Utilization of Marjoram to Improve the Nutritional Value and the Safety of Snacks

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ABSTRACT
The herb marjoram is one of the most important crops for increasing Egypt's foreign currency earnings. Marjoram is also a common spicy medicinal herb. It's also used in food all over the world to add flavor. The mineral content, vitamin A content and fatty acid profile of the marjoram herb were estimated in this study. The sensory properties, quality properties, mineral content, fatty acid composition and physical properties of snacks containing marjoram powder (2.5, 5, and 7.5 %) were also assessed fatty acids (PUFA), followed by monounsaturated fatty acids (MUFA) and saturated fatty acids (SFAs). The data revealed that the marjoram herb has mineral content. The vitamin A content of the marjoram herb, on the other hand, was 1570.36 mg/kg. Marjoram herb also contains a high amount of unsaturated fatty acids (74.35%), especially Linolenic acid (44.9 %). The results, on the other hand, showed that there were no major variations in all sensory properties between the marjoram-fortified snacks and the control snacks at p ≤ 0.05. The addition of marjoram powder to snacks improved the snack's consistency. The most prevalent fatty acids in marjoram-fortified snacks were polyunsaturated. On the other hand, Elaidic acid isomers in snacks containing marjoram powder decreased as marjoram powder levels increased. As different levels of marjoram powder were increased, all minerals present in snacks increased. When the amount of marjoram powder added was increased from 0 to 7.5 %, the water absorption index of snack samples increased and the expansion ratio decreased. Finally, adding marjoram powder to the snack formulation improved the micronutrient content, sensory quality, Tran's fatty acid content and nutritional quality of the snacks.

Keywords: Marjoram, minerals, fatty acids and snacks product

1. Introduction
Marjoram is a perennial herb or under shrub with sweet pine and citrus flavors that belongs to the Lamiaceae family. There are approximately 360 species in the genus Origanum. (El-Eshmawy et al., 2009).

Marjoram leaves, whether fresh or dried, and their essential oil are commonly used in food processing as a food ingredient, herbal tea, flavoring, coloring, nutritional, and natural preservatives (Holley and Patel, 2005). Sweet marjoram leaf, in particular, contains 3% volatile oil, tannins, steroids, flavonoid glycosides, and triterpenoids including oleanolic and ursolic acids (Vagi et al., 2002).

The main source of minerals for humans and medicinal formulations that can be used to supplement the deficiency of specific elements is food. Many micronutrients contained in herbs can be found in plant materials. Herbs also have the benefit of being bioavailable (Vallverdu-Queralt et al., 2014).

In the coming decades, the World Health Organization (WHO) predicts that coronary heart disease (CHD) will remain the world's third leading cause of death (Mackay and Mensah, 2004).

TFA use is linked to an increased risk of coronary heart disease and diabetes mellitus (Mozaffarian et al., 2006). Packaged snacks, bakery items, poultry, deep-fried, swift, and frozen foods are all major sources of TFA in the diet (Micha and Mozaffarian, 2008).

Snack foods are delicious, low-cost items that come in a variety of flavors and appeal to people of all ages. Corn snacks are a form of snack made from corn grits, rice, wheat, or other cereals, and are
often flavored with cheese, oil, chili, onion or garlic powder, and a variety of other spices. However, many customers are reducing their snack intake due to health concerns, as many of these items contain 25% oil, which contains saturated fatty acids as well as a high content of Tran's fatty acids (Majumdar and Singh, 2014).

By incorporating additional sources such as soy protein isolate, various efforts have been made to produce snacks with higher nutritional value and fewer side effects (Veronica et al., 2006). The current research aimed to evaluate the mineral content, vitamin A percentage, and fatty acid profile of the marjoram herb. Additionally, the sensory, consistency, mineral content, fatty acid composition, and physical properties of snacks containing marjoram powder were assessed.

