

Value adding search among a selection of Tunisian fennel (*Foeniculum vulgare* Mill.) cultivars: Nutritional composition, chlorophyll and β -carotene contents of fennel seeds

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Abstract

Foeniculum vulgare has an important medicinal and economic role due to the frequent use of different parts of the plant. However, fennel seeds are the most exploited especially in culinary preparations and food industries. In order to highlight the benefits of this spice, physico-chemical composition of 7 fennel cultivars was carried out. Results revealed high contents of sugars, proteins and ash, and low contents of fat and water. The highest sugar content was displayed by the cultivar Cv₂ (61±1.87 %) and the lowest one was obtained by cultivar Cv₅ (31.41±1.77 %). Statistically significant differences between the 7 fennel cultivars were shown among their respective protein contents. Interestingly, all of the 7 cultivars, except one (Cv₃: 7.91±0.07 %), revealed high levels of protein contents. Moreover, assessment of physiological parameters of the 7 cultivars gave evidence of high β -carotene contents. Despite, chlorophyll assessment results gave moderate content levels. Taking into account results from the present work, in addition to our previous published findings, 4 fennel cultivars were selected, essentially, based on their nutritional composition while searching for future potential industrial applications.

1. INTRODUCTION

Foeniculum vulgare is a native plant of the eastern Mediterranean basin. It is distributed in Central Europe and the Mediterranean regions (Vienna et al., 2005; Zahid et al., 2009; Aprotosoiaie et al., 2010). Fennel is an aromatic plant belonging to the Apiaceae (Umbelliferae) family. The name of the genus is due to the fineness of the leaf segments reminiscent of hay (Latin: fenum) (Beniston, 1975). The genus *Foeniculum* is very polymorphic and is divided into two subspecies: ssp. *piperitum* and ssp. *vulgare* (Badoc, 1988; Vienna et al., 2005; EFSA, 2009). *Foeniculum vulgare* Mill. subsp. *vulgare* is made up of three varieties: var. *vulgare* (bitter, common, wild or medicinal fennel), var. *dulce* (sweet fennel) and var. *azoricum* (bulb fennel)

(Amimar et al., 2001; Vienna et al., 2005; Kothe, 2008).

F. vulgare is widely cultivated for its edible fruit (bulb-shaped fennel) or for its seeds. Fennel is one of the most important vegetable with high nutritional value due to its richness in potassium, sodium, phosphorus and calcium. Also, fennel is well-known for its high content levels of vitamins compared to human needs (Badgujar et al., 2014). Moreover, fennel seeds contain around 7.27% of water content, 56.35% of carbohydrates, 9.96% of lipids, 23.19% proteins, 10.50% of ash, and 17.51% of dietary fiber (Bukhari et al., 2014).

In addition to primary metabolites, fennel is very rich in secondary metabolites, namely phenolic compounds, hydrocarbons and volatile compounds, extracted from different parts of the

plant. Generally, these phytochemicals are found in the essential oil (EO). Some of the phytoconstituents of *F. vulgare* have found application as colorants and anti-aging agents (Rasul et al., 2012). They also have remarkable biological and pharmacological activities. Applications in food industries have also taken place such as the addition of fennel seeds EO in Labneh (Abou Ayana and Gamal El Deen, 2011) and the fortification of yoghurt with the decoction of fennel seed powder (Caleja et al., 2016) and (Ben Abdesslem et al., 2019).

In this context, a biochemical study of 7 fennel cultivars was carried out as part of a varietal selection work searching for potential industrial applications.

2. MATERIAL AND METHODS

2.1. Plant material

The seeds of 7 cultivars of *F. vulgare* (Table 1) were collected in the research station of the Regional Research Center of Horticulture and Organic Agriculture, Chott Meriam, Sousse Governorate, Tunisia. These cultivars, among a collection of 62 fennel entries, have been the subject of a morphological characterization. A

Table 1. Origin of the 7 fennel cultivars (Cv₁-Cv₇)

Cultivar name	Cultivar code	Original source	Pays
TUN ₅₀	Cv ₁	Cap Bon (commercial)	Tunisia
CTAB ₁₃	Cv ₂	Sousse (CTAB)	Tunisia
IND ₁₅	Cv ₃	Inde (commercial)	India
BLMC ₃₂	Cv ₄	Sousse (farmer 2)	Tunisia
BLMC ₅	Cv ₅	Sousse (farmer 2)	Tunisia
CHR ₅	Cv ₆	Monastir (farmer)	Tunisia
BLMB ₁₁	Cv ₇	Sousse (farmer 1)	Tunisia

CHR: Chrahill region; BLMB: Baloum region; BLMC: Baloum region; CTAB: Centre Technique de l'Agriculture Biologique; TUN: Tunisian fennel; IND: Indian fennel.

selection process based on this characterization came out with the 7 cultivars as a sub-collection representative of the initial morphological diversity. The powder of each sample was used for physico-chemical analysis.

