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Quality and flavour stability of coffee substitute prepared by extrusion of wheat germ and chicory roots

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Summary. A mixture of roasted chicory roots and wheat germ (1:1 w/w) was subjected to extrusion processing for preparation of coffee substitute. Comparative studies concerning sensory characteristics and headspace volatiles were carried out between genuine coffee and a freshly prepared coffee substitute. The sensory evaluation revealed similarities between the two samples. The comparative odour profile analysis showed that the sweetish/caramel-like note scored higher in our coffee substitute sample than in real coffee, whereas the other odour quality attributes showed an opposite trend. The high quality of the fresh coffee substitute was correlated to the presence of volatiles that are responsible for the fresh coffee aroma, such as: 2-methylbutanal, 3-methylbutanal, 2-methylfuran and 2,3-butanedione in high concentration. Storage of coffee substitute samples revealed a noticeable decrease in concentration of the Strecker aldehydes and diketones and a remarkable increase in phenolic compounds, whereas pyrazine and furan derivatives showed no linear changes during storage. The ratio of 2,3-butanedione/2-methylfuran (B/M) was used as an indicator for aging of coffee substitute samples. The variation in this ratio (B/M) during storage for 6 months was consistent with that of the odour profile analysis.

Keywords: Coffee substitute – Extrusion – Volatilies – Chicory roots – Wheat germ – Sensory evaluation

Introduction

The popularity of coffee as a beverage is ever increasing despite the fact that there are reports of negative side-effects of excessive consumption, in particular with respect to the alkaloid caffeine present in coffee, which can cause addiction and stimulate the central nervous system. It has an effect on the cardiovascular system with a slight increase in blood pressure and heart-beat (Ramalakshmi and Raghavan, 1998).

During roasting of coffee beans some reaction pathways take place, leading to the formation of a wide range of volatile compounds (Ishikawa et al., 2004; Rocha et al., 2004; Franca et al., 2005). Sucrose, the main oligosaccharide of green coffee splits into the reducing sugars glucose and fructose. These in turn react with free amino acids and free amino groups of proteins via Maillard reaction to form aminoketones and/or aminoaldose after Amadori or Heyns rearrangement of the intermediate glycosylamine adducts (Ledl and Schleicher, 1990). Amadori and Heyns products react further into a complex cascade of reactions, which lead to numerous odorant volatiles and coloured compounds. A wide range of volatile compounds and the reaction pathways of their formation during roasting of coffee have been reported (Yeretzian et al., 2002).

From an economical and health-care point of view, many previous studies have been carried out for the preparation of coffee substitutes by using Maillard technology in the same way in which it is used in producing real coffee. These substitutes were composed of chicory roots, malt, barley and rye (Holsher, 1990; Kanjahn and Maier, 1996, 1997). Although many of the impact odorants of roasted coffee were represented in the aroma of roasted wheat germ (El-Saharty et al., 1998), so far no attention has been paid for using such valuable by-product, of wheat milling as a precursor for the preparation of coffee substitute.

It is well documented that flavour development during roasting depends on the time-temperature history to which the food products are subjected. Consequently, a rational management of roast quality requires defining and controlling critical parameters of the roast history. Extrusion is a thermal processing technique that involves the application of high heat, high pressure, and shear forces to an uncooked mass, such as wheat flour. These processing conditions result in a number of chemical changes that include gelatinization of starch molecules, crosslinking of proteins, and the generation of flavours (Riha et al., 1996; Bredie et al., 2002; Marsman et al., 1998). In comparison to traditional roasting, the extrusion process is characterized by a rapid heating, formation of glassy material within a relatively short time after the product leaves the die (Bredie, 1998).

Therefore, in the present study a blend of wheat germ and milled chicory roots was subjected to an extrusion process for the preparation of an economic coffee substitute at high quality. To assess the quality of the prepared coffee substitute sample, it was organoleptically evaluated and its aroma composition was investigated by using gas chromatographic-mass spectrometric (GC-MS) analysis in comparison with real coffee.

