Asian Journal of Agriculture and Food Sciences (ISSN: 2321 – 1571)
Volume 03 – Issue 02, April 2015

Effects of Coffee Processing Technologies on Aroma Profiles and Sensory Quality of Ruiru 11 and SL 28 Kenyan Coffee Varieties

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ABSTRACT--- ***The study aimed at comparing the effects of three coffee processing methods on aroma profiles and sensory quality of Ruiru 11 and SL 28 coffee varieties. The processing methods varied onstages of processing and method of mucilage removal. The green coffee beans obtained from the three processing methods were graded and roasted, ground and analyzed for the aroma profilesand sensory quality. Headspace Solid phase Microextraction fibre (SPME) technique were used for the extraction of aroma compounds from coffee samples and characterization of the compounds with use of gas chromatography mass spectrometry (GC-MS).Sensory quality were analyzed by an expert panelist. Various volatile aroma compounds were identified in roasted coffee and classified into their chemical classes involving furans, ketones, pyrazines ketones pyridines, pyrroles and acids. The intensity of aroma compounds were compared in terms of their peak areas and variations were noted between the processing methods with the ecopulper showing higher levels of pyrazines such as 2-methylpyrazine, 2-ethyl-6-methylpyrazine, and wet pulper showing higher levels of furans such asfurfuryl formate andfurfuryl alcohol, acetate. The hand pulper washigh in the level of acids and esters such as acetic acid and propanoic acid, ethyl ester.Similar aroma compounds were identified in headspace of Ruiru 11 and SL 28and there were variations in the intensities of aroma groups such as pyrroles and pyridines.It was concluded that the eco-pulper and hand pulper methods gives better aroma quality than the wet pulper while SL 28 variety gives higher sensory quality than Ruiru 11.***

Keywords--- Coffee, processing, aroma, sensory quality

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1. INTRODUCTION

The characteristic flavor and aroma of coffee result from a combination of hundreds of chemical compounds produced by the reactions that occur during roasting[20]. The aroma of roasted coffee depends on the components of green coffee which are influence by many factors such as variety of coffee, climatic conditions, agricultural factors and post-harvest treatment [4,8, 11].Different coffee varieties contribute to the distinctive aromatic compounds unique to each type or origin of green coffee [2, 10]. Two major types of coffee beans are Arabica (*Coffea Arabica*) and Robusta (*Coffea canephora*). Arabica is more valuable because its produces better tasting beverage which is therefore more expensive than the Robusta coffee [3, 10]. Kenya produce mainly the Arabica coffee and some of the common cultivars includes; K7, SL28, SL34, Batian and Ruiru 11 [8]. Coffee commonly consumed as beverage is a product of roasted coffee beans obtained after a series of processing steps done to the ripe coffee cherries. Coffee cherries are initially processed by removingthe outer layer of fleshy pulp. This can be accomplished by a dry or a wet method. The wet method requires use of specific equipment and substantial quantities of water[12, 11].In Kenya, coffee is commonly processed bythree wet pulping methods which may be categorize as, the continuous wet processing, manual pulping and the ecological processing methods. The continuous wet processing method uses excess water during pulping, washing and grading and removes mucilage through fermentation and washing. The manual process normally used under small scale involvesuse of simple manual operated machines to pulp coffee with little water and the mucilage removed through fermentation and washing processes. The ecological processingtechnique is also done as a continuous process using a machine called eco-pulper which pulp andremoves mucilage mechanically without the fermentationstage[18, 7].Fermentation is an important step normallydone todegrade mucilage from the coffee beans and hence facilitate their removal by washing. It is also reported to improve the flavor and aroma of coffee. Therefore the eco-pulper method not having the microbial fermentation stage may be viewed as a risk that could affect the aroma quality of coffee.[7], reported that the ecological method gives a poor aroma quality than the methods with fermentation and especially for the light and dark roasted coffee. Roasting is the important step in the production of coffee because it enables the development of flavour, aroma and colour. The temperature and time of roasting will influence the development of flavour compounds [10]. During roasting a complex mixture of aroma compounds is formed through a number of different chemical reactions (Maillard reactions, Strecker degradation, caramelisation, oxidation) to produce a complex mix of aroma compounds [6].More than 1000 volatile compounds have been identified in the headspace of roasted coffee.The main classes of compounds that have been identified in roasted coffee are; furans, pyrazines, ketones, alcohols, aldehydes, esters, pyrroles, thiophenes, sulfur compounds, benzenic compounds, phenolic compounds, pyridines, thiazoles, oxazoles, lactones, alkanes, alkenes, and acids [8, 6,7]. The ketones, acids, phenols, furans and pyrans, thiophenes, pyrroles, oxazoles, thiazoles pyridines and pyrazines are often found to be correlated to roasting intensity and methodology. Quantification of coffee volatiles is challenging due to the wide range of concentrations, high volatilities, wide range of physicochemical properties (for example polarity, pK, charge) and their potential to polymerise and bind to other coffee components [6]. Gas Chromatography Mass Spectrometry (GC-MS) is commonly used for the analysis of volatile organic compounds in green beans, roasted beans and the final brewed coffee [8]. The aroma of the brew is different from that of ground roasted coffee although the change in the aroma profile is not caused by the formation of new odorants but by a shift in the concentrations [19, 8].[8], did evaluation of the aroma profiles of coffee brew but no study has been reported on the aroma profiles of roast and ground coffee with consideration on the effect of processing methods on the Kenyan coffee varieties. The main purpose for this study was to evaluate the aroma profiles and sensory qualityof coffee produced by the common coffee wet processing technologies.