2.2. Determination of macronutrients

The protein, ash and moisture contents of the samples were determined using AOAC procedures. Then, the crude protein content of the samples was estimated by the kjeldhal method (AOAC, 2006). Whereas the ash content was determined by incineration at 600°C for 3h (AOAC, 2000). Also, the moisture content was

calculated according to the AOAC (1990) method. The dosage of total sugars was carried out according to the phenol/sulphuric acid method described by (Dubois *et al.*, 1956). In addition, total fat content was evaluated by the standardized Soxhlet method described by AFNOR NFEN ISO 659 (1988).

2.3. Determination of photosynthetic pigment

Total chlorophyll and carotenoids contents were measured using the method described by Chu *et al.* (1976) and Kingsbury (1986). Powder of each cultivar (200 mg) was homogenized in acetone (80%). The solution was centrifuged and the absorbance of the supernatant was measured at 412; 431; 460 and 480 nm. Then, chlorophyll (chlorophyll a and b, Chla and Chlb respectively) and carotenoids (β -carotene contents were calculated using the following equations:

$$\text{Chla (mg/mL)} = -1,709*(A_{412}) + 11,970*(A_{431}) - 2,993*(A_{460}) - 5,708*(A_{480})$$

$$\text{Chlb (mg/mL)} = -0,171*(A_{412}) - 0,23*(A_{431}) + 11,871*(A_{460}) - 13,248*(A_{480})$$

$$\beta\text{-carotene (mg/mL)} = -0,43*(A_{412}) + 0,251*(A_{431}) - 4,376*(A_{460}) + 13,216*(A_{480})$$

2.4. Statistical analysis

The collected data were subjected to univariate statistical analysis (ANOVA), using SPSS software version 20 (IBM Corp, 2011). The Duncan test for comparison of means was applied at $P < 0.05$.

3. RESULTS AND DISCUSSION

3.1. Chemical composition of fennel seeds

Assessment of fennel seeds' composition of each cultivar is summarized in Table 2. The results of statistical analysis showed a significant

Table 2. Biochemical Composition expressed as a percentage by mass of fresh material (%FM) of fennel seeds*

Cultivar	Moisture (%)	Ash (%)	Sugar (%)	Proteins (%)	Lipids (%)
Cv ₁	6.34±0.20 ab	7.01±0.40 a	51.48±4.93 b	19.68±0.92 c	7.56±0.34 cd
Cv ₂	6.84±0.02 bc	7.53±0.39 ab	61±1.87 c	18.50±1.05 c	8.31±0.54 e
Cv ₃	5.89±0.13 a	8.20±0.62 bc	55.23±5.33 bc	7.91±0.07 a	6.53±0.50 b
Cv ₄	7.8±0.63 de	8.54±0.29 c	35.21±1.33 a	25.19±1.66 e	5.43±0.27 a
Cv ₅	8.05±0.53 e	8.78±0.22 c	49.07±2.11 b	29.88±0.94 f	6.67±0.20 b
Cv ₆	6.95±0.82 bcd	7.12±0.43 a	31.41±1.77 a	13.24±0.75 b	8.03±0.23 de
Cv ₇	7.54±0.42 cde	6.80±0.44 a	53.58±3.87 b	24.42±0.48 d	7.22±0.29 bc

*Means followed by different letters in the same column were significantly different ($p < 0.05$) using Duncan test.

difference between cultivars ($P < 0.05$). Hence, the different cultivars presented a great variability within the studied components. In general, we notice that the fennel seed contains less than a tenth of water, with fennel from cultivar 5 (Cv₅) having the highest water content, while cultivar 3 (Cv₃) presented the lowest content (5.89%). This result is in agreement with results of previous study of Rather *et al.* (2016) where the authors concluded that water content of fennel cultivar was around 6.3%. The cultivar 2 (Cv₂) showed the highest sugar content (61%) followed by Cv₃, Cv₇ and Cv₁ cultivars with sugar contents equal to 55.23, 53.58 and 51.48 %, respectively. These findings are close to those found by Malhotra (2012) and Rather *et al.* (2016) with sugar content levels around 36.6% and 42.3% for fennel from Hungary and India, respectively.