Materials and methods

Plant materials and chemicals

Chicory roots (*Cichorium intybus* L.) were kindly donated by commercial sources and wheat germ (*Triticum vulgare*) purchased from Cairo Milling Company, Giza, Egypt.

Authentic compounds and standard *n*-paraffin (C_8-C_{22}) were purchased from Sigma-Aldrich Co. (St. Louis, MO, USA) and Merck (Darmstadt, Germany). All other chemicals were of analytical grade.

Preparation of coffee substitute

A mixture of milled chicory roots and wheat germ (1:1 w/w) was homogeneously mixed and roasted for 0.5 h at 180 °C in closed system by using a rotary evaporator with an efficient cooling system. The roasted mixture was cooled and its moisture was adjusted at 16.5%, then subjected to an extrusion process under the following conditions:

A single screw extruder Brander 20 DN equipped with EDCE 330 (Food Science and Technology Institute, Giza, Egypt) was used. The screw diameter was 4.57 cm and the length/diameter ratio was 1.12 cm. The screw speed was set at 140 rpm. Sample was feed at 45 kg/h. The die nozzle diameter was 3 mm, die temperature was 150 °C and the maximum temperature was set at 250 °C. After cooling, the extruded sample was milled and immediately packaged in glass bottles under nitrogen and stored at room temperature in dark until analysis.

Sensory evaluation

Similarity of sensory attributes of coffee substitute to the real coffee

The panelists (10 assessors) rated the similarity of different sensory attributes (odour, colour, taste and appearance) of the coffee substitute as compared to the genuine coffee on a category scale 0 (no similarity) to 3 (identical). The results obtained by the panelists were averaged and the standard deviations calculated (Mayer and Grosch, 2001).

Odour profile analysis

A comparative odour profile analysis was carried out for genuine coffee and the coffee substitute sample. The sensory test of the odour attributes was investigated according to the international standards (Fadel and Farouk, 2002). The panel was carried out by 10 experienced assessors, asked to identify the various smelling attributes of each sample. The attributes which will be used to describe the olfactory sensations for the samples were selected. This was done by individual evaluation followed by a common run. Then the individual panelist separately scored the intensities of the selected odour attributes on a category scale of 0.0 (not perceptible) to 3.0 (strongly perceptible) in increments of 0.5.

Isolation of headspace volatiles

About 100 g of coffee or coffee substitute sample was placed in a conical flask containing 500 ml distilled water. The mixture solution at 60 °C was stirred using Teflon-coated magnetic bar. The volatiles were purged with purified nitrogen (grade of N_2 >99.99%), at flow rate 100 ml/min for 5 h to three cooling traps at low temperature (ice-water/ice-acetone/dry ice-acetone). Volatile chemicals collected in each trap were recovered with diethyl ether-pentane (1:1, v/v) (Fadel et al., 2006). The solvents containing volatiles were dried over anhydrous sodium sulphate for 12 h and concentrated with a Vigreux column (25 cm) to final volume of 100 µl.

Gas chromatographic (GC) analysis

GC analysis was performed by using a Hewlett-Packard model 5890 instrument equipped with flame ionization detector (FID). A fused silica capillary column DB5 (60 m × 0.32 mm ID) was used. The oven temperature was maintained initially at 50 °C for 5 min, then programmed from 50 to 250 °C at a rate of 4 °C/min. Helium was used as the carrier gas, at a flow rate of 1.1 ml/min. The sample size was 1 µl, split ratio 1:10, the injector and detector temperatures were 220 and 250 °C, respectively. The retention indices (Kovats index) of the separated volatile components were calculated with reference to the retention times of a series of C_8-C_{22} *n*-paraffin standard (Aldrich Chemical Co.) run at the same conditions.

Gas chromatographic-mass spectrometric (GC-MS) analysis

The analysis was carried out by using coupled gas chromatography with a Hewlett-Packard (5890)/mass spectrometry Hewlett-Packard-MS (5970). The ionization voltage was 70 eV, mass range m/z 39–400 amu. The GC conditions were carried out as mentioned above. The isolated peaks were identified by matching with data from the library of mass spectra (National Institute of Standard and Technology) and comparison with those of authentic compounds and published data (Adams, 1995). The quantitative determination was carried out based on peak area integration.

Results

Table 1 shows the similarities of the different sensory qualities, odour, taste, colour and appearance of the fresh roasted coffee substitute compared with those of actual coffee. The sensory odour profile analysis was carried out with coffee substitute sample and compared with that of coffee sample (Fig. 1). The effect of storage for 6

Table 1. Similarity of the sensory attributes of fresh roasted coffee substitute to the real coffee

Attributes	Odour	Taste	Colour	Appearance
Similarity score[a]	2.7 ± 0.5[b]	2.5 ± 0.3	2.8 ± 0.5	2.7 ± 0.4

[a] Similarity was scored by ten assessors on a category scale from 0.0 (no similarity) to 3.0 (identical)

[b] Values are the mean of 10 assessors ± SD

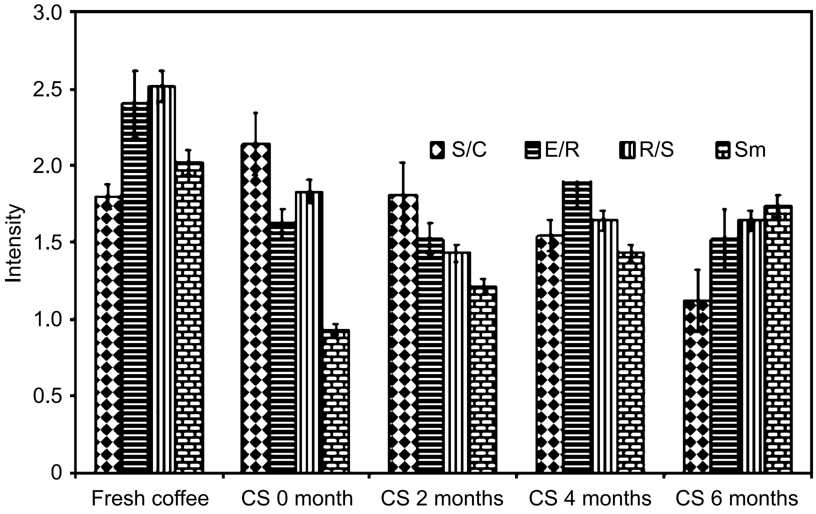

Fig. 1. Odour profile of fresh roasted coffee and coffee substitute (CS) stored from 0 to 6 months, odour quality: S/C, sweetish caramel; E/R, earthy roasty; R/S, roasty/sulphurous; Sm, smoky

months on the odour profile of coffee substitute is also illustrated in Fig. 1.

More than 90 volatile components were identified in both real coffee and coffee substitute. However, only the most potent components for coffee aroma along with their area percentages were listed in Table 2. These compounds were related to different chemical classes such as furans (8), pyrazines (12), sulfur containing compounds (5), lipid oxidation products (12), Strecker aldehydes (4), diketones (2), phenolic compounds (7), and pyridines (1).

Discussion

Sensory evaluation of the coffee substitute in comparison with real coffee

The sensory evaluation of the fresh coffee substitute sample was carried out by rating the similarity of the different quality characteristics (odour, taste, colour, appearance) in comparison with those in genuine coffee sample. The results (Table 1) revealed the high quality of the coffee substitute sample. Comparative study between the sensory profile of the coffee substitute and real coffee have been carried out (Fig. 1). The odour sensory attributes: sweetish/caramel like, earthy/roasty, roasty/sulphurous and smoky were selected and scored by the panelists. These four attributes are the most potent odour qualities of roasted coffee (Mayer and Grosch, 2001). The sweetish/caramel like scored higher ($P > 0.05$) in coffee substitute than in coffee sample whereas the other odour qualities showed the opposite trend. During storage, the sweetish/caramel odour quality decreased gradually. The smoky attribute showed the opposite trend and its intensity showed a remarkable increase at the end of storage time. No linear behaviour was detected for the earthy/roasty and roasty/sulphurous attribute. The results are consistent with those of Mayer and Grosch (2001).

Volatile components in real coffee and coffee substitute

In order to explain the changes in the odour profile analysis, we subjected the aroma in the headspace of coffee and coffee substitute (fresh and stored samples) to the high resolution gas chromatographic (HRGC) and GC-MS analysis.

Comprehensive analysis of the most potent odorants in roasted coffee had been reported (Holscher, 1990; Blank et al., 1992; Holscher and Steinhart, 1994; Semmerlroch and Grosch, 1996; Mayer and Grosch, 2001; Yeretzian et al., 2002; France et al., 2005). It is obvious from Table 2 that except for 3-methyl-2-butene-1-thiol and 2-isobutyl-methoxypyrazine, most of the identified compounds in the headspace volatiles of real coffee are represented in coffee substitute sample. These results are in agreement with a previous study carried out by Holscher (1990), who studied the role of some aroma impact compounds in roasted coffee and coffee surrogates made from roasted chicory, malt, rye or barley or blends of them. The absence of these compounds was attributed to the absence of their precursors in the unroasted materials used in preparation of coffee surrogate.

Furans were the most abundant compounds identified in real coffee and fresh coffee substitute sample (Table 2). These compounds are well known to be sugar degradation products after Maillard reaction and after pyrolysis (Baltes and Bochmann, 1987). 2-Furfural was the major identified compound in both sample under investigation, however its concentration in coffee substitute was about

Table 2. Volatile compounds identified in headspace of real coffee and coffee substitute (fresh and stored from 0 to 6 months)

Peak no	KI[a]	Components	Coffee	Coffee substitute				Methods of identification[b]
				Period of storage (months)				
				Zero time	2	4	6	
1	607	2,3-Butanedione	1.51*	5.0	2.78	3.55	3.00	MS + KI
2	613	2-Methylfuran	7.07	12.1	6.61	8.36	8.05	MS + KI + St
3	646	2-Methylbutanal	0.33	5.7	2.11	2.09	1.28	MS + KI
4	651	3-Methylbutanal	0.37	1.66	0.76	0.82	0.7	MS + KI
5	662	Acetic acid	0.67	0.65	0.17	1.03	3.9	MS + KI
6	689	Pentanal	–	1.06	0.54	0.81	1.92	MS + KI
7	698	2-Pentanone	–	0.46	0.19	2.2	1.35	MS + KI
8	725	2,3-Pentanedione	0.26	0.5	0.58	0.42	0.93	MS + KI
9	728	Thiazol	0.82	0.15	0.55	0.37	0.50	MS + KI
10	732	Pyridine	7.02	0.34	0.17	0.43	4.1	MS + KI
11	740	Pyrazine	9.6	0.34	0.28	0.81	0.68	MS + KI
12	809	Hexanal	1.56	4.88	0.20	0.68	0.68	MS + KI + St
13	819	Dihydro-2-methyl-3-(2H) furanone	2.59	0.28	0.30	0.12	0.65	MS + KI
14	823	2-Methyl-2-buten-1-thiol	4.61	–	–	–	–	MS + KI
15	834	2-Methylpyrazine	2.06	0.56	0.27	0.12	–	MS + KI + St
16	850	2-Furfural	12.28	46.85	48.28	40.53	42.17	MS + KI + St
17	864	2-Furanmethanol	0.45	0.19	9.42	0.92	–	MS + KI
18	865	2-Hexenal	–	–	8.84	–	–	MS + KI
19	876	Hexanol	–	0.03	1.10	–	–	MS + KI
20	880	2-Methyl-3-furanthiol	1.61	0.3	0.12	0.10	0.23	MS + KI
21	901	Methional	2.31	0.28	0.19	0.11	–	MS + KI
22	914	2-Ethylpyrazine	1.63	0.14	0.63	0.53	0.64	MS + KI + St
23	918	2-Furfurylthiol	2.67	0.65	0.51	0.64	0.61	MS + KI + St
24	930	2,3-Dimethylpyrazine	2.67	2.79	0.21	0.64	0.13	MS + KI + St
25	940	Vinylpyrazine	0.37	0.03	0.18	0.05	–	MS + KI
26	971	5-Methyl-2-furfural	1.2	0.27	0.53	0.10	0.09	MS + KI
27	979	1-Octene 3-one	0.58	0.16	0.29	0.31	0.59	MS + KI
28	987	5-Methyl-2-acetylfuran	0.85	–	0.14	–	–	MS + KI
29	990	2-Pentylfuran	0.60	0.43	0.37	0.41	0.66	MS + KI
30	997	2,4,5-Trimethylthiazol	0.15	0.61	0.26	–	–	MS + KI
31	999	2,4,5-Trimethylpyrazine	11.36	0.78	0.74	0.49	0.85	MS + KI + St
32	1003	2-Ethyl-3-methylpyrazine	2.47	0.49	0.38	0.35	0.35	MS + KI
33	1022	2-Ethyl-5-methylpyrazine	1.42	0.84	3.09	10.12	0.82	MS + KI
34	1029	2-Hydroxy-3-methyl-2-cyclopenten-1-one (Cyclotene)	0.63	0.18	0.15	2.48	0.68	MS + KI
35	1048	Phenylacetaldehyde	0.62	0.83	0.37	0.66	0.47	MS + KI
36	1075	m-Cresol	0.42	–	–	–	–	MS + KI
37	1090	2-Ethyl-3,5-dimethylpyrazine	3.75	0.77	0.72	0.96	2.17	MS + KI
38	1092	Guaiacol	0.2	0.19	0.3	0.7	0.97	MS + KI
39	1103	Linalool	0.39	–	–	–	–	MS + KI + St
40	1110	Nonanal	–	0.43	0.57	0.98	0.4	MS + KI
41	1117	2-Phenylethanol	0.11	–	–	–	–	MS + KI
42	1145	Methyl-6,7-dihydro-5(H) cyclopentapyrazine	0.24	0.11	0.11	0.22	–	MS + KI
43	1160	4-hydroxy-2,5-dimethyl-3(2H) furanone (Furaneol)	0.26	0.38	0.72	0.25	0.22	MS + St
44	1166	2-Methyl-3,5-diethylpyrazine	0.20	1.02	0.93	2.03	2.15	MS + KI
45	1170	2-Nonenal	–	1.06	0.33	1.95	2.34	MS + KI
46	1175	3-Ethylphenol	0.78	–	–	–	–	MS + KI
47	1180	2-Isobutylmethoxypyrazine	3.07	–	–	–	–	MS + KI
48	1190	3,4-Dimethylphenol	2.03	0.19	0.14	0.17	0.22	MS + KI
49	1196	5-Ethyl-4-methyl-3-hydroxy-2(5H)furanone (Abhexone)	0.99	0.11	0.36	0.55	0.13	MS + KI
50	1208	2,4-Nonadienal	0.42	0.85	0.93	0.08	0.75	MS + KI

(*continued*)

Table 2 (*continued*)

Peak no	KI[a]	Components	Coffee	Coffee substitute				Methods of identification[b]
				Period of storage (months)				
				Zero time	2	4	6	
51	1280	Ethyl guaiacol	0.53	0.14	0.37	1.01	2.0	MS + KI
52	1295	2,4-Decedienal EZ	0.45	1.05	0.77	3.34	3.9	MS + KI
53	1310	2,4-Decadienal EE	–	0.32	0.18	0.08	0.36	MS + KI
54	1320	4-Vinyl guaiacol	1.2	0.38	0.33	0.43	0.82	MS + KI
55	1350	γ -Nonalactone	–	0.24	0.67	5.09	0.92	MS + KI
56	1375	β-Damascenone	2.44	0.28	0.54	0.43	0.65	MS + KI
57	1394	Vanilline	0.58	0.14	0.16	0.22	0.12	MS + KI + St
58	1519	δ-Decalactone	–	2.78	0.48	1.2	2.89	MS + KI

Values expressed as relative area percentages to total identified compounds. Compounds listed according to their elution on DB5 column

[a] Kovats index

[b] Compounds identified by GC-MS (MS) and/or by Kovats index on DB5 (KI) and/or by comparison of MS and KI of standard compound run under similar GC-MS conditions

* Values are the average of two experiments

– Not detected

4-fold higher than that in real coffee. This compound was the predominant identified compound in the headspace of roasted chicory roots (Baek and Cadwallader, 1998). The contribution of 2-furfural to the overall aroma may be slight because of its high aroma threshold of 23 ppm (Buttery et al., 1988). 2-Methylfuran comprised the second major compound in the volatiles of coffee and coffee substitute (Table 2). The fresh taste quality of roasted coffee can be estimated from the concentration of this compound (Holscher and Steinhart, 1992). 5-Methyl-2-furfural was detected in relatively low concentration in real coffee and coffee substitute sample (Table 2). Yeretzian et al. (2002) detected 2-furfural and 5-methyl-2-furfural at higher concentration in roasted coffee headspace volatiles at medium level, however, their concentrations decreased dramatically in the dark roasted coffee.

Three furanones are represented in the headspace of fresh roasted coffee: dihydro-2-methyl-3(2H)furanone; 4-hydroxy-2,5-dimethyl-3(2H)furanone (furaneol) and 5-ethyl-4-methyl-3-hydroxy-2(5H)furanone (abhexone). Furanones are mainly associated with a caramel-like, sweet, fruity, nutty and burnt odour impression and have proved to be important flavouring chemicals in food industry (Ziegleder, 1991; Fadel and Farouk, 2002). Furaneol and abhexone are reported among the potent odorants of coffee aroma (Blank et al., 1992; Mayer and Grosch, 2001). The presence of furaneol at very low concentration in the present study may be attributed to its low flavour release in the headspace of the fresh roasted sample. This result is in agreement with that of Mayer and Grosch (2001). They calculated the flavour release of the odorants in the headspace of fresh roasted coffee sample as the ratio of the concentration of the odorants in the headspace of roasted coffee sample to the total concentration of the odorants in the sample. It was only 1.3% of furaneol.

Two sulfur-containing furans could be identified in the present study, 2-methyl-3-furanthiol and 2-furfurylthiol. It is well documented that 2-furfurylthiol is one of few odorants which can be described as slightly roasted coffee-like, it has a very intense odour note during sniffing assessment (Holscher, 1990). It was identified in roasted model systems consisting of rhamnose or 2-furfural and sulfur containing amino acids (Silwar and Tressel, 1989). In the present study, 2-furfurylthiol was represented in noticeable lower level in coffee substitute sample shown in Table 2 compared with that in real coffee however due to its very low threshold 0.05 ppb (Silwar and Tressel, 1989) a coffee-like aroma impact was still very likely in the coffee substitute sample (Holscher, 1990) this result confirms that of odour sensory evaluation (Table 1).

Eleven pyrazines derived from Maillard reaction were identified and reported in Table 2, of which 2,4,5-trimethyplyrazine was the predominant compound in headspace volatiles of real coffee whereas it represented by much lower concentrations in coffee substitute volatiles. Eighty pyrazines were identified in roasted coffee (Flament, 1989) but only a few seem to be of great importance for coffee flavour. 2-Ethyl-3,5-dimethylpyrazine showed the same trend, it was represented by 3.75% and 0.77% in volatiles of real coffee and coffee substitute, respectively. Screening of coffee brews by aroma extract dilution analysis and gas chromatography-olfactometry of headspace samples revealed this compound as odorant with high flavour dilution factor. Semmelroch and Grosch (1996) confirmed its contribution to coffee aroma. 2-Methyl-3,5-diethylpyrazine showed opposite trend, it was about five fold higher in coffee substitute sample than in real coffee sample. This compound was determined among the most potent odorants of roasted wheat germ, it possessed roasted coffee aroma (El-Saharty et al., 1998).

Four Strecker aldehydes, 2/3-methylbutanal, methional and phenylacetaldehyde and two dicarbonyls, 2,3-butanedione and 2,3-pentandione, were represented in Table 2. These compounds are among the most potent odorant of coffee aroma (Blank et al., 1992). The Strecker aldehydes formation is mainly depending on the precursor amino acids. The short chain Strecker aldehydes 2/3 methylbutanal are key compounds for the pleasant smell arising from freshly roasted and ground coffee (Holscher and Steinhart, 1992; Mayer and Grosh, 2001). 2,3-Butanedione, 2-methylfuran, 2-methylbutanal and 3-methylbutanal were represented in higher concentrations in coffee substitute sample compared with those in real coffee sample (Table 2). These compounds are responsible for the fresh note of coffee flavour. Furthermore, their high volatility might enhance their odour impact (Holscher and Steinhart, 1992). 2,3-Butanedione, 3-methylbutanal and 2-ethyl-2,5-dimethylpyrazine were determined among the predominant aroma active compounds in the volatiles of roasted chicory (Baek and Cadwallader, 1998).

The seven identified phenolic compounds were qualitatively and quantitatively predominant in volatiles of real coffee in comparison with coffee substitute sample (Table 2). Most of these compounds are formed by a thermal degradation of phenolic acids like ferulic acid, which are the major constituents of green coffee (Holscher and Steinhart, 1994). Guaiacol and vinylguaiacol are responsible for the smoky phenolic odour note of coffee aroma (Semmelroch and Grosch, 1996). Vanilline seemed to be of lower sensory importance for coffee aroma, it possessed sweet (vanilla) note (Blank et al., 1991). Eight volatile compounds numbers, 6, 7, 19, 40, 45, 53, 55 and 58 (Table 2) were only detected in the aroma of coffee substitute sample, however most of them were previously reported in the volatiles of roasted coffee (Flament, 1991). The presence of these lipid degradation products in the coffee substitute volatiles is not surprising, considering that wheat germ is known to be rich in unsaturated fatty acids.

The effect of storage for 6 months on the headspace volatiles of the coffee substitute sample was investigated (Table 2). 2-Furfural, the major compound in coffee substitute aroma decreased gradually during storage, with a 10% decrease after storage for 6 months. In a previous study, the roasted chicory stored for 300 days in air at room temperature showed a 60% decrease in 2-furfural content (Kanjahn and Maier, 1997). 2-Furfurylthiol the most potent odorant of coffee aroma, showed a slight decrease after storage for 6 months. 2-Methylfuran showed no linear change during storage, as mentioned before this compound is responsible for the fresh note of coffee aroma (Holscher and Steinhart, 1992).

To give a clear-cut picture on the effect of storage on the volatiles of coffee substitute aroma the total area percentages of the main chemical classes, that influence in odour quality, were calculated and are presented in Fig. 2.

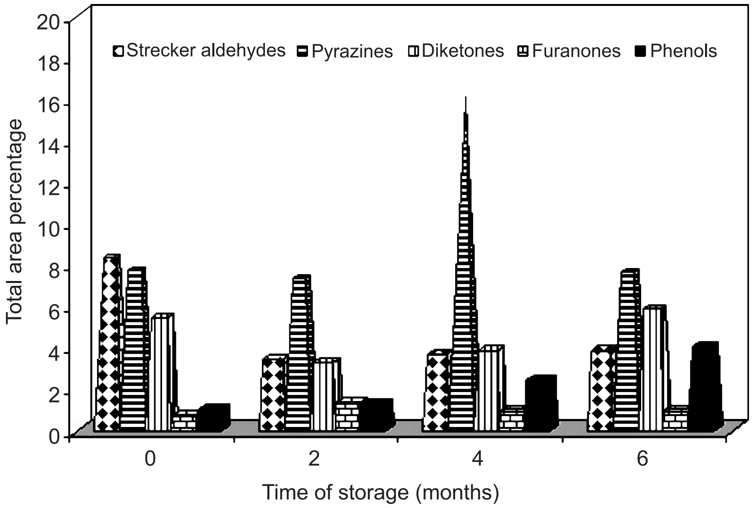

Fig. 2. Effect of storage on the total area percentage of the main chemical classes that affect the odour profile of coffee substitute sample

The Strecker aldehydes and diketones showed the same behavior, showing a noticeable decrease after storage for 2 months followed by a slight decrease during the rest of storage time. Mayer and Grosch (2001) correlated the decrease in the intensity of the sweetish/caramel like odour quality from freshly ground coffee powder to coffee powder 15 min after grinding to the distinct decrease of the amount of Streaker aldehydes and diketones. These results confirm the results of the odour profile analysis (Fig. 1).

The total content of the pyrazines and furanones showed no linear changes during storage, however, there were no remarkable differences between their content in fresh and stored sample for 6 months (Table 2). Pyrazines possess the earthy roasty note (Blank et al., 1991). The high score of the earthy roasty note in the sample stored for 6 months (Fig. 1) are mainly attributed to the presence of some potent odorants such as 2-ethyl-3,5-dimethylpyrazine and 2-methyl-3,5-diethylpyrazine in considerable concentration of 3.75% and 0.2%, respectively.

The phenolic compounds which are responsible for the smoky phenolic odour note, showed remarkable increase during storage being after 6 months more than 5-fold higher than their concentration in the fresh sample. This result is in agreement with that of Mayer and Grosch (2001). They assumed that the odour contribution of volatiles like guaiacol, which might be responsible for the smoky note, was reduced in the fresh coffee sample by higher headspace concentration of the Streaker aldehydes and diketones.

Different ratios of selected volatile compounds in coffee aroma have been proved to be useful in measuring staling, however, the ratio 2,3-butanedione/2-methylfuran (B/M) was preferred and proposed by Leino et al. (1992) as useful indicator of aging coffee. In the present study this ratio (B/M) was calculated during storage of the coffee substitute sample (see Fig. 3). It is obvious that the value of B/M was nearly constant during storage up to 4 months followed by slight decrease after 6 months. This finding is consistent with the results of odour profile analysis of the coffee substitute sample stored for 6 months (Fig. 1).

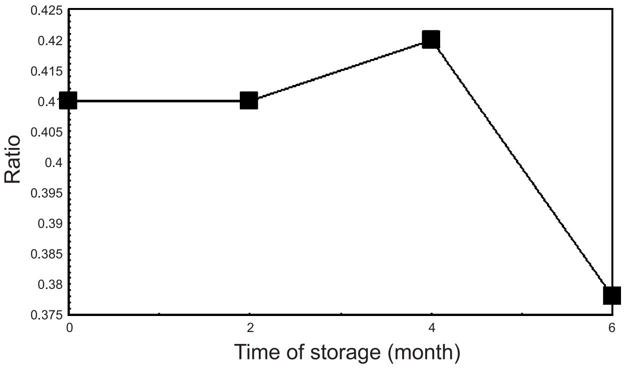

Fig. 3. Changes in 2,3 butanedione/2-methyl furan ratio during storage of coffee substitute samples

From the aforementioned results it can be concluded that high quality coffee substitute can be prepared by using the suitable edible plant sources containing the appropriate precursors for generation of coffee aroma. Also the present study is an attempt to use the extrusion processing in preparation of coffee substitute having high quality.

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