2. MATERIALS AND METHODS

2.1 Site and Sample Preparation

Coffee cherries of varieties commonly referred as Ruiru 11 and SL 28 (Arabica coffee) were harvested during the short and peak harvesting seasons between the year 2012 and 2013. The coffee cherries were harvested from Dedan Kimathi University farm located in Nyeri County Kenya (0° 25' 0" S / 36° 57' 0" E). Ripe cherries were obtained from coffee plants grown on the same field, by selective picking method, sorted and processed by three different pulping methods which includes the wet pulper, hand pulper and an eco-pulper methods. Wet pulper method was done by continuous pulping operation with water involve in pulping, transport and grading of parchment. The parchments obtained were put in plastic containers with perforation at the bottom and allowed to ferment by dry method for 16 to 18 hours. Once fermentation was complete, the parchments were washed to remove the mucilage and graded to have heavier and the lighter parchment. The heavier parchments were selected for research and transferred to the drying tables for drying in the sun to attain moisture content of 10 $\pm$ 1%. Hand pulper method was done by use of a motorized manual pulping machine and little water used during pulping. The parchment obtained were subjected to fermentation in plastic containers with perforation at the bottom to allow dry fermentation for 16 to 18 hours. Once fermentation was complete, the parchment were washed and graded to separate lighter and heavier parchment. The heavier parchments were selected and transferred to the drying tables for drying in the sun to the required moisture content of 10 $\pm$ 1%. The Eco-pulper method was done by first submerging coffee cherries with water in a tank to separate the heavier and lighter cherries which were then pulped separately using an eco-pulper. Heavier cherries were selected for research and after pulping the parchment were passed through a demucilager unit which removes the mucilage mechanically with some water poured continuously to clean the parchment. Clean coffee parchments were put in trays and transferred to drying tables for drying in the sun to the required moisture content of 10 $\pm$ 1%. The dry parchments from the three processing methods were package in sealed polythene bags and stored in a freezer at -18^{O}C until time for analysis.

2.2 Coffee Roasting

Green coffee (150g) were weighed and roastedat temperatures between 200-245^{0}C for 12 minutes to attain a medium roast level using laboratory roaster (Gene Café, CBR-101, Korea). The roasted coffee were put in small wire mesh trays and allowed to degas for 12 hours in room temperature. After degassing, grinding was done to attain uniform grounds and packaged in air tightscrew cup bottles and stored at -80^{0}C until time of analysis.

2.3 Analysis of Aroma Compounds by Headspace Solid Phase Micro-Extraction, Gas Chromatography Mass Spectrometry

2.3.1Extraction of Volatile Compounds from Ground Roasted Coffee by Headspace Solid Phase Micro-Extraction Method

Solid Phase Micro-Extraction fibre (SPME) coated with 65 μm Polydimethylsiloxane/Divinylbenzene (PDMS/DVB) Fused silica, purchased from Supelco Inc (Bellefonte, PA, USA) was used for the head space extraction. Prior to the head space extraction, the fibres was conditioned at 250^0Cfor30 minutes in the GC injector according to the manufacturer's recommendation. Ground roasted coffee samples (1g) were placed in a 10ml Headspace vial. Headspace SPME analyte extraction was done by placing the sample vial in an oven set at temperatures of 60^0C, for 30 minutes to reach sample headspace equilibrium.The SPME fiber was exposed to the coffee powder headspace for 10 minbefore injection into the Gas Chromatography.

2.3.2Chromatographic Conditions

The SPME fibre containing the headspace volatile compounds was immediately insertedinto the GC injection port and thermally desorbed for 6 min at 250^0C in a gas chromatograph model 2010 Plus (Shimadzu). The fused silica capillary column ZB-Wax PLUS(Zebron GC Columns, ID; 0.25 mm, 30 m length, film thickness, 0.25µm) was used. Helium was used as the carrier gas at a flow rate of 1ml/min. The injection port temperature was maintained at 250^0C, while the oven temperature was programmed at 50^0C,maintain for 1min and programmed to rise at 10^0 C/min to 250^0C and held at that temperature for 5minute.Mass spectra were recorded at detector voltage 0.2 kV scanning from 40-400m/z range, the ion source and transfer line temperature were maintained at 250^0C.

2.3.3Identification of Volatile Aroma Compounds

Coffee volatile aroma compounds in roasted coffee were identified by comparing their calculated relative retention indexes with those given in the literature, and matching of the mass spectrometric fragmentation pattern corresponding to the various peaks in the samples total ion chromatogram with those present in the National Institute of Science and Technology (Gaithersburg, Maryland, USA) mass spectral database. The relative retention indexes were calculated from the retention times of the compounds and of the linear alkanes (Retention Index Standard, Sigma). Quantification was done by integrating peak areas and calculating the percentage area of peaks for individual compounds from the total contents of volatiles on the chromatograms.

2.4Sensory analysis

The sensorial analysis of coffee samples were carried out to determine the quality of coffee and was done by six qualified cuppers according to the method described by [9]. Scores were awarded to each sensorial attribute depending on their intensity in the samples. For each sensorial attribute the samples received a score on a scale of 0 to 10. The attributes for aroma, aftertaste, acidity, body, flavor, clean, sweet, balance and overall score were evaluated, resulting in a final score count that indicated the quality of coffees.

2.5Statistical analysis

The experiment was done by Completely Randomized Design with three replicates and analysis of data evaluated using the Statistical Package for Social Scientist (SPSS version 18). Analysis of variance (ANOVA) was conducted, and the differences between the means analyzed using the Least Significant Difference (LSD). Statistical significance was established at $p \leq 0.05$.

3. RESULTS AND DISCUSSIONS

3.1 Volatile Aroma Compounds Identified in Headspace of Roasted Coffee

The aroma compounds in roasted coffee powder for Ruiru 11 and SL 28 were analyzed by use of SPME-HS-GCMS techniques. Figure 1 shows the chromatograph for the aroma profiles determine in the headspace of roasted coffee. The coffee varieties showed similar aroma profiles from roasted coffee. The list of volatile compounds identified in roasted coffee are presented in Table 1. From the 54 volatile compounds identified in roasted coffee, there were 9 pyrazines, 17 furans, 9 ketones, 4 pyrroles, 4 pyridines, 3 phenols, 2 acids and 6 esters. All processing methods used for our study showed the same aroma profiles and the chromatograms differed only in the percentage of surface area below the peaks forsome individual peaks. The intensities of aroma compounds were compared between the processing methods and the coffee varieties studied.

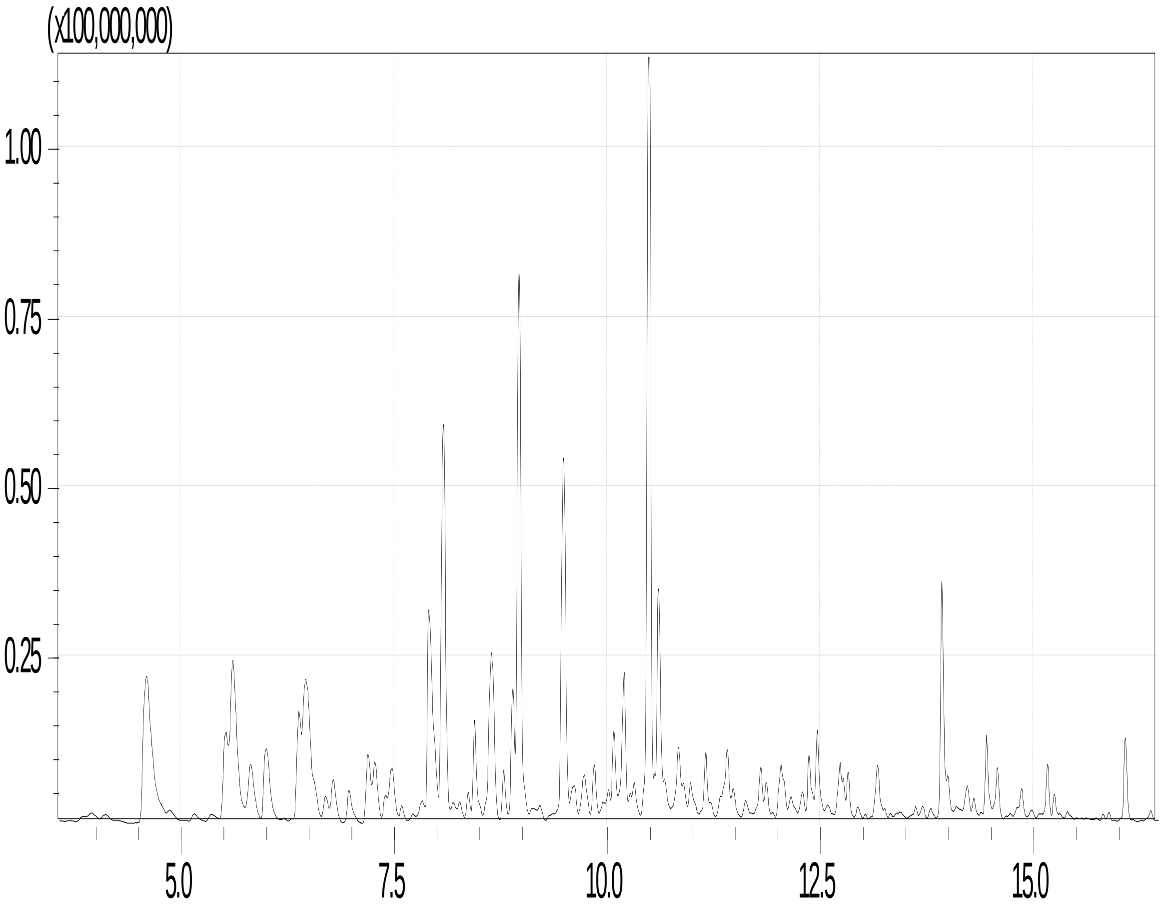

Figure 1: Chromatograph of aroma profiles of roasted coffee analysed by SPME/GC-MS

Table 1: Volatile Compounds Identified in Headspace of Roasted Coffee

Peak	Compound	Retention Index	Peak	Compound	Retention Index
1	2,3-Pentanedione	1068	28	2-Furanmethanol	1661
2	Pyridine	1198	29	Isovaleric acid	1670
3	Dihydro-2-methyl-3(2H)-furanone	1268	30	2-Furfuryl-5-methylfuran	1677
4	2-Methylpyrazine	1274	31	3-Ethyl-2-hydroxy-2-cyclopenten-1-one	1691
5	Acetoin	1290	32	2-Acetyl-3-methylpyrazine	1703
6	Hydroxypropanone	1304	33	1-Acetyl-1,4-dihydropyridine	1719
7	2,5-Dimethylpyrazine	1332	34	4,5-Dimethyl-4-hexen-3-one	1735
8	2,6-Dimethylpyrazine	1338	35	2,6-Dimethyl-4-thiopyrone	1742
9	2,3-Dimethylpyrazine	1356	36	1-Cyclopentenecarboxylic acid	1748
10	1-Hydroxy-2-butanone	1376	37	2(5H)-Furanone	1762
11	2-Ethyl-6-methylpyrazine	1393	38	3-Acetoxypyridine	1777
12	2-Ethyl-5-methylpyrazine	1399	39	3-Methyl-2-butenoic acid	1799
13	Trimethylpyrazine	1415	40	Tetrahydro-2-pyranone	1823
14	Acetic acid	1449	41	1-Furfurylpyrrole	1830
15	Furfural	1462	42	3-Methylcyclopentane-1,2-dione	1839
16	Furfuryl methyl sulfide	1485	43	Guaiacol	1864
17	Furfuryl formate	1491	44	3-Ethyl-2-hydroxy-2-cyclopenten-1-one	1906
18	2-Acetylfuran	1507	45	Maltol	1980
19	Propanoic acid, ethenyl ester	1527	46	Furfuryl ether	1988
20	Furfuryl alcohol, acetate	1533	47	Phenol	2010
21	5-Methyl-2-furfural	1576	48	2-Furoylacetonitrile	2018
22	3-Octanone	1586	49	Pyrrole-2-carboxaldehyde	2034
23	Furfuryl propionate	1595	50	2,5-Dimethyl-4-hydroxy-3(2H)-furanone	2047
24	2-Furfurylfuran	1606	51	5-Acetyldihydro-2(3H)-furanone	2076
25	2-Acetyl-5-methylfuran	1620	52	2-Formyl-1-methylpyrrole	2116
26	2-Formyl-1-methylpyrrole	1625	53	4-Vinylguaiacol	2205
27	4-Hydroxybutanoic acid	1636	54	3-Pyridinol	2340

3.2 Effects of Processing Methods on Volatile Compounds of Roasted Coffee

Furans constituted the most abundant group of aroma compounds with respect to the number of identified compounds and the intensity in the coffee headspace. They accounted an average of 42% with 17 derivatives. The eco-pupler method showed a mean of 43.1%, the wet method (41.2%) and the hand pulper method (41.7%) for Ruiru 11 samples. For the SL 28 samples; the eco-pulper method showed a mean of 42.9%, wet pulper method (43.8%) and hand pulper method (43.3%) for the furan levels in the head space of roasted coffee. The level of furans was in agreement with the report of Clark [5] who indicated that the intensity of furans make up 38to 45% of total volatile compounds of roasted coffee. The processing methods showed very close values for the intensity of furans and their concentrations were not significantly different. However there was some variations among specific furan derivatives identified in the headspace of the roasted coffee. Table 2 shows the relative peak areas of individual compounds calculated as percentage of the total surface areas below the peak. The headspace was dominated by furan derivatives such as 2 furanmethanol, furfuryl alcohol acetate, furfuryl formate, furfural, acetylfuran and furfuryl ether. The intensity of 2 furanmethanol was the highest at 10-12%.

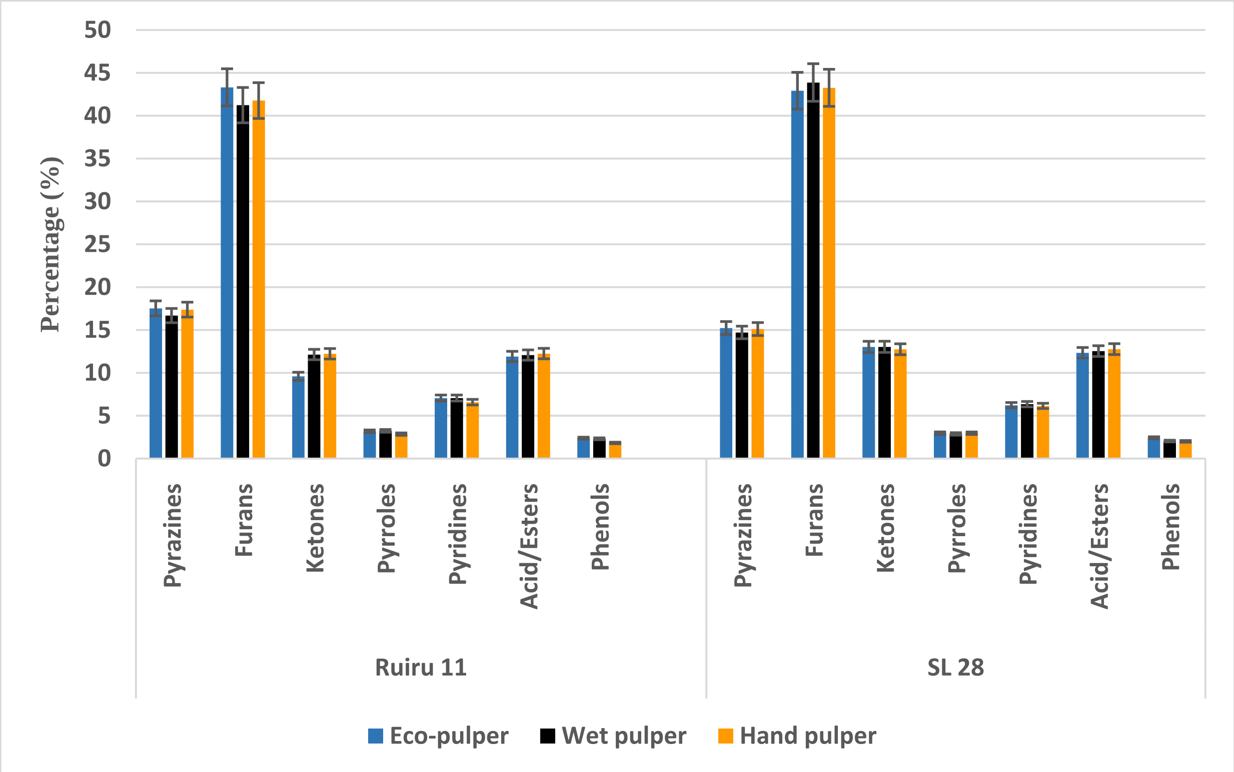

Figure 2: Total area for chemical classes of volatile compounds of roasted coffee for Ruiru 11 and Sl 28

There was no significant variations between the processing methods in the intensity of 2 furan methanol but the SL 28 samples showed slightly higher intensity than Ruiru 11 samples. This could be attributed to variations in the level of carbohydrates between the coffee varieties. Though the variations between the processing methods were not consistent between the varieties, the wet pulper showed higher intensity for furfuryl formate, but were not significantly different from eco-pulper method on the levels of furfuryl alcohol acetate. The hand pulper showed higher intensity on the level of furfural and 2-Acetylfuran. The eco pulper also showed higher variations in the level of furfuryl ether. The key aroma compounds such as furfural, furfuryl alcohol acetate and furfuryl formate whose concentration occurs in higher levels were considered to improve the quality of coffee. [17], reported that when the levels of furfural and furfuryl formate occur in higher amounts the quality of coffee is improved. The presence of 2 furanmethanol gives a burnt aroma to the coffee and its higher concentration in the headspace of roasted coffee has also been reported by other authors such as [4]. Furans are typical ingredients of roasted coffee. They impart the caramel, burnt aroma [13]. They are generally known to originate from thermal processes which involve degradation of carbohydrates and sugars in coffee during roasting [17]. [16], indicated that the formation of fufural and furfuryl alcohol could be formed due to heating of hexoses or pentoses. Hence the variations between the processing methods could occur due to the variations in the type of sugars and reactions occurring during roasting. Pyrazines are ranked the second in abundance in the emissions from the headspace of coffee brews [4]. According to [5], pyrazines constitute 25 to 30% of the headspace of roasted coffee. From our study they accounted a level of 15 to 18% with 9 derivatives. Figure 2 shows the total surface area for the chemical classes of aroma compounds of roasted coffee. The eco-pulper method showed a level of 17.5%, the wet pulper (16.7%) and the hand pulper (17.4%) for the pyrazines in Ruiru 11 samples. The SL 28 samples indicate that the eco-pulper method showed a level of 15.2%, the wet pulper(14.2%) and the hand pulper (15.1%). Hence the eco-pulper showed slightly higher levels of the pyrazines than the other methods. The level of pyrazines were also higher for Ruiru 11 than for the SL 28 samples. Pyrazines are considered to be formed by Maillard reactions, Strecker degradation and pyrolysis of hydroxyl amino acids in presence of carbohydrates [1, 9]. Hence the variations in the levels of this compounds could be attributed to the differences in the levels of proteins and amino acids.

Table 2: Mean Relative Peak Areas (%) for Volatile Compounds Identified in Roasted Coffee of Ruiru 11 and SL 28.

	Ruiru 11			SL 28		
Compound	Eco-pulper	Wet pulper	Hand pulper	Eco-pulper	Wet pulper	Hand pulper
2,3-Pentanedione	1.84^{a}	2.04^{a}	1.92^{a}	1.84^{a}	1.75^{a}	1.62^{a}
Pyridine	5.99^{a}	5.97^{a}	5.57^{a}	5.39^{a}	5.23^{a}	5.10^{a}
Dihydro-2-methyl-3(2H)-furanone	1.83^{b}	1.88^{b}	2.07^{a}	1.59^{b}	1.76^{a}	1.65^{ab}
2-Methylpyrazine	4.86^{a}	4.67^{b}	4.66^{b}	4.48^{a}	4.33^{b}	4.34^{b}
Acetoin	1.05^{b}	1.07^{ab}	1.09^{a}	1.39^{ab}	1.45^{a}	1.37^{b}
Hydroxypropanone	0.99^{a}	1.07^{a}	1.28^{a}	1.55^{b}	1.66^{a}	1.68^{a}
2,5-Dimethylpyrazine	2.16^{a}	2.12^{b}	2.17^{a}	1.76^{ab}	1.69^{b}	1.78^{a}
2,6-Dimethylpyrazine	5.29^{a}	5.15^{b}	5.27^{a}	4.67^{a}	4.56^{b}	4.64^{a}
2-Ethyl-6-methylpyrazine	1.56^{a}	1.47^{b}	1.48^{b}	1.23^{a}	1.14^{b}	1.17^{ab}
2-Ethyl-5-methylpyrazine	1.26^{a}	1.24^{a}	1.24^{a}	1.08^{a}	1.09^{a}	1.10^{a}
Acetic acid	3.51^{b}	3.55^{b}	4.01^{a}	3.89^{b}	3.97^{b}	4.20^{a}
Furfural	5.11^{a}	5.10^{a}	5.45^{a}	6.08^{b}	6.35^{a}	6.27^{a}
Furfuryl formate	1.15^{a}	1.16^{a}	1.21^{a}	1.35^{b}	1.42^{a}	1.37^{b}
2-Acetylfuran	3.48^{b}	3.53^{ab}	3.65^{a}	3.48^{b}	3.58^{a}	3.56^{a}
Propanoic acid, ethyl ester	1.76^{a}	1.75^{a}	1.76^{a}	1.65^{b}	1.64^{b}	1.68^{a}
Furfuryl alcohol, acetate	8.75^{a}	8.67^{a}	8.52^{a}	8.26^{ab}	8.41^{a}	8.12^{b}
5-Methyl-2-furfural	5.21^{a}	5.48^{a}	5.58^{a}	5.60^{a}	5.84^{a}	5.87^{a}
4-Hydroxybutanoic acid	2.03a	2.02a	1.95b	2.08^{a}	2.11^{a}	2.01^{b}
2-Furanmethanol	10.84^{a}	10.71^{a}	10.63^{a}	12.10^{a}	12.34^{a}	12.12^{a}
Isovaleric acid	3.04^{b}	3.20^{a}	3.15^{a}	3.36^{b}	3.44^{ab}	3.52^{a}
3-Ethyl-2-hydroxy-2-cyclopenten-1-one	1.40^{a}	1.40^{a}	1.35^{a}	1.22^{a}	1.14^{a}	1.20^{a}
Guaiacol	1.15^{a}	1.05^{ab}	0.87^{b}	0.95^{a}	0.71^{b}	0.70^{b}
Furfuryl ether	2.61^{a}	1.55^{b}	1.46^{b}	1.44^{a}	1.44^{a}	1.36^{b}
Maltol	2.75^{a}	2.73^{a}	2.55^{a}	2.99^{a}	2.91^{a}	2.84^{a}

1values are means (± SD) of triplicate determinations

2means designated by different letters in a row are significantly different at ($P < 0.05$)

Pyrazines were dominated by derivatives such as 2-Methylpyrazine, 2,6-Dimethylpyrazine, 2,5-Dimethylpyrazine, 2-Ethyl-6-methylpyrazine, 2-Ethyl-5-methylpyrazine. Occurrence of 2,6-Dimethylpyrazine in the headspace of roasted coffee showed the highest intensity than the other derivatives. It is reported to be one of the most important derivative of pyrazines which contribute to the coffee aroma due to its low odour threshold of 18 mg/kg water and has a nutty and maize like [4]. The other derivative was 2-methyl pyrazine which also occurred at higher levels but it is considered to be the least important due to its high odour threshold of 60 mg/kg water [4]. The other important derivative of pyrazine is 2,5-Dimethylpyrazine which occurred as the third in level of abundance with a threshold of 15 mg/kg water also contributes to the nutty and maize like aroma [4]. The occurrence of other derivatives such as 2-Ethyl-6-methylpyrazine and 2-Ethyl-5-methylpyrazine are considered to be the least important because it gives less pleasant aroma described as soil-like aroma. The intensity of this derivatives were the lowest among the pyrazines. The eco-pulper showed a higher significant level for most of the pyrazine derivative such as 2 methylpyrazine and 2-Ethyl-6-methylpyrazine. The eco-pulper was not significantly different from the hand pulper in the levels of 2,6-Dimethylpyrazine and 2,5-Dimethylpyrazine. This may not give the eco-pulper an upper hand in terms of aroma since the compounds which showed higher variations are considered less important in influencing aroma such as 2 methylpyrazine and 2-Ethyl-6-methylpyrazine. However the levels of 2,6-Dimethylpyrazine and 2,5-Dimethylpyrazine were significantly higher than in the wet pulper methods. Higher concentration of this compounds may give a more nutty and roasted smell to the coffee

[14]. Hence the eco pulper method having more levels of this pyrazines than the other methods could be attributed to the difference in the levels of protein and free amino acids contents caused by the residual mucilage [7]. The mucilage in the center cut of coffee beans may not be completely removed by mechanical methods and this could contribute to high levels of proteins and amino acids. The levels of protein and sugar content in the mucilage is indicated to be 8.9% and 2.4%, respectively [12]. The headspace of roasted coffee revealed the presence of carbonyl compounds such as 2,3-pentanedione and hydroxypropanone. Carbonyl compounds are important ingredients of coffee aroma. Some of them are very volatile. Carbonyl derivatives have diverse notes, e.g. pleasant scent of flowers or butter-like, rancid and rotten stench [13].During the roasting process, oxidation of wax deposited on the surface of coffee beans and lipids leached from their core and leads to generation of numerous carbonyl compounds [13]. Ketones accounted 9-12% of the headspace of roasted coffee. The headspace analysis of roasted coffee revealed high concentration of cyclic ketone such as 3-ethyl-2-hydroxy-2-cyclopenten-1-one and 3-Methylcyclopentane-1,2-dione. Cyclic ketones have a sweet, caramel-like smell [4]. The processing methods studied did not show variations in the level of these compounds. The headspace analysis revealed low concentration of phenol compounds accounting to a level of 2%. The group was represented by derivatives such as phenol, guaiacol and p-vinylguaiacol. Their aroma contribution is diverse, such as spicy, clove-like or smoky. Guaiacol was dominant in the group and such compounds are formed through degradation of free phenolic acids and considered as a character impact odorant that gives a phenolic note to coffee aroma [17, 11]. Theeco-pulper method showed higher intensity forguaiacol than the other processing methodsand could indicatepresence of more phenolics compounds in the samples retained after processing than in the wet and hand pulper methods. Pyridines are considerably less desirable components of coffee aroma because they impart bitter, astringent aroma [13]. Three compounds of this group were identified in the roasted coffee and include; pyridine, 3-acetoxypyridine and 3-hydroxypyridine. Their concentration accounted to a level of 6 to 7% of the headspace of roasted coffee. The eco-pulper, wet pulper and hand pulper methods showed an intensity of 7, 7 and 6.5% respectively in Ruiru 11 samples. The concentration in SL 28 samples were 6.2, 6.3 and 6.1 for the eco-pulper, wet pulper and hand pulper methods respectively. This indicates that the processing methods did not vary much in the level of pyridines but were slightly more in Ruiru 11 than in SL 28 samples. Pyrroles, like pyridines, are reported to give negative effects to the aroma of coffee. This group was represented by2-Formyl-1-methylpyrrole pyrrole-2-carboxaldehyde and 1-Furfurylpyrrole. Pyrroles impart aroma that resembles mushrooms and smoke [13]. The headspace of roasted coffee accounted an average level of 3% for pyrroles and the processing methods did not show any significant variations in their concentrations.Pyridines and pyrroles result from thermal degradation of trigoneline and their lack of variations between the processing methods could be correlated to the similarity in the levels of trigoneline. Volatiles acids and esters occupied a headspace of 10% and were dominated by compounds such as acetic acid, isovaleric acid, propanoic acid, ethenyl ester and 3-Methyl-2-butenoic acid.There were some variations noted in the concentrations of this compounds between the processing methods studied. The hand pulper method showed slightly higher intensities than the eco-pulper and wet pulper samples. This could be attributed to the high level of mucilage in the samples owing to the high content of pulp mixed with the coffee parchment during fermentation resultingfrom inefficiency of the method to completely separate pulp from the coffee beans. The high content of mucilage and pulp during fermentation may result in increased release of this compounds which can then penetrate the coffee beans. Acetic acid and lactic acid are produced early in coffee fermentation while propionic and butyric acid are produced later [15]. Maltol is one of the desirable component of roasted coffee which is reported to add a sweet and burnt smell to coffee aroma [4]. The processing methods did not show variations in the level of maltol and the intensity of this compound was not significantly different in Ruiru 11 and SL 28 samples.It can be concluded that Ruiru 11 and SL 28 shows similar aroma compounds in roasted coffee and littlevariations occurs in the intensities of most compounds classified as furans, pyrazines, ketones, pyrrole and pyridines. It was observed that Ruiru 11 samples shows higher intensities in the levels of some chemical classes such as pyrazines, pyrroles and pyridines. Therewere little variations observed in the levels of individual compoundsbetween the processing methods with the eco-pulper showing higher intensity than the other methods in the levels of some pyrazines such as 2 methypyrazine and 2-Ethyl-6-methylpyrazine. The wet pulper showed higher concentrations for some furan compounds such as furfuryl formate and furfuryl alcohol acetate. The hand pulper showed higher level for the ketones and some acid and esters. This variations between processing methods and coffee varieties in the level of aroma compounds may also lead to variations into the sensory quality of coffee.