The obtained results as shown in Table 2 indicate that fennel seeds from Cv₄, Cv₅ and Cv₇ showed high protein contents in addition to high water contents. Cultivar Cv₅ had the highest protein content (29.88%), exceeding the Algerian fennel seed protein content (17.5%) as reported by Lazouni *et al.* (2007). As for lipids, fennel seeds contain 10 to 14.41% oil (Malhotra, 2012); which is composed of saturated and unsaturated fatty acids. During this study, all fennel cultivars presented low to medium lipid contents ranging from 5.43 to 8.31%. The lowest values were found in cultivars with high water and protein contents, while the maximum value was found in Cv₂ with the highest carbohydrate content. Our results agree with those of Bukhari *et al.* (2014) and Faten *et al.* (2011). Indeed, these authors showed lipid contents of fennel seeds were equal to 9.76% and 9.96%, respectively. For the ash content of the different fennel cultivars, our results are in line with those

from Kaur and Arora (2010) work which showed that fennel seeds contain 9.8% ash.

In general, the 7 fennel cultivars had a rich nutrients composition, especially in sugars and proteins, medium water and ash contents, and low lipid contents when compared to data from the literature. Basically, observed differences between cultivars at the level of biochemical composition can be attributed to genetic reasons.

3.2. Photosynthetic parameters of fennel seeds

Assessment of total chlorophyll contents revealed that the highest amount belongs to the

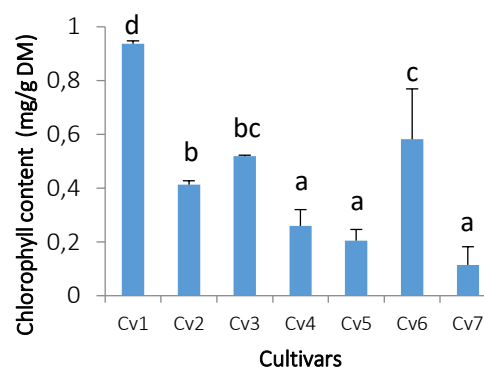


Fig. 1. Total chlorophyll content of fennel seed cultivars

cultivar Cv₁ (Fig. 1). Whereas, the lowest β -carotene content was measured in Cv₅ (Fig2). Significant differences ($P < 0.05$) were observed among cultivars for chlorophyll content.

Indeed, the cultivar Cv₁ presented the highest total chlorophyll content with 0.93 ± 0.01 mg/g DM, while cultivar Cv₇ presented the lowest level of total chlorophyll content (0.11 ± 0.06 mg/g DM). Chlorophyll is considered as a healthy

compound. It has several atouts: it is the main photosynthetic pigment and it has the particularity of being an excellent oxygen provider; it is an excellent acid-base regulator; it maintains the internal pH balance, and it is a powerful antioxidant (Leventinac, 2011).

The fennel cultivars had similar classification based on total chlorophyll content and β -carotene content (Fig. 2), where the lowest values were again displayed by cultivars Cv₅, Cv₄ and Cv₇. Whereas, highest β -carotene content was measured in the case of cultivar Cv₁. Overall, all fennel cultivars had substantial levels of β -carotene, which increases their nutritional value. Moreover, it is interesting to know the content of chlorophylls and β -carotene in fennel seeds given the large number of applications in the food, pharmaceutical and cosmetic industries of this spice. Hence the need for its characterization and the selection of high-performance cultivars that meet natural, economic and industrial requirements.

Fennel seeds exhibited a high content in sugars and proteins with an appreciable content in water content, ash and lipids. Fennel seeds also showed high β -carotene content and a considerable level of total chlorophyll content. Subsequently, our data showed high nutritional value of fennel, especially for some of the cultivars. It makes it possible to suggest valorization of the fennel seeds' powder in different food applications like incorporation in cake, bread, or meat, or any other kind of industrial applications.

