 2).

The positive and negative ideal solutions of antioxidant parameters were determined by taking the maximum and minimum values for each criterion:

The positive ideal solutions = {0.133, 0.095, 0.099, 0.036}

The negative ideal solutions = {0.088, 0.006, 0.068, 0.023}

Then the distances from positive and negative ideal solution were calculated and the relative closeness of each value was calculated. The final rankings according to distances and closeness coefficient of each sample was shown in Table 3.

Table 2. The weighted normalized matrices for registered chickpea cultivars

Registered Cultivar	FRSA	ICA	TPC	WSPC
Aksu	0.0883	0.0243	0.0676	0.0267
Arda	0.1326	0.0576	0.0945	0.0227
Aydin	0.1085	0.0850	0.0818	0.0320
Azkan	0.1138	0.0950	0.0716	0.0245
Çakir	0.1071	0.0769	0.0988	0.0292
Diyar	0.1031	0.0258	0.0916	0.0305
Gülümser	0.1114	0.0060	0.0955	0.0258
Hasanbey	0.1244	0.0466	0.0915	0.0241
Ilgaz	0.1145	0.0437	0.0819	0.0320
İnci	0.1284	0.0164	0.0910	0.0285
İzmir	0.1261	0.0550	0.0760	0.0309
Seçkin	0.1200	0.0765	0.0911	0.0363

Table 3. The ranking of registered chickpea cultivars evaluated by the TOPSIS method.

Registered Cultivar	S*	S^{-}	C*	Rank
Aksu	0.0895	0.0188	0.1732	12
Arda	0.0401	0.0731	0.6458	5
Aydin	0.0314	0.0833	0.7260	2
Azkan	0.0351	0.0927	0.7253	3
Çakir	0.0320	0.0800	0.7141	4
Diyar	0.0758	0.0353	0.3174	10
Gülümser	0.0922	0.0363	0.2826	11
Hasanbey	0.0511	0.0593	0.5371	7
Ilgaz	0.0570	0.0490	0.4622	8
İnci	0.0795	0.0479	0.3759	9
İzmir	0.0468	0.0630	0.5734	6
Seçkin	0.0236	0.0820	0.7765	1

S^{*}: The distance of each alternative from positive ideal solution, **S^{-} :** The distance of each alternative from negative ideal solution, **C*:** The closeness coefficient of each alternative

According to the analysis, Seçkin cultivar had the 1st rank as having the highest antioxidant potential and followed by Aydın, Azkan, and Çakır. This study was the first study that TOPSIS method was applied to cultivar selection based on defined property. In the literature of food science and agriculture, 21 studies were reported comprising TOPSIS evaluation to choose the best alternative according to Web of Science.

CONCLUSIONS

Chickpea is one of the most important crop in the world due to being cheap and having high nutrition quality especially good protein content. However, it is mostly cultivated in arid and semi-arid area, the adaptation studies have been conducted for Central Europe, North America and Canada. Chickpea products such as flours, proteins, hydrolysates are suitable for functional food additive in processed foods with their good technological properties and considerable bioactive properties. This study screened the antioxidant potentials of registered chickpea cultivars based on different property measurements and the problem about the choosing the best cultivars was tackled by TOPSIS method for the first time in the literature. It was also seen that TOPSIS method has the potential to choose the best cultivar in multi criteria decision problems in this area.

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