3.3 Effects of Processing on Sensory Attributes and Total Quality between Coffee Varieties

The results for the sensory attributes for the two varieties of coffee, SL28 and Ruiru 11 are shown on Figure 3. Considering the SL 28 samples, the processing methods showed similar scores of 7.7 for the aroma, flavor and aftertaste. The acidity showed a score of 7.9, 7.8 and 7.8, for the eco-pulper, wet pulper and hand pulper, respectively. The body and balance showed same score of 7.7, 7.6 and 7.7 for eco-pulper, wet pulper and hand pulper, respectively. For the overall acceptability, the eco-pulper and hand pulper also showed higher scores of 7.8 while wet pulper showed a score of 7.7. Considering Ruiru 11 samples, the aroma showed scores of 7.7, 7.6 and 7.5 for the eco-pulper, wet pulper and hand pulper, respectively. The flavor was rated as 7.6, 7.6 and 7.7 for the eco-pulper, wet pulper and hand pulper, respectively. The processing methods showed similar scores of 7.7 for the aftertaste attribute. For acidity, the hand pulper showed a higher score of 7.9 while the eco-pulper and wet pulper showed similar scores of 7.8. The processing methods showed similar scores of 7.7 for the body of coffee brew. The eco-pulper method showed a higher score of 8.2 for the balance attribute while the wet and hand pulper methods showed same score of 8.0 for this parameter.

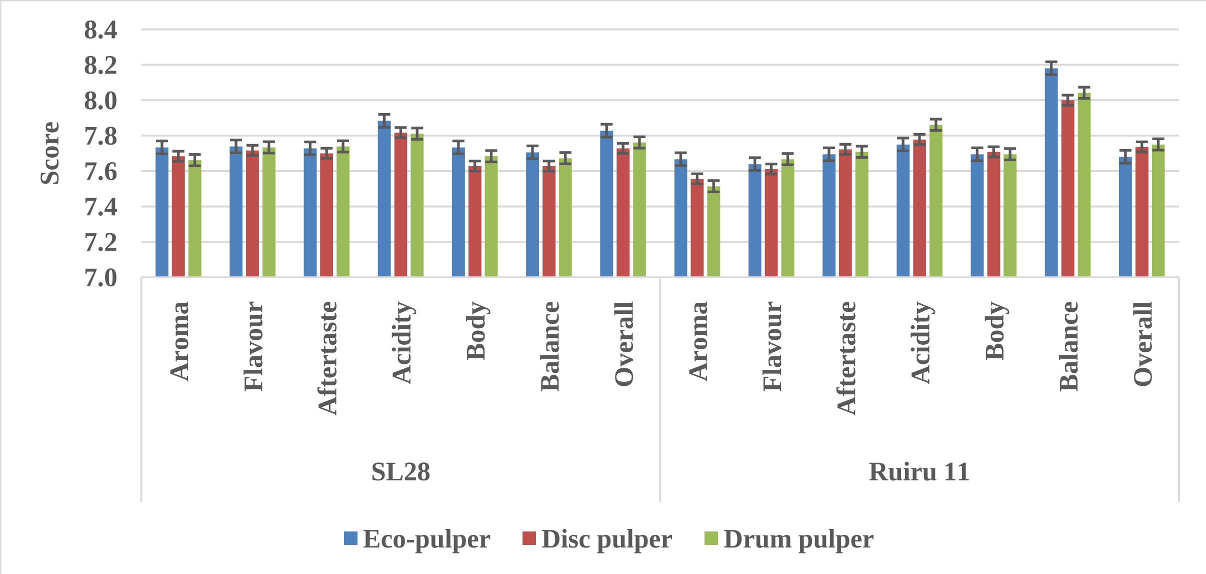

Figure 3: SensoryAttributes Levels for SL 28 And Ruiru 11 Samples Processes by three Different Methods

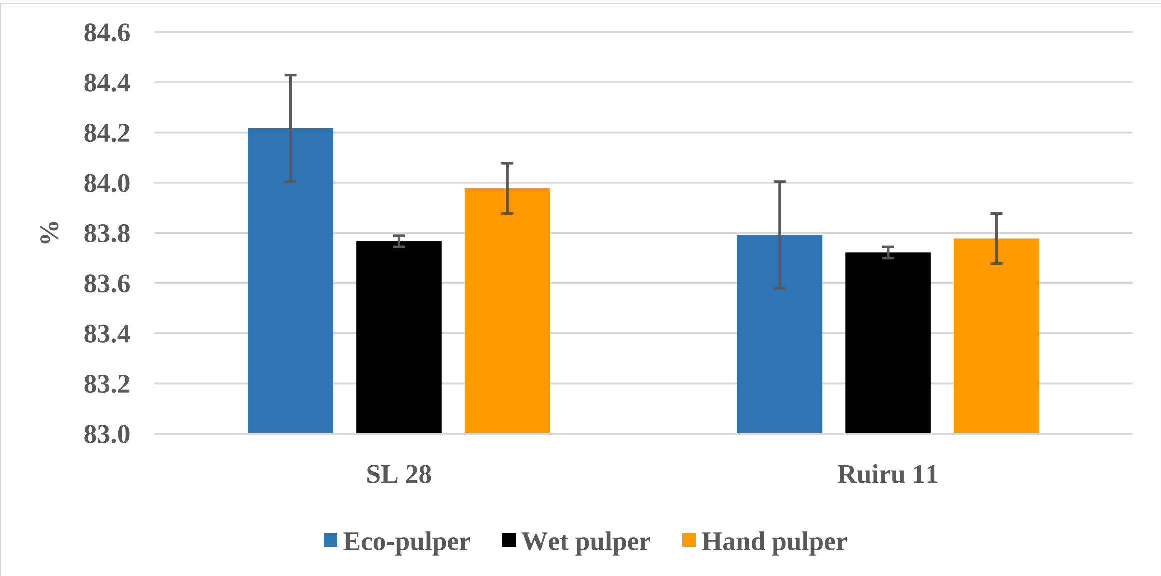

Figure 4: Total Quality Levels for SL 28 and Ruiru 11 Samples Processed by three Different Methods

Regarding the overall acceptability, the hand pulper method showed higher score of 7.8 while the eco-pulper and wet pulper methods showed same scores of 7.7. Clean cup, uniformity and sweetness of the coffee brews gave similar scores of 10 for all the processing methods and varieties studied. From the results it could be observed that eco-pulper,wet pulper and hand pulper showed similar values for the flavor and aftertaste. The aroma was slightly higher in the eco-pulper samples than for the other methods. The eco-pulper method and hand pulper methods also showed higher values for the acidity, body, balance and overall acceptability of coffee brews.The variations could be attributed to the level of components contributing to the parameters. The samples with an intense body could have a high score in terms of quality and this is due to the presence of more solids dissolved in the beverage such as lipids, proteins and sugars. The high score for aroma may be influenced by the intensity of aroma compounds contained in roasted coffee. Therefore the eco-pulper method showing higher level for aroma could be due to the high intensity of most of the pyrazines compounds and mainly 2-ethyl-6-methyl pyrazines and 2-methylpyrazines which was observed in this study. The higher concentration of pyrazines is reported to gives a more nutty and roasted smell to the coffee [14]. The hand pulper also showing higher levels for the attributes such as acidity and overall acceptability could also be due to the high levels of ketones and acids as was also noted in the study.The cyclic ketones contributes to a sweet, caramel-like smell to the coffee aroma [4].The results for the final quality of coffee are shown in Figure 4.From the results, the eco-pulper, wet pulper and hand pulper showed mean final quality of 84.2%, 83.7% and 83.9%, respectively for SL 28 samples. Considering Ruiru 11 samples, the eco-pulper, wet pulper and hand pulper showed mean final quality of 83.8%, 83.7% and 83.8%, respectively. The general observations indicate that the eco-pulper showed slightly higher level for the final quality in SL 28 samples but the levels were not significantly different between the processing methods for Ruiru 11. It was also noted that the SL 28 samples showed higher level for the final quality than Ruiru 11 samples. The low levels observed for Ruiru 11 samples could be related to the higher levels of the undesirable aroma compounds such as pyridines and pyrroles which was noted in the analysis of aroma compounds of roasted coffee.

3.4 Conclusion

The study revealed that there were variations between the different coffee processing methods and the coffee varieties in terms of concentration of aroma compounds of roasted coffee. It showed higher levels of pyrazines, furans and ketones from eco-pulper, wet pulper and hand pulper methods respectively. The coffee varieties showed some slight variations in the level of pyrroles and pyridines. The eco-pulper and hand pulper methods showed better aroma quality than wet pulper and SL 28 variety showed better overall sensory quality than Ruiru 11.

4. ACKNOWLEDGEMENT

This work was sponsored by DAAD through collaboration of Dedan Kimathi University of Technology, Kenya and Technical University of applied Science, Wildau. The initial part of the project was done with Funds offered by the National Council of Science and Technology (NACOSTI). We acknowledge the services of technical staff of Molecular Biotechnology Department, Wildau.

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