Seminar report

ESPRESSO COFFEE: THE SCIENCE OF QUALITY

By

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DECLARATION

I, Sharon Jacob (2018-12-027) hereby declare that the seminar entitled 'Espresso coffee: The science of quality' has been prepared by me, after going through various references cited at the end and has not copied from any of my fellow students.

Vellanikkara   Sharon Jacob

25/01/2020   2018-12-027

CERTIFICATE

This is to certify that the seminar report entitled 'Espresso coffee: The science of quality' has been solely prepared by Sharon Jacob (2018-12-027) under my guidance and has not been copied from fellow students.

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1. Introduction

Coffee is a brewed drink prepared from roasted ground coffee beans, the seeds of berries from *Coffea* species. The genus *Coffea* is native to Tropical Africa particularly Ethiopia and Sudan. In India, coffee is traditionally grown in the Western Ghats spread over Karnataka (68.7%), Kerala (22%) and Tamil Nadu (5.6%) (Coffee Board of India, 2018). Coffee cultivation is also being expanding rapidly to the non-traditional areas of Andhra Pradesh and Odisha as well as to the North Eastern states. Indian coffee has created a niche for itself in the international market and the Indian Coffees are earning high premium, particularly Indian Robusta which is highly preferred for its good blending quality. Arabica Coffee from India is also well received in the international market. Coffee is a dark colored, bitter, and slightly acidic with a stimulating effect in humans, primarily due to its caffeine content (Cappelletti, *et al*., 2015).

It is one of the most popular beverages in the world and there are a wide varieties of coffee like drip, filter, French press, espresso *etc*. Espresso coffee (EC) is a polyphasic beverage prepared only with ground roasted coffee and water, constituted by a foam layer of small bubbles with a particular tiger tail pattern, on the top of an emulsion of microscopic oil droplets in an aqueous solution of sugars, acids, protein-like material and caffeine, with dispersed gas bubbles and colloidal solids. These physico-chemical characteristics of espresso coffee are responsible for their peculiar sensorial properties which include a strong body, a full fine aroma, a bitter/acid balance taste and a pleasant lingering aftertaste, exempt from unpleasant flavor defects (Petracco, 2005).

Illy and Viani (2005) proposed that the Latin etymology of the word espresso, literally meaning pressed out, clearly points out the importance of pressure in espresso brewing, making the technique an integral part of the definition. Espresso is a brew obtained by percolation of hot water under pressure through tamped/compacted roasted ground coffee, where the energy of the water pressure is spent within the cake. Thus it is clear from the definition that many parameters are involved in the preparation of a perfect cup of espresso coffee holding all its peculiar qualities.

2. History

Angelo Moriondo, from Turin, patented a steam-driven "instantaneous" coffee beverage making device in 1884 (No. 33/256). The device is "almost certainly the first Italian bar machine that controlled the supply of steam and water separately through the coffee powder" and Moriondo is certainly one of the earliest discoverers of the expresso machine. In 1901, Luigi Bezzera, from Milan, came up with a number of improvements to the espresso machine. In 1903, the patent was bought by Desiderio Pavoni, who found the La Pavoni company and began to produce the machine industrially (one a day) in a small workshop in Milan (Bersten, 1993). Later on many modifications happened to the espresso machine and also varieties of coffee types were invented, with espresso as its base. Thus espresso coffees got popularised with the spread of coffee outlets, internationally known as “Starbucks” and “Café Coffee Day”, the Indian coffee chain.

Plate 1: Espresso coffee

3. Espresso coffee

Espresso coffee, basically, is an Italian preparation. It is believed to be a method of roasting but actually it is a method of coffee preparation. The espresso coffee beverage, which is a polyphase colloidal system, has the liquid phase topped by a wet foam of tiny sphere-shaped gas bubbles. Each sphere is surrounded by a liquid film, the lamellae, that separate it from its neighbours and hosts biopolymers and natural surfactants. Foaming biopolymers of coffee, the proteins/melanoidins fraction and polysaccharides fraction, were extracted from defatted and roasted ground coffee. The meaning of the word espresso/express is that it is made for a special purpose, on the moment, on order according to Illy (2005). If an espresso is kept waiting, smoothness of taste is lost and perceived acidity increases with time, regardless of cooling. Furthermore, if the cup cools down, an unbalanced saltiness becomes noticeable.

The steps involved in preparation of espresso coffee starting from harvest are similar to the normal coffees till roasting of the green beans. The main steps from roasting of the beans are discussed here under.