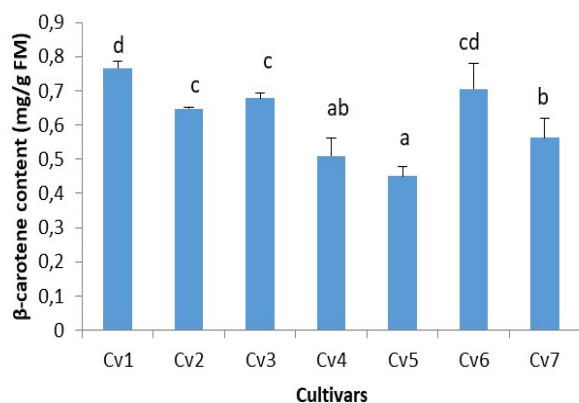


Fig 2. β -carotene content of fennel seed cultivars

Additionally to the present work, we had carried out composition analysis of the essential oil of our fennel cultivars' seeds (Ben Abdesslem *et al.*, 2020). Also, we had previously established a new formulation of steamed yoghurt with the addition of FEO at a dose of 5 μ l/100 ml of

pasteurized milk (Ben Abdesslem *et al.*, 2019). We have shown that this fortification had no significant effect on pH variation. Besides, recorded pH values were within the interval of acceptable values and in agreement with the literature (Shahdadi *et al.*, 2015; Caleja *et al.*, 2016). As for titratable acidity (TA), the incorporation of FEO did not affect the viability of lactic acid bacteria which continued to produce lactic acid until the end of storage period. Globally, physico-chemical, rheological (such as syneresis and viscosity), and microbial properties of formulated yoghurt were improved following the addition of FEO and extended its shelf-life by one day compared to the control (Ben Abdesslem *et al.*, 2019).

Potentially, several industrial applications, using fennel seed powder or FEO, could be carried out based on present work results in addition to our previous studies. For instance, the cultivar Cv₂ was found rich in sugars (61%), in trans-anethole (72.73%) (Ben Abdesslem *et al.*, 2020) and β -carotene (0.647 mg/mg DM) that are considered of high interest in diets nowadays. On the other hand, cultivar Cv₆ with a considerable nutritional composition, in addition to its richness in chlorophyll (0.584 mg/mg DM) and β -carotene, as well as its essential oil with high content of trans-anethole (66.73%), could be considered for the preparation of a tea using dried seeds (Saber and Eshra, 2019). Moreover, cultivar Cv₁ had a high content of phenolic compounds and a very effective antibacterial activity against *Staphylococcus aureus*, *listeria monocytogenes* and *Esherichia coli* (Ben Abdesslem *et al.*, 2020). Also, essential oil of cultivar Cv₁ was shown to have a high content of methyl-chavicol (76.29%) (Ben Abdesslem *et al.*, 2020). Hence, cultivar Cv₁ is intended to be used in the pharmaceutical industry. Furthermore, cultivar Cv₇, had a high contents of sugars (52.45%), proteins (22.67%) and lipids (8.08%), β -carotene, in addition to its flavouring seeds' essential oil (high content of trans-anethole 81.21%), could be used as a flavoring agent for the preparation of cake, biscuit or bread (Das *et al.*, 2013; Sayed Ahmed *et al.*, 2017).

To sum up the essential features of best selected cultivars, Table 3 is giving a detailed description of 4 selected cultivars. As shown in Table 3, several industrial applications could be considered during future research that needs to be performed in collaboration with a specialized industrial structure.

Table 3. Best selected fennel cultivars based on their seed's powder features and respective potential industrial applications

Cultivar	Advantages	Disadvantages	Applications
Cv ₂	High content of sugars 61 %), proteins (18.50 %) & lipids (8.31%). High content of β-carotene (0.647 mg/g DM). High content of trans-anethole (72.73%).	Height at flowering (173 cm).	Determination of the chemical composition of sugars by HPLC. Tea or Mouth freshner (Barros <i>et al.</i> , 2010). Tea or Mouth freshner (Mukhwas) (Saber and Eshra, 2019); PMFME (Fennel Processing).
Cv ₆	High content of sugars (53.24%), proteins (16.13%), & lipids (6.4%). High content of chlorophyll (diet) (0.584 mg/g DM). High content of β-carotene (0.71 mg/g DM). High content of trans-anethole (66.73%) & limonene (10.24%).	Height at flowering (136.25 cm).	Determination of the chemical composition of sugars by HPLC (Barros <i>et al.</i> , (2010). Fennel seed liqueur (Traditional method).
Cv ₁	High content of sugars (51.48%), proteins (19.68%). High content of chlorophyll (diet) (0.937 mg/g DM). High content of β-carotene (0.767 mg/g DM). High phenolic content (46.35 mg GAE/ g DM). Significant antibacterial activity against <i>S. aureus</i> ; <i>L. monocytogenes</i> and <i>E. coli</i> .	High content of methylchavicol (76.29%) (Carcinogenic molecule).	Pharmaceutical industry
Cv ₇	High content of sugars (52.45%), proteins (22.67%) & lipids (8.08%). Low content of chlorophyll (green colouring effect) (0.284 mg/g DM). High content of β-carotene (0.497 mg/g DM). High yield of essential oil (4.3%) High content of trans-anethole (81.21%).	Moderate antioxidant and antibacterial activities.	Food industry: Flavoring agent in baking cake, biscuit, bread...etc), and confectionary industries. Dairy products (yogourt, cheese ...etc.) (Ben Abdesslem <i>et al.</i> , 2019; Das <i>et al.</i> , 2013; Sayed-Ahmed <i>et al.</i> , 2017).