2. Materials and Methods

2.1. Materials

Marjoram herb for this study was obtained from the Desert Research Centre in Cairo, Egypt, All of the ingredients for the snacks were purchased from local market in Kafir El-Sheikh, Egypt. The chemicals and reagents were provided from El-Gomhoria Chemicals and Drug Company in Tanta, Egypt. All of the reagents and chemicals were grade pure.

2.2. Methods

2.2.1. Preparation of marjoram herb

The marjoram grass was dried for 30 hours in a hot oven at 40°C, and then milled in a hammer mill (Moulinex Odacio 3). The powder was sieved through a cell sieve with a mesh size of 50.

2.2.2. Determination of Minerals content:

Minerals content in marjoram herb and snack samples were determined calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) according to Chapman and Pratt's (1978), using atomic absorption spectrophotometer (Zeiss FMD3). Whereas, potassium (K) and sodium (Na) were determined using a flame photometer according to the method defined by Kirk and Sawyer (1991). Total phosphorus was determined by ascorbic acid technique using the colorimetric method that described by Murphy and Riley (1962).

2.2.3. Determination of vitamin A by HPLC

Vitamin A was determined using HPLC according to the method described by Plozza et al., (2012). The tests were carried out using an Agilent technologies 1200 series high-performance liquid chromatography system with a variable wavelength detector (330 nm for vitamin A) and a water series 2695 quaternary solvent delivery system with a cooled autosampler at 4°C and heated column compartment at 30°C. The compounds were isolated on a 10 μm Bondclone 3.9 x 300 mm C18 column with a C18 guard column (phenomenex, Sydney, Australia). At a flow rate of 1 ml/min, the mobile process was made up of water: methanol (5:95).

2.2.4. Fatty acid profile

The fatty acids composition of the oil extracted from marjoram herb and snacks samples was determined at room temperature using the method described by Conkerton et al., (1995). The ISO 1995 method was used to prepare fatty acids methyl ester of marjoram herb and snack samples, which were then, analyzed using a gas chromatograph (GC-1000, DANI, Italy) and a flame ionization detector that was slightly modified according to Azadmard and Dutta (2006). Fatty acids were identified by acquiring chromatograms and comparing their retention times to those of normal fatty acid methyl esters (Sigma Aldrich, St. Louis, MO).

2.2.5. Preparation on Snack

Snacking preparation process was carried out using the procedure of Selani et al., (2014). Corn was incorporated by marjoram powder at levels of 2.5, 5, and 7.5 % in primary experiments. By applying a mixture of water and oil (1:2 ratio v/v), the moisture content of both treatments was increased to 18%. A Brabender laboratory twin-screw extruder, model 2150510, serial 94011, with a die opening of 4mm and a screw speed of 249 rpm was used to complete the extrusion operation. The compression
ratio of the extruder screw was 3:1, the length/diameter ratio was 20/1, the length was 38 cm, and the
diameter was 19 mm. The first (feed) zone's temperature was set to 80°C, while the second (metering)
zone's temperature was set to 90°C, and the third zone's temperature was set to 140°C.

2.2.6. The sensory evaluation of snacks incorporated with marjoram powder:
Sensory testing was carried out on three various rates (2.5, 5, and 7.5 %) of snacks containing
marjoram powder, and it was compared with snack prepared with marjoram powder as control sample.
The samples were addressed to a jury of twenty people drawn from the University laboratories. All
snack samples were evaluated for sensory properties as defined by Meilgaard et al., (2007).

2.2.7. Chemical composition of snacks incorporated with marjoram powder
Chemical compositions as moisture content, crude protein, total lipids and the ash content were
determined according to AOAC (2010). Available total carbohydrates were determined by subtracting
[100 - (protein + fiber + fat + ash)] from the total.

2.3. Physical properties of snacks incorporated with marjoram powder
2.3.1. Water solubility and absorption index
Water solubility and absorption index were estimated in different snack samples according to
Huang and Ma (2016).
The was mixed for three minutes, then left at 27°C for 30 minutes, shaking every 10 minutes for
10 seconds, and centrifuged for ten minutes at 3000g (Kubota KN-70 Centrifuge, Japan). After that, The
centrifuge tube was weighed again after the supernatant was carefully poured into an aluminum dish.
The following equations were used to measure the water solubility and absorption index

\[
\text{Water solubility index} \, \% = \frac{\text{Dry solids weight supernatant}}{2} \times 100
\]

\[
\text{Water absorption index} \, (g/g) = \frac{\text{Weight grain of gel}}{2} \times 100
\]

2.3.2. Bulk density
The bulk density was determined according to the methods described by Chau (1998). By gently
tapping the cylinder on the benchtop 20 times, a known amount of snacks were packed into a 10 mL
graduated cylinder. When the volume of the contents could no longer be decreased, a precise volumetric
measurement was taken, and the result was expressed in gram per cm³.

2.3.3. Radial expansion
Radial expansions were determined as outlined by Huang and Ma (2016) using the following
equation:

\[
\text{Radial expansion} = \frac{D}{D^2}
\]

Where D (cm) is the average diameter of cross-sectional of twenty extruded snacks pieces and
D2 (cm) is the diameter of the die nozzle. The diameter of cross-sectional was measured using a caliper
(Mitutoyo, Tokyo, Japan).

2.4. Statistical analysis
The samples were analyzed in triplicate, and the findings are presented as mean value ± standard
deviation. The data were compared using analysis of variance with a significance level of 5% (Ribeiro,
2004).
3. Results and Discussion

3.1. Minerals and vitamin A content of marjoram herb:
The mineral content of the marjoram herb was estimated, and the results are shown in Table (1). The data observed that the marjoram herb used in this study could provide a significant amount of minerals to satisfy consumer mineral needs (Recommended Dietary Allowance). The most common inorganic elements found in the studied marjoram herb were Na, K, Ca, Mg, Cu, Fe, Zn, Mn, and P by 3505.5, 2057.6, 1996.5, 9459.4, 159.5, 223.5, 26.8, 20.1 and 2987.7 mg/kg, respectively. Meanwhile, the vitamin A content of the marjoram herb was 1570.36 mg/kg.

Mineral content differed and was inversely proportional to the quality of the herbs. Basil was the best source of Ca, K, Mg, and P, while herbs (a combination of different herbs) had the lowest number, which was most likely, the explanation for the low amount of macro- and micro-components (Zaguła et al., 2016).

Table 1: Minerals and vitamin A content (mg/kg) of marjoram herb.

| Sample       | Minerals and vitamin A (mg/kg) |
|--------------|--------------------------------|
|              | Na    | K     | Ca     | Mg    | Cu    | Fe    | Zn    | Mn    | P    | Vitamin A |
| Marjoram herb | 3505.5 | 2057.6 | 1996.5 | 9459.4 | 159.5 | 223.5 | 26.8  | 20.1  | 2987.7 | 1570.36    |

3.2. The fatty acids profile of marjoram herb
Fatty acids obtained from food have a variety of effects on human cardiovascular health. Saturated fatty acids are modestly positively associated with the risk of cardiovascular disease (CVD). Poly- and mono-unsaturated fatty acids minimize the risk of CVD (Michas et al., 2014). As a result, keeping track of the fatty acid content of foods is a vital process that can aid in the maintenance of a balanced lifestyle. Table (2) showed that the main fatty acid composition of marjoram were Linolenic, palmitic, linoleic, oleic, palmitoleic, stearic, arachidic and myristic acid (44.9, 16.68, 14.9%, 8.4, 4.58, 3.26, 1.15 and 1.11%, respectively). Lauric, tridecanoic, tetradecenoic, pentadecanoic, heptadecanoic, vaccinic, and behenic acids were found a small concentration in marjoram. Surprisingly, is a high percentage of unsaturated fatty acids (74.35%), especially omega 3 (44.9 %).

Table 2: Fatty acids profile (%) of marjoram herb.

| Fatty acids | Symbol | (%) |
|-------------|--------|-----|
| Saturated fatty acids | | |
| Lauric acid | C12:0 | 0.67 |
| Tridecanoic acid | C13:0 | 0.74 |
| Myristic acid | C14:0 | 1.11 |
| Pentadecanoic acid | C15:0 | 0.66 |
| Palmitic acid | C16:0 | 16.68 |
| Heptadecanoic acid | C17:0 | 0.6 |
| Stearic acid | C18:0 | 3.26 |
| Arachidic acid | C20:0 | 1.15 |
| Behenic acid | C22:0 | 0.7 |
| Total | % | 25.57 |
| Unsaturated fatty acids | | |
| Tetradecenoic acid | C14:1 | 0.67 |
| Palmitoleic acid | C16:1 | 4.58 |
| Oleic acid, C18:1 | C18:1 | 8.4 |
| Vaccinic acid, C18:1 | C18:1 | 0.9 |
| Linoleic acid, C18:2 | C18:2 | 14.9 |
| Linolenic acid, C18:3 | C18:3 | 44.9 |
| Total | % | 74.35 |
| Non-identified fatty acids | % | 0.08 |
3.3. Characterization of snacks incorporated with marjoram powder

3.3.1. Sensory evaluation of snacks incorporated with marjoram powder

The sensory properties of food products are one of the most important factors in accepting and choosing them for consumption. Data presented in Table (3) shows Sensory evaluation of snacks indicated that, there were no significant differences at p ≤ 0.05 for color, odor, taste, texture, appearance and overall acceptability between snacks fortified with different level of marjoram and the control snacks. Apparent also from the same table that, the highest value of color, taste, odor, texture, appearance and overall acceptability was observed with snacks fortified with 7.5% marjoram were (7.8, 7.8, 7.5, 7.8, 7.7 and 7.6 respectively) These results are in conformity with the finding stated (Burt, 2004) who found that, Many spices, herbs and extracts have been added to a range of foods to enhance their shelf-life and sensory characteristics.

Table 3: Sensory evaluation of snacks incorporated with different levels of marjoram powder.

| Treatments | Color | Taste | Odor | Texture | Appearance | Overall Acceptability |
|------------|-------|-------|------|---------|------------|-----------------------|
| Control    | 7.7 ± 0.28<sup>a</sup> | 7.6 ± 0.92<sup>a</sup> | 7.1 ± 0.23<sup>a</sup> | 7.6±0.79<sup>a</sup> | 7.5 ± 0.74<sup>a</sup> | 7.3 ± 0.93<sup>a</sup> |
| 2.5 %      | 7.6 ± 0.21<sup>a</sup> | 7.7 ± 0.84<sup>a</sup> | 7.1 ± 0.24<sup>a</sup> | 7.6±1.1<sup>a</sup> | 7.5 ± 0.43<sup>a</sup> | 7.3 ± 0.39<sup>a</sup> |
| 5 %        | 7.6 ± 0.33<sup>a</sup> | 7.7 ± 0.56<sup>a</sup> | 7.3±0.51<sup>a</sup> | 7.7±4.0<sup>a</sup> | 7.6±0.33<sup>a</sup> | 7.5±0.50<sup>a</sup> |
| 7.5 %      | 7.8 ± 0.14<sup>a</sup> | 7.8 ± 0.92<sup>a</sup> | 7.5±0.32<sup>a</sup> | 7.8±0.23<sup>a</sup> | 7.7±0.45<sup>a</sup> | 7.6±0.78<sup>a</sup> |

Where: all values are means of twenty samples (±SD), Means within column with different letters are significantly different at p ≤ 0.05.

3.3.2. Chemical compositions of snacks incorporated with marjoram powder

The moisture, protein, fat, ash, fiber and available carbohydrates contents of snacks control and incorporated snacks with different levels of marjoram (2.5, 5 and 7.5 %) were shown in Table (4). The control snack had 10.12% moisture, 8.18 % protein, 1.70 % crude fat, 1.38 % ash, 1.11 % crude fiber and 87.22 % available carbohydrates, according to the results. In addition, the moisture, Protein, Crude fat, ash, and Crude fiber content of snacks containing marjoram powder increased as the percentage of marjoram increased significantly. The marjoram herb had high protein, ash, and fiber content of 11.2, 29.0 and 18.5 %, respectively. Furthermore, adding marjoram to beef burgers improved cooking properties such as increased water holding ability (WHC), decreased cooking losses, and shrinkage during cooking. (Badawy and Ali, 2018).

Table 4: Quality properties (% dry weight) of snacks incorporated with different levels of marjoram powder.

| Treatments | Moisture | Protein | Crude fat | Ash | Crude fiber | available carbohydrates |
|------------|----------|---------|-----------|-----|-------------|-------------------------|
| Control    | 10.12±0.32<sup>c</sup> | 8.18±0.49<sup>b</sup> | 1.70±0.08<sup>b</sup> | 1.38±0.27<sup>d</sup> | 1.11±0.27<sup>d</sup> | 87.63±0.79<sup>c</sup> |
| 2.5 %      | 10.92±0.12<sup>b</sup> | 8.32±0.10<sup>b</sup> | 1.92±0.14<sup>c</sup> | 1.77±0.33<sup>c</sup> | 3.32±0.51<sup>c</sup> | 84.67±0.97<sup>b</sup> |
| 5 %        | 11.15±0.27<sup>b</sup> | 8.55±0.33<sup>a</sup> | 2.19±0.12<sup>b</sup> | 2.39±0.47<sup>b</sup> | 4.85±0.31<sup>b</sup> | 82.02±0.43<sup>c</sup> |
| 7.5 %      | 11.51±0.38<sup>c</sup> | 8.60±0.19<sup>a</sup> | 2.98±0.10<sup>a</sup> | 3.28±0.29<sup>a</sup> | 6.95±0.11<sup>a</sup> | 78.19±0.67<sup>d</sup> |

Mean followed by different letters in the same row differs significantly p ≤ 0.05.

3.3.3. Fatty acids profile of snacks incorporated with marjoram powder

The data from the fatty acid analysis of the snacks containing marjoram powder are presented in Tables (5). Polysaturated fatty acids (PUFA) were the most common, followed by monounsaturated fatty acids (MUFA), and saturated fatty acids (SFAs). The most concentrated saturated fatty acid in various snack samples was palmitic acid (C16:0). The percentage of C16:0 in snacks containing marjoram powder ranged from 14.02% in a control sample to 11.08 % in snacks containing marjoram powder (7.5%). Stearic acid (C18:0) was also identified in the samples. Many of the samples had high levels of oleic fatty acid (C18:1).According to Geraldo and Alfenas (2008), consuming a high-fat diet rich in oleic acid does not cause the inflammatory response seen in response to consuming a hyperlipidemic diet high in SFAs and TFAs. In addition Oleic acid, Linoleic acid, Linolenic acid of snacks containing marjoram powder increased as the percentage of marjoram increased. Fataneh et al.,
(2018) found that oleic acid content increased and palmitic acid content decreased significantly \((p \leq 0.05)\) in all samples at 10% and 15% inclusion levels. Linoleic acid \((C18:2)\) levels ranged from 46.21 % (control snacks) to 47.32 % (snacks 7.5 %), with linoleic acid being the most abundant PUFA in all snack samples. According to Vardavas et al., (2007), this is the most common PUFA found in snacks. An increase in linoleic acid intake has been shown to reduce the risk of cardiovascular diseases (Lopes et al., 2007). Trans fatty acids (TFAs) were present in moderately high concentrations; the primary TFA was elaidic acid isomers \((C18:1t)\), which is found in hydrogenated vegetable oil (Wagner et al., 2008).

It is clear from the data in Table (5) that the elaidic acid isomers of snacks containing marjoram powder decreased as the amount of marjoram powder increased. Filho (2014) points out that the TFA content of a snack piece, such as a ham and cheese croissant, is higher than the World Health Organization's intake guidelines (approximately 1% of total energy per day). Since January 2004, the Danish Nutritional Council has amended a limit of 2% TFAs in oils and fats used in local and imported processed foods (Krettek et al., 2008).

| Treatments | Palmitic acid (16:0) | Stearic acid (18:0) | Oleic acid (18:1) | Elaidic acid (C18:1t) | Linoleic acid (18:2) | Linolenic acid (18:3) |
|------------|----------------------|--------------------|-------------------|----------------------|---------------------|----------------------|
| Control    | 14.02                | 5.09               | 23.47             | 5.25                 | 46.21               | 2.55                 |
| 2.5 %      | 12.79                | 5.06               | 23.59             | 4.17                 | 46.04               | 2.59                 |
| 5 %        | 11.98                | 5.04               | 23.74             | 2.01                 | 47.08               | 2.77                 |
| 7.5 %      | 11.08                | 5.03               | 23.91             | 1.19                 | 47.32               | 2.83                 |

Sajad et al., (2021) revealed that the composition of different fatty acids such as, palmitic, oleic, stearic, linoleic, and \(\alpha\)-linolenic acids found in snacks product. It was observed from the results that fatty acid composition was not affected by extrusion.

### 3.3.4. Minerals content of snacks incorporated with marjoram powder

Minerals content of snacks incorporated with different levels of marjoram powder were analyzed and the data are presented in Table (6). The obtained results indicated that all inorganic elements detected in studied snacks included primarily Na, K, Ca, Mg, Fe, Zn, Mn and P (Table 6) increased by increasing different levels of marjoram herb. The nutritional value of snacks was increased by adding marjoram herb as a source of minerals.

| Treatments | Minerals (mg/kg) |
|------------|------------------|
|            | Na   | K     | Ca   | Mg   | Fe   | Zn   | Mn   | P    |
| Control    | 519.2 | 948.8 | 258.5 | 373.3 | 49.2 | 7.6  | 1.2  | 17.7 |
| 2.5 %      | 5360  | 1128.9 | 289.0 | 447.8 | 51.3 | 7.9  | 1.8  | 17.3 |
| 5 %        | 5420  | 1204.3 | 326.0 | 583.7 | 58.3 | 8.9  | 2.0  | 20.4 |
| 7.5 %      | 6363.2 | 1265.3 | 364.7 | 649.7 | 62.6 | 9.1  | 2.4  | 21.9 |

### 3.3.5. Physical properties of snacks incorporated with marjoram powder:

Water solubility index, water absorption index, bulk density and expansion ratio of snacks incorporated with marjoram powder showed in Table (7). The water solubility index, bulk density and expansion ratio of all snack samples were found to be non-significant. The findings ranged from 13.20 % for snacks containing 7.5% marjoram powder to 15.29 % for the control snacks. These results are in the same line with those of Anton et al., (2009) revealed that corn snacks treated with carrot pomace had lower water solubility index values. The water absorption index increased when the amount of marjoram powder added was increased from 0 to 7.5 %. The expansion ratio of snack samples decreased as the amount of marjoram powder added increased.

The higher protein and fiber content of the ingredients may explain the increased bulk density of the snack samples. Hydrophilic interactions, polar interactions, and hydrogen bonding can occur when high protein content interacts with water and other components (Sajad et al., 2021).
Table 7: Physical properties of snacks incorporated with different levels of marjoram powder.

| Treatments | Water solubility index (%) | Water absorption index (g gel/g) | Bulk density (g/cm³) | Expansion ratio (%) |
|------------|-----------------------------|---------------------------------|----------------------|---------------------|
| Control    | 15.29±0.88<sup>a</sup>     | 5.30±0.24<sup>b</sup>          | 0.379±0.04<sup>a</sup> | 3.21±0.08<sup>a</sup> |
| 2.5 %      | 14.66±0.38<sup>a</sup>     | 6.82±0.33<sup>a</sup>          | 0.382±0.22<sup>a</sup> | 3.09±0.18<sup>a</sup> |
| 5 %        | 14.98±0.21<sup>a</sup>     | 7.19±0.19<sup>a</sup>          | 0.385±0.17<sup>a</sup> | 2.79±0.19<sup>a</sup> |
| 7.5 %      | 13.20±0.27<sup>b</sup>     | 7.91±0.11<sup>a</sup>          | 0.388±0.08<sup>a</sup> | 2.50±0.27<sup>a</sup> |

Mean followed by different letters in the same row differs significantly p ≤ 0.05.

4. Conclusion

The fact that marjoram is high in minerals and polyunsaturated fatty acids summarizes the findings of this study. Furthermore, marjoram became a snack manufacturer and discovered that the nutritional value, physical properties, and sensory properties of various snack samples improved. In addition, Tran’s fatty acids percent decreased. As a result, customers, especially children, will find the snack product to be safer and healthier.

References

Aguirre‐zabal, M., J. Mateo, M. Dominguez and J. Zumalacárregui, 2000. The effect of paprika, garlic and salt on rancidity in dry sausages. Meat Science, 54: 77-81.

Anton, A.A., R.G. Fulcher and S.D. Armfield, 2009. Physical and nutritional impact of fortification of corn starch-based extruded snacks with common bean (Phaseolus vulgaris L.) flour: Effects of bean addition and extrusion cooking. Food Chem., 113(4): 989-996.

AOAC 2010. Official Methods of Analysis of AOAC International. 18th Edition, AOAC International, Gaitherburg, 2590.

Azadmard, S. and P.C. Dutta, 2006. Rapid separation of methyl- sterols from vegetable oils by solid- phase extraction. Lipid Technology, 18:231–234.

Badawy, W.Z. and M. Ali, 2018. Improvement of some Functional and Nutritional Characteristics of the Beef Burger Using Marjoram Herb. J. Food and Dairy Sci., Mansoura Univ., 9 (7): 263 – 271.

Burt, S., 2004. Essential oils: their antibacterial properties and potential applications in foods a review. Inter. J. of Food Microbio., 94: 223-253.

Chapman, H.D. and P.F. Pratt, 1978. Methods of Analysis for Soils, Plants and Waters. Division of Agric. Sci., Univ. California, Berkeley, USA. 309.

Chau, C.F., 1998. Nutritional values of three leguminous seeds and functional properties of their protein and fiber fractions (Ph.D. Dissertation). The Chinese University of Hong Kong.

Conkerton, E.J., P.J. Wan, and O.A. Richard, 1995. Hexane and heptane as extraction solvents for cottonseed: A laboratory-scale study. Journal of the American Oil Chemists’ Society, 72: 963–965.

El-Eshmawy, K., H. Khidr, M. El-Sebai and A. Saafan, 2009. Egyptian exports of some medicinal and aromatic plants and factors affecting it in the foreign markets. Australian J. of Basic and Applied Sciences, 3: 4665-4674.

Fataneh, H., T. Mohammadali, A. Sodeif and P.S. Geoffrey 2018. Quality properties of puffed corn snacks incorporated with sesame seed powder. Food Sci. Nutr., 8(6):85–93.

Filho, P.A.C., 2014. Developing a rapid and sensitive method for determination of trans fatty acids in edible oils using middle-infrared spectroscopy. Food Chem., 158: 1–7.

Geraldo, J.M. and R.C.G. Alfenas, 2008. Papel da dieta na prevenção e no control da inflamação crônica: evidências atuais. Arquivos Brasileiros de Endocrinologia Metabologia, 52: 951–967.

Holley, R.A. and D. Patel, 2005. Improvement in shelf-life and safety of perishable foods by plant essential oils and smoke antimicrobials. Food Microbio., 22: 273-292.

Huang, Y.L. and Y.S. Ma, 2016. The effect of extrusion processing on the physiochemical properties of extruded orange pomace. Food chem., 192: 363-369.

Kirk, R.S. and R. Sawyer, 1991. Pearson's Chemical Analysis of Foods, Churchill Livingstone, London.

Krettek, A., S. Thorpenberg, and G. Bondjers, 2008. Tran’s fatty acids and health: A review of health hazards and existing legislation, URL, http://www.europarl.europa.eu
Lopes, C., A. Aro, A. Azevedo, E. Ramos, and H. Barros, 2007. Intake and adipose tissue composition of fatty acids and risk of myocardial infarction in a male Portuguese community sample. J. of the American Dietetic Association, 107: 276–286.

Mackay, J. and G. Mensah, 2004. The atlas of heart disease and stroke. Gen eva : WHO. Available at URL:www.who.int/cardiovascular_diseases/en/cvd_atlas_25_future.pdf.

Majumdar, R.K. and R.K. Singh, 2014. The effect of extrusion conditions on the physicochemical properties and sensory characteristics of fish-based expanded snacks. J. of Food Processing and Preservation, 38: 864–879.

Meilgaard, M.C., G.V. Civileand and B.T. Carr, 2007. Sensory Evaluation Techniques, 4th Ed. CRC Press: New York.

Micha, R. and D. Mozaffarian, 2008. Trans fatty acids: effects on cardio metabolic health and implications for policy. Prostaglandins, Leukotrienes and Essential Fatty Acids, 79:147-152.

Michas, G., R. Micha, and A Zampelas, 2014. Dietary fats and cardiovascular disease: putting together the pieces of a complicated puzzle. Atherosclerosis, 234: 320–328.

Mozaffarian, D., M.B. Katan, A. Ascherio, M.J. Stampfer, and W.C. Willett, 2006. Trans fatty acids and cardiovascular disease. New England, J. of Medicine, 354: 1601-1613.

Murphy, J. and J.P. Riley, 1962. A modified single solution method for determination of phosphate in natural waters, Anal. Chem. Acta., 27: 31-36.

Plozza, T., V.C. Treenergy and D. Caridi, 2012. The simultaneous determination of vitamins A, E and β-carotene in bovine milk by high performance liquid chromatography-ion trap mass spectrometry (HPLC-MSn). J. Food Chem., 134:559-563.

Ribeiro, J.J.I., 2004. Análises Estatísticas no Excel: Guia Prático. Viçosa: Editora UFV.

Sajad, A.W., A.G. Nawaz, and K. Pradyuman, 2021. Quality characteristics, fatty acid profile and glycemic index of extrusion processed snacks enriched with the multicomponent mixture of cereals and legumes. Legume Science, 163: 559-563.

Selani, M.M., C.T. Brazaca, W.S. dos Santos Dias and R.A. Ratnayake, 2014. Flores, and A. Bianchini, Characterisation and potential application of pineapple pomace in an extruded product for fiber enhancement. Food chem., 163: 23-30.

Vagi, E., B. Simandi, H. Daood, A. Deak and J. Sawinsky, 2002. Recovery of pigments from Origanum majorana L. by extraction with supercritical carbon dioxide. J. of Agri. and Food Chem., 50: 2297-2301.

Vallverdu-Queralt, A., J. Regueiro, M. Martinez-Huelamo, J.F. Alvarenga, L.N. Leal, and R.M. Lamuela-Raventos, 2014. A comprehensive study on the phenolic profile of widely used culinary herbs and spices: Rosemary, thyme, oregano, cinnamon, cumin and bay. Food Chem., 154: 299-307.

Vardavas, C.I., S. Yiannopoulos, M. Kiriakakis, E. Poulli and A. Kafatos, 2007. Fatty acids and salt contents of snacks in the Cretan and Cypriot market: a child and adolescent dietary hazard. Food Chem., 101: 924–931.

Veronica, A.O., O.O. Olusola and E.A. Adebowale, 2006. Qualities of extruded puffed snacks from maize/soybean mixture. J. of Food Process Engineering, 29:149–161.

Wagner, K.H., E. Plasse, C. Proell and S. Kanzler, 2008. Comprehensive studies on the trans fatty acid content of Austrian foods: Convenience products, fast food and fats. Food Chemistry, 108: 3. 1054-1060.

Zagula, G., A. Fabisiak, M. Bajcar, M. Czernicka, B. Saletnik and C. Puchalski, 2016. Mineral components analysis of selected dried herbs. Econtechmod. An International Quarterly Journal, 05 (1): 127-132.