3.1. Roasting

Roasting is the application of heat to the dried green raw beans (Plate 2a). Heat energy is applied to the surface of the whole green bean, mainly by external hot gas flow, with additional radiation and contact heat transfer depending on the type of roaster. The temperature of the bean surface increases with heat conduction into the porous material due to the temperature gradient. When the inside temperature reaches the evaporation temperature of the bean moisture, the evaporation front starts moving towards the centre of the bean. During this first part of roasting process, the walls of the whole bean are still relatively firm. Thus, the vapour that has been generated cannot permeate and the pressure build-up makes the bean volume expand. Roasting reactions, browning with formation of flavour compounds at elevated inner pressures, begin at higher temperatures ($T>160^0C$) at the bean surface moving towards the inner dry pre expanded structure of the bean. Gaseous reaction products, mainly carbon dioxide, are generated and entrapped within the cell structure, increasing inner pressure until they permeate through the walls that are weakened and partly destructed by the high temperatures as well (Perren *et al*., 2001). Roasting is responsible for changes in profile of different constituents which results in characteristic flavor, aroma and colour.

3.2. Grinding

Grinding is performed by a grinder (Plate 2b), or coffee-mill, and the resulting product is ground coffee. The term ‘grind’ applies to an important variable in espresso coffee preparation referring to the degree of comminution associated with the concept of fineness of ground coffee. The main objective of grinding is to increase the specific extraction surface, or rather, to increase the extent of the interface between water and the solid per unit weight of coffee, so as to facilitate the transfer of soluble and emulsifiable substances into the brew. Two apparently contradictory needs must be satisfied to prepare a good cup of espresso, on one hand a short percolation time is required, while, on the other hand, high concentration of soluble solids must be reached (Illy and Viani, 2005). Both requirements can only be attained if a close contact between solid particles and extraction water is maintained. Thus, espresso percolation needs a plurimodal particle size distribution, where the finer particles enhance the exposed extraction surface needed for chemical need action and the coarser ones allowing the water flow which is the physical need.

Thus, two phases of comminution must be taken into consideration in the design of a grinder:

- a crushing phase, where the convolute structure of the brittle roasted bean is broken down into fragments of approximately one millimetre
- a second phase, properly called as grinding, in which such fragments are subjected to shearing forces

3.3. Percolation

Percolation is the last stage before serving, which crucially contributes to the quality of the beverage. A cup of espresso coffee is prepared by percolating a definite quantity of liquid through a compact bed of ground coffee particles, the cake (Plate 2d). The coffee cake is usually contained in an impermeable metal holder, generally made of stainless steel for its inalterability and easy cleaning. The holder is popularly called as portafilter (Plate 2c). When dealing with espresso, the liquid involved in this process is water, heated to a temperature just above 90^0C by means of direct or indirect heating. The driving force that generates the flow is produced by the pressure drop undergone by the hot water that enters the cake with positive hydrostatic pressure. Pressure energy is partly dissipated as heat by the friction generated when water flows through the particles, and partly transformed into kinetic energy of the beverage which flows into the cup. Two processes take place during percolation, one is extraction of water soluble substances and the other is the emulsification of insoluble coffee oils. Caffeine extraction yield is usually within the range of 75–85% (Petracco, 1989).

(a) (b) (c) (d)

Plate 2: Steps in EC preparation (a) Roasting (b) Grinding (c) Ground coffee in portafilter (d) Percolation

4. Factors influencing the cup quality of espresso

There are many factors during percolation that influence the cup quality of espresso coffee like temperature, pressure, coffee/water ratio, crema stability, water quality *etc*. These factors are discussed in brief in the following section.

4.1. Temperature

Water temperature is one of the greatest influencing factors on the final quality of EC, because hot water can extract different chemical compounds from the roasted and ground coffee. Chemical substances like aldehydes, ketones, pyrazines *etc* are volatile and are responsible for the aroma. Others are soluble and non-volatile like caffeine, trigonelline, acids, sugars, *etc* which are considered as the taste source. The extracted insoluble compounds like proteins, polysaccharides and melanoidins become the coffee's body and foam. An adequate extraction produces a good espresso which will have a balanced bitter/acid taste, a strong body, a full fine aroma, a pleasant aftertaste and a large amount of persistent, consistent and hazelnut foam with a 'tiger-skin' effect (Illy and Viani, 1995; Cipolla, 1999). According to a work conducted by Andueza *et al*. (2003), the temperature during extraction directly influenced physico-chemical characteristics, sensory attributes and aroma/flavour of espresso coffee.