(Ben Abdesslem *et al.*, 2019; 2020 & present work)

4. CONCLUSION

The present work brought valuable information on the potential valorization of the different fennel cultivars at an industrial level. Collaboration with an industrial unit aiming the application of fennel powder as a natural aroma among cake constituents is intended in the near future.

REFERENCES

- Abou Ayana, I.A.A., and Gamal El Deen, A.A. (2011). Improvement of the properties of goat's milk labneh using some aromatic and vegetable oils. *Int. J. of Dairy Sc.*, 6: 112–123.
- AFNOR. (1988). V03-908. Juin 1988. Graines oléagineuses. Détermination de la teneur en huile. Méthode simplifiée par extraction à l'hexane.
- Amimar, Z., Lamarti, A., Badoc, A., Reduron, J.P., Ouahabi, S. and Muckensturm, B. (2001). Clonage du fenouil doux par culture d'apex. *Bull. Soc. Pharm. Bordeaux*, 140, pp.43-58.
- AOAC, (1990). Official methods of analysis. 15rd edn. USA, Virginia: Association of Official Analytical Chemists.
- AOAC. (2000). Association of Official Analytical Chemists, 17th ED. published by A.O.A.C. International Maryland, U.S.A.
- AOAC. (2006). Association of Official Analytical Chemists. Official Methods of Analysis. In: Horwitz, W. (Ed.), 18th Ed. AOAC Press, Arlington, VA, USA. pp. 1-48.
- Aprotosoiaie, A.C., Spac, A.D., Hancianu, M., Miron, A., Tanasescu, V.F., Dorneanu, V. and Stanescu U. (2010). The chemical profile of essential oils obtained from fennel fruits (*Foeniculum vulgare* Mill.). *FARMACIA*, Vol. 58 (1); 46-54.
- Badgujar, S.B., Patel, V.V. and Bandivdekar A.H. (2014). *Foeniculum vulgare* Mill: A review of its Botany, Phytochemistry, Pharmacology, Contemporary Application and Toxicology. *Biomed Res. Int.*
- Badoc, A. (1988). Contribution à l'étude du genre *Foeniculum* Mill. Thèse Doct. Sci., Univ. Lille Flandres Artois, 246 p.
- Barros, L., Carvalho, A.M., and Ferreira, I.C.F.R. (2010). The nutritional composition of fennel (*Foeniculum vulgare*): shoots, leaves, stems and inflorescences. *LWT-FOOD SCI TECHNOL*, 43(5): 814–818.
- Ben Abdesslem, S., Boulares, M., ElBaz, M., Ben Moussa, O., St-Gelais, A., Hassouna, M., and Aider, M. (2020). Chemical composition and biological activities of fennel (*Foeniculum vulgare* Mill.) essential oils and ethanolic extracts of conventional and organic seeds. *Journal of Food Processing and Preservation*.45(1): 1-13.
- Ben Abdesslem, S., Ben Moussa, O., Boulares, M., Elbaz, M., Chouaibi, M., Ayachi, S., and Hassouna, M. (2019). Evaluation of the effect of fennel (*Foeniculum vulgare* Mill.) essential oil addition on the quality parameters and shelf-life prediction of yoghurt. *Int. J. Dairy Technol.* 73(2): 403-410.
- Beniston, N.T. and Beniston, W.S. (1975). Fleurs d'Algérie. ENL. Alger, 134.
- Bukhari, H., Shehzad, A., Saeed, K., Butt, M. S., Tanveer, S., Iftikhar, T., and Din, U.S. (2014). Compositional profiling of fennel seed. *Pakistan J. Food Sci*, 24(3): 132–136.
- Caleja, C., Barros, L., Antonio, A.L., Carocho, M., Oliveira, M.B and Ferreira, I.C.F.R. (2016). Fortification of yogurts with different antioxidant preservatives: a comparative study between natural and synthetic additives. *Food Chem.*, 210: 262–268.
- Chu, T.M., Aspinall, D., and Paleg, L.G. (1976). Stress metabolism. VII, salinity and proline accumulation in barley. *Aust J Plant Physiol*, 3(2): 219-228.
- Das, L., Raychaudhuri, U., and Chakraborty, R. 2013. Herbal fortification of bread with fennel seeds. *Food Technol. Biotechnol*, 51(3): 434-440.
- Dubois, M., Gilles, J.K., Hamilton, A.K., Rebers, P.A., and Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Anal. Chem*, 28: 350-356.
- EFSA, (2009). EFSA Scientific cooperation (ESCO) working group on botanicals and botanical preparations; Advice on the EFSA guidance document for the safety assessment of botanicals and botanical preparations intended for use as food supplements, based on real case studies on request of EFSA. *EFSA Journal*, 7 (9): p: 280; p: 104.
- Faten, A.E., Farag, M., and Hanan, A.K. (2011). Chemical analysis of fennel seeds, basil leaves and their essential oil contents. *J. Biol. Chem. Environ. Sci*, 6(2): 127-145.
- IBM Corp. 2011. IBM SPSS Statistics for Windows Version 20.0. Armonk, NY: IBM Corp.
- Kaur, G.J. and Arora, D.S. (2010). Bioactive potential of *Anethum graveolens*, *Foeniculum vulgare* and *Trachyspermum ammi* belonging to the family Umbelliferae - Current status. *J. Med. Plant Res.*, 4(2): 87-94.
- Kingsbury, R. W. (1986). Salt sensitivity in wheat. *Plant Physiol*, 80: 651-654.
- Kothe, H.W. (2008). 1000 plantes aromatiques et médicinales. Terre editions. Toulouse, 328p.

- Lazouni, H.A., Benmansour, A., Taleb-Bendiab, S.A., and Chabane, S.D. (2007). Composition des constituants des huiles essentielles et valeurs nutritives de *Foeniculum vulgare* Mill. *Sciences & Technologie*, 25: 7-12.
- Leventİnanç, A. (2011). Chlorophyll: Structural Properties, Health Benefits and Its Occurrence in Virgin Olive Oils. Review Paper / DerlemeMakale. *Akademik Gıda* 9 (2): 26-32.
- Malhotra, S, K. (2012). Fennel and fennel seed. Indian Council of Agricultural Research, Indxia. In book: Handbook of Herbs and Spices, Edition: 2, Chapter: Fennel and fennel seed, pp.275-302.
- Rasul, A., Akhtar, N., Khan, B.A., Mahmood, T., Zaman, S., and Shoab Khan, H.M. (2012). Formulation development of a cream containing fennel extract: in vivo evaluation for anti-aging effects. *Pharmazie*, 67(1):54–58.
- Rather, M.A., Dar, B.A., Sofi, S.N., Bhat, B.A., and Qurishi, M.A. (2016). *Foeniculum vulgare*: A comprehensive review of its traditional use, phytochemistry, pharmacology, and safety. *Arab. J. Chem*, 9: 1574–1583.
- Saber, J.I., and Eshra, D.H. (2019). Using fennel seeds and their oil as a preservative and functional food to produce some food and drink products to alleviate cough symptoms. *Alex. Sci. Exch*, 40(3): 406-414.
- Sayed-Ahmad, B., Straumite, E., Šabovics, M., Krūma, Z., Merah, O., Saad, Z., Hijazi, A., and Talou, T. (2017). Effect of addition of fennel (*Foeniculum vulgare* L.) on the quality of protein bread. *Proc. Latvian Acad. Sci, Section B*, 71(6): 509-514.
- Shahdadi, F., Mirzaie, H., Kashaninejad, M., Khomeiri, M., Ziaifar, A.M., and Akbaria, A. (2015). Effects of various essential oils on chemical and sensory characteristics and activity of probiotic bacteria in drinking yoghurt. *Commun. Agric.*, 3: 16-21.
- Vienna, C.F., Bauer, R., Carle, R., Tedesco, D., Tubaro, A. and Zitterl-Eglseer, K. (2005). Assessment of plants/herbs, plant/herb extracts and their naturally or synthetically produced components as “additives” for use in animal production. *FEEDAP* ; 297p.
- Zahid, N.Y., Abbasi, N.A., Hafiz, I.A. and Ahmad, Z. (2009). Genetic diversity of indigenous fennel (*Foeniculum vulgare* Mill.) Germplasm in pakistan assessed by RAPD markers. *Pak. J. Bot.*, 41 (4): 1759-1767.