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# Chemical Characterization of Harar and Berry Coffee Beans with Special Reference to Roasting Effect

[1]M. S. Tawfik and [2]N. A. El Bader
[1]Department of Human Nutrition, Medical Studies and Sciences Sections, Building 2, King Saud University, P.O. Box 22452, Riyadh 11495 and [2]Department of Food Science and Technology, Faculty of Agriculture, Alexandria University, Alexandria, Egypt

**Abstract**: The chemical composition of two Abyssinian coffee; Harar and Berry beans, which are dominating the coffee market in the Gulf area were determined. Green beans were heavier and had a higher humidity than roasted beans. Although they did not differ with respect to pH, Harar beans were more acidic (titarable acidity). The oil (~12%) and protein (~13%) contents were comparable with other *arabiaca* coffee varieties. Roasting did not noticeably alter the levels of these ingredients. Moreover, caffeine followed the same trend. The fatty acids contents of coffee lipid were determined by capillary chromatography. Results revealed that the major fatty acid contents were almost similar in both green coffee types. The ranking of the main fatty acids were palmitic, linoleic, stearic and linolenic. The total free amino acid profile indicated that Gln, Asp, Lys and Leu acids were the dominants in the green coffee of both types. While, the minor ones were Arg, Ala, Cys, Val and Phe. In Harar and Berry beans, roasting process did not lead to change the fatty and amino acids either in composition or distribution. In addition the effect of roasting on the coffee matrix also was discussed.

**Key words:** Harar, Berry, arabica coffee, chemical composition, roasting effect

## INTRODUCTION

Considering the importance of coffee as a worldwide beverage and the increasing demand of the international coffee market for quality, it becomes important to understand the factors affecting product quality[1].

The perception of flavour compounds in a food matrix depends on the composition of this matrix. It has been shown that the macromolecules, such as proteins, are involved in the retention of flavour compounds[2,3].

Chemical composition of roasted coffee beans is assumed to be the main factor controls the beverages quality. Green unroasted coffee by its own has no desirable taste and aroma however, its composition is directly affects the flavour of the roasted beans.

These desirable characteristics are produced only during the roasting process. During this heat procedure the coffee beans undergo several stages including; during, roasting (>180-200°C) and cooling. Major chemical modifications occur in chlorgenic acid[4], sucrose[5], Trigonelline[6] and amino acids[7,8]. While it is reported that there is no significant differences in the fatty acid content between green and roasted coffee samples[9].

In Gulf area, especially in Saudi Arabia coffee is not only the most popular beverage but also it plays a key role in the lifestyle of these communities. Arabian coffee beverage is mainly prepared from roasted beans belonging to Harar and Berry varieties or blends of them. It is believed that Harar and Berry beans are the wild types of coffee beans, which were originally found in North Africa, coffee motherland.

Consequently and since ancient time until now Abyssinian coffee beans are dominating the coffee market in the Arab land.

Roasting of such beans is a homemade in which beans are roasted in house electric roaster. The long time and temperature of this process operation is always not severe in compare to the commercial procedure. Hence, the bean colour is tended to be light brown.

Therefore, this study aims to build up more information on the chemical composition of Harar and Berry coffee beans and to evaluate its compositional changes in due to roasting effect.

## MATERIALS AND METHODS

**Coffee samples:** Raw (green) and roasted Harar and Berry coffee beans were obtained from Riyadh commercial market. The samples were powdered before analysis and kept at refrigerated temperature (4°C) during the analysis.

### Analytical methods

**Humidity:** The humidity of the beans was determined after 48 h at 105°C[10].

**Corresponding Author:** Dr. Manal Said Tawfik, Department of Human Nutrition, King Saud University
Tel: +966 1 4775406 /1604 Fax: +966 1 4789540

**pH and acidity:** The pH and titratable acidity of the coffee samples were obtained according to Angelucci *et al.* (1982). Ground coffee (2.25 g) was mixed with 10 mL of hot water (80°C), cooled to room temperature and the pH determined.

For the determination of acidity 10 g of ground coffee was mixed with 75 mL of 80% ethanol (v/v) and maintained under gentle agitation for 16 h. A portion of 25 mL of this extract was diluted to 100 mL with distilled water and the titratable acidity determined with 0.1 N NaOH using phenolphthalein as pH indicator.

**Lipid:** Total lipid content was determined using a Soxhlet apparatus with hexan[12].

**Ash:** Ash content was determined according to the official method[10].

**Analysis of fatty acids:** The fatty acids in coffee samples were converted to fatty acids methyl esters (FAME) by heating in 7% $BF_3$-methanol, according to the procedure reported by AOAC[13].
FAME were identified on a Shimadzu GC MS QP5050A system (Japan). The carrier gas (helium) had a flow rate of 20 mL/min, split ratio 40. A sample was injected on a capillary column (60 x 0.25 mm x 0.2 μm) packed with df Non-bonded SP-2340/silar 10 CP (US Patent).

**Protein:** Crude protein was determined according to the Kjeldahl method, using the conversion factor 6.25[10].

**Analysis of amino acids:** Amino acids were done by HPLC (Agilent 1100) following hydrolysis in 6 N HCl for 22 hours at 110°C. Sulfur amino acids were determined after samples were pre-oxidized with performic acid prior to acid hydrolysis[14].

**HPLC analysis of caffeine:** Caffeine was determined in 80% methanolic extracts. Extraction was carried in a boiling water 2 h with occasional agitation. After cooling at room temperature, the extracts were diluted with distilled water to 10% of methanol. Caffeine was determined by reversed–phase high–performance liquid chromatography (RP-HPLC)[15]. Pure standard of caffeine was used in the HPLC analysis for the determination of the contents in the seeds (Fig. 1).

## RESULTS AND DISCUSSION

In the present study, the main figures of the chemical composition of Harar and Berry green and roasted beans are determined.

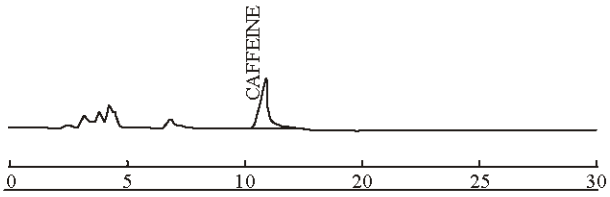


Fig. 1: Analysis of caffeine

Table 1: Humidity, pH and acidity of green and roasted coffee beans

| Coffee | Humidity | pH | Titratableacidity (mLNaOH $g^{-1}$) |
|---|---|---|---|
| GB | 5.16[a] | 5.94[a] | 1.34[a] |
| RB | 3.50[b] | 5.98[a] | 1.32[a] |
| GH | 6.20[c] | 5.68[b] | 1.74[b] |
| RH | 3.41[d] | 5.60[b] | 1.60[b] |

Means of three replicates. Different letters in each column indicate significant differences. GB: green Berry; RB: Roasted Berry; GH: Green Harar; RH: Roasted Harar

Table 1 shows that humidity of the Green Harar (GH) was higher than Green Berry (GB). Moisture contents are lower in compare to the reported values; 8.5-13%[16]. These could be explained by a very low humidity in Riyadh area. As a result of roasting process, the humidity decreased to reach an average of 3.45%, however, Franca *et al.*[17] found that moisture content of Brazilian roasted coffee had a lower value (1.5%).

Data on titratable acidity and pH values (Table 1) show that prior to roasting, the Harar beans had the highest acidity and the lowest pH values. The same tendency was maintained after roasting. Roasting process did not cause a significant loss of acidity. In contrary, Franca *et al.*[17] reported that acidity levels decreased considerably after roasting. Those results might be reflected the differences in the roasting conditions (temperature and time). In the present study, the acidity levels are within the range reported in the literature; 0.9-1.9%[7]. It is documented that low coffee quality is not associated with pH value but with high acidity[18].

In regard to oil content, the results showed there are no significant differences between Harar and Berry beans (Table 2). These results are in agreement with reported values (9-16%) of green arabica coffee beans[12,19]. Roasting did not alter significantly the oil content. France *et al.*[17] reported the same behaviour. It is generally accepted that healthy coffee beans had a higher oil contents than defective ones[20].

In the present study, the ash content of both green and roasted beans is within the literature reported range (4-5%)[17], without significant differences between Harar and Berry beans (Table 2).

The protein content of green Harar beans was slightly

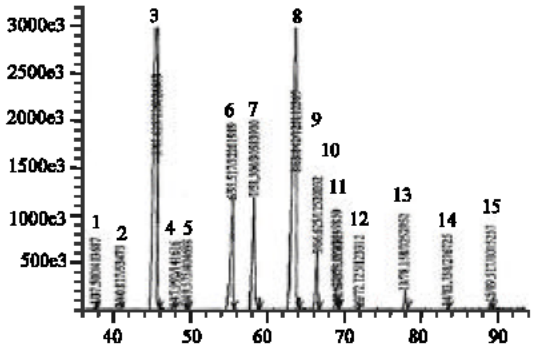


Fig. 2: Chomatogram of fatty acids in green Berry Beans. 1) C14:0; 2) C15:0; 3) C16:0; 4) C16:1; 5) C17:0; 6) C18:0; 1) C18:1; 7) C18:2; 8) C18:2; 9) C18:3; 10) C20:0; 11) C20:1; 12) C21:0; 13) C22:0; 14) C23:0; 15) C24:0

Table 2: Total oil content, ash content, protein content and caffeine content of green and roasted coffee beans

| Coffee | Oil content (%) | Ash content (%) | Protein content (%) | Caffeine (%) db |
|---|---|---|---|---|
| GB | 12.55[a] | 4.79[a] | 13.49[a] | 1.01[a] |
| RB | 11.32[a] | 4.16[a] | 13.19[a] | 1.00[a] |
| GH | 12.30[a] | 4.10[a] | 14.52[b] | 1.20[a] |
| RH | 11.83[a] | 4.08[a] | 14.39[b] | 1.18 |

[a]Db = dry basis

Means of three replicates. Different letter in each column indicate significant differences. GB: Green Berry; RB: Roasted Berry; GH: Green Harar; RH: Roasted Harar

Table 3: Fatty acids composition in green and roasted coffee beans

| Fatty acids (%) | | GB | RB | GH | RH |
|---|---|---|---|---|---|
| Myristic acid | C14:0 | 0.12[a] | 0.08[a] | 0.18[b] | 0.06[a] |
| Pentadecanoic acid | C15:0 | 0.02[a] | 0.03[a] | 0.05[b] | 0.03[a] |
| Palmitic acid | C16:0 | 39.31[a] | 35.73[a] | 40.88[b] | 39.39[a] |
| Palmitoleic acid | C16:1 | 0.04[a] | 0.01[a] | 0.02[a] | 0.01[a] |
| Margaric acid | C17:0 | 0.13[a] | 0.13[a] | 0.10[a] | 0.12[a] |
| Stearic acid | C18:0 | 10.08[a] | 10.92[a] | 9.71[b] | 9.51[b] |
| Oleic acid | C18:1 | 9.54[a] | 10.21[a] | 10.21[a] | 10.19[a] |
| Linoleic acid | C18:2 | 39.02[a] | 39.20[a] | 38.12[b] | 37.50[b] |
| Linolenic acid | C18:3 | 3.91[a] | 4.32[a] | 3.88[a] | 3.43[a] |
| Eicosenoic acid | C20:0 | 1.23[a] | 1.17[a] | 1.12[a] | 1.13[a] |
| 11- Eicosenoic acid | C20:1 | 0.22[a] | 0.23[a] | 0.22[a] | 0.25[a] |
| Heineicosenoic acid | C21:0 | 0.04[a] | 0.10[b] | 0.04[a] | 0.03[a] |
| Behenic acid | C22:0 | 1.01[a] | 1.18[a] | 1.14[a] | 0.80[b] |
| Tricosenoic acid | C23:0 | 0.09[a] | 0.10[a] | 0.06[b] | 0.06[b] |
| Tetracosenoic acid | C24:0 | 0.32[a] | 0.30[a] | 0.27[b] | 0.24b |

Means of three replicate determinations. Different letter in each raw indicate significant differences. GB: Green Berry; RB: Roasted Berry; GH: Green Harar; RH:Rroasted Harar

higher in comparison to green Berry beans. Moreover, protein levels did not noticeably changed after roasting (Table 2). Macrae[7] reported that protein levels of green coffee had a range between 11 to 16.6%. Further he suggested that the protein contents in coffees of different qualities or even of different species should not be remarkably different.

Results in Table 2 show that caffeine content in green Harar and Berry beans had an average value of 1.0% db. Macrae[7] reported that caffeine levels in green coffee should vary remarkably, even within the same species. Reported range is within 0.9-1.9% db for arabica coffee.

Roasting did not significantly affect caffeine levels of either Harar and Berry beans. According to Franca *et al.* [17], the caffeine content remained relatively constant for both black and sour beans upon roasting for all types of beans. In another study, the same scientists found that roasting caused a reduction of 30% in caffeine content[17]. These could be related to the differences in roasting conditions between both studies.

The fatty acid profile of Harar and Berry beans is presented in Fig. 2 and Table 3. The main fatty acids found in both coffee varieties, in an average percent are palmitic acid (40%), linoleic acid (38.5%), stearic acid (9.9%) and linolenic acid (3.9%). Minor acids were eicosenoic acid and behenic acid whose contents were leveled to 1%, whereas the rest of fatty acids were found in traces.

On the other hand, no significant differences in the fatty acid composition between green and roasted beans were detectable (Table 3). The same ranking of fatty acids in arabica coffee is reported by Martin *et al.*[9].

The individual amino acid content is listed in table 4 for green and roasted Harar and Berry beans. In general, the total amino acid profile in green beans indicates that the average of the main amino acids are Glutamic acid (1.85 g/100g), Aspartic acid (0.89 g/100g), Lysine (0.89 g/100g) and Leucine (0.79g/100g), which were similar in both coffee varieties. While minor amino acids are Glycine, Arganine, Alanine, Cystine, Valine and Phenylalanine (Table 4). In except of Lysine, roasting process had no effect on the amino acids content. According to Clifford[21] the arabica coffee matrix is offered high degree of protection against temperature effects. It

Table 4: Amino acids composition in green and roasted coffee beans

| Amino acid g/ 100g dw | GB | RB | GH | RH |
|---|---|---|---|---|
| Aspartic acid (Asp) | 0.89[a] | 0.85[a] | 0.89[a] | 0.80[a] |
| Glutamic acid (Glu) | 1.86[a] | 1.83[a] | 1.85[a] | 1.81[a] |
| Serine (Ser) | 0.39[a] | 0.38[a] | 0.38[a] | 0.37[a] |
| Histidine (His) | 0.28[a] | 0.27[a] | 0.30[a] | 0.25[a] |
| Glycine (Gly) | 0.59[a] | 0.56[a] | 0.57[a] | 0.53[a] |
| Threonine (Thr) | 0.34[a] | 0.33[a] | 0.32[a] | 0.30[a] |
| Argnine (Arg) | 0.54[a] | 0.50[a] | 0.56[a] | 0.48[a] |
| Alanine (Ala) | 0.44[a] | 0.42[a] | 0.44[a] | 0.40[a] |
| Tyrosine (Tyr) | 0.28[a] | 0.27[a] | 0.27[a] | 0.25[a] |
| Cystine (Cys) | 0.47[a] | 0.46[a] | 0.55[a] | 0.42[a] |
| Valine (Val) | 0.47[a] | 0.47[a] | 0.46[a] | 0.44[a] |
| Methionine (Met) | 0.16[a] | 0.16[a] | 0.17[a] | 0.16[a] |
| Phenylalanine (Phe) | 0.51[a] | 0.51[a] | 0.50[a] | 0.47[a] |
| Isoleucine (Ile) | 0.37[a] | 0.37[a] | 0.36[a] | 0.34[a] |
| Leucine (Leu) | 0.79[a] | 0.81[a] | 0.79[a] | 0.76[a] |
| Lysine (Lys) | 0.89[a] | 0.62[b] | 0.90[a] | 0.55[b] |

Average of triplicate determination. Different letter in each raw indicate significant differences. GB: Green Berry; RB: Roasted Berry; GH: Green Harar; RH: Roasted Harar

is assumed that the high fat content would be expelled to the surface during roasting acted as barrier, protecting the inner bean matrix.

The same order of amino acid content in arabica coffee is reported by Casal *et al*.[22]. Further, he found that amino acids such as Tyr, Val, Leu, Phe and Ala remined almost constant for all roasting temperatures assayed since these amino acids are more thermal stable. The Harar and Berry samples showed the presence of Ser, Thr and Cys while it is not detected in the previous study of Casal *et al*.[22]. Furthermore, the presented results were similar to others reported in the literature[21,23], except for Pro and OH-Pro which it could not be detected.

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