4.1.1 Influence of temperature on physico-chemical parameters and sensory attributes of samples

Lingle (1996) proposed that extraction percentages should be in the range of 18–22% (180-220g/kg) in order to obtain a coffee beverage with the most desirable flavour. Andueza *et al*. (2003) studied the influence of temperature on physico-chemical parameters and sensory attributes of samples prepared using different blends at different temperatures. Among the physical parameters, only the foam index increased (Table 1). It is said that this might be due to the high extraction of total solids. Other extracted compounds, such as total lipids and caffeine, tended to increase with water temperature. However, in general, the extraction of trigonelline and chlorogenic acid increased until 92°C and then tended to decrease with further increase in temperature. In case of sensory attributes, the panel of judges perceived astringent and bitter flavour for the samples extracted at 96^{0}C and 98^{0}C especially for arabica and robusta natural blend. For robusta torrefacto blend, more than 22% extraction has to be revised since extract products are also contributed from caramalised sugar. Robusta torrefacto blend is prepared by roasting robusta coffee beans along with sugar, which gets caramalised due to high temperature.

Table 1: Influence of temperature on physico-chemical parameters

Parameters	Arabica				Robusta natural blend				Robusta torrefacto blend			
	88^0C	92^0C	96^0C	98^0C	88^0C	92^0C	96^0C	98^0C	88^0C	92^0C	96^0C	98^0C
Extraction (g/kg)	192	209	222	222	199	203	212	215	226	231	233	233
Foam index (%)	12.1	12.3	12.3	12.8	17.4	17.5	20.3	21.0	18.4	20.4	22.3	23.9
Caffeine (mg/ml)	2.02	2.05	2.09	2.31	3.03	3.05	2.94	3.02	2.90	2.89	2.96	2.92
Trigonelline (mg/ml)	0.81	0.94	1.15	1.39	1.16	1.30	1.08	1.07	0.97	1.34	1.33	0.79
Chlorogenic acid(mg/ml)	1.01	1.12	1.01	0.92	1.47	1.27	1.32	1.35	0.97	1.11	1.05	1.08

4.1.2 Influence of temperature on aroma/flavour

Methanethiol has been related to freshness aroma in ground roasted and to sulphurous flavour in coffee brew (Semmelroch and Grosch, 1995). Acetaldehyde and propanal may be responsible for fruity flavour in coffee brew (Maeztu et al, 2001; Semmelroch and Grosch, 1995). 2-Methylpropanal, 2-methylbutanal and 3-methylbutanal, Strecker degradation products of valine, isoleucine and leucine, were suggested to be the compounds responsible for malty flavour in coffee brew (Semmelroch and Grosch, 1995; 1996). 2,3-Butanedione and 2,3-pentanedione were associated with buttery flavour (Blank *et al*., 1991; Semmelroch and Grosch, 1995). On the other hand, hexanal was responsible for green aroma. Pyrazines have been associated with roasty and earthy/musty flavours in ground roasted coffee and coffee brew. Guaiacol, a phenolic compound, was responsible for phenolic, spicy and burnt aromas/flavours.

During an experiment conducted by Andueza *et al*. (2003), the highest values for sulphur compounds, aldehydes and ketones and the lowest ones for pyrazines were obtained at 92°C, when the EC samples were prepared at different temperatures using different coffee blends . All odorants related to freshness, fruity, malty and buttery flavours, except 2-methylbutanal and 2,3-

butanedione, were significantly lower in 88°C than in 92°C for arabica EC. The 88°C samples were perceived by the panel of judges as having lower odour, flavour and body intensities in comparison with higher-temperature samples. Also, these EC samples had lower overall acceptability values. The best profile of key odorants and flavour notes (Fig. 1), having persistent, consistent and hazelnut foam with a 'tigerskin' effect and the highest overall acceptability were obtained for 92°C arabica EC. Therefore 92°C was considered to be the optimal temperature for the preparation of a good arabica EC.

The sensory characteristics of robusta natural blend EC samples were very similar at all temperatures. The highest percentages of key odourants related to freshness, fruity, malty and buttery flavours in robusta natural blend EC were obtained at 92°C, while the highest percentages of key odourants related to roasty and earthy/musty flavours were extracted at 96°C (Fig. 2). Moreover, in 96°C and 98°C robusta natural blend ECs, the judges perceived that the foam was darker. Therefore the optimal water temperature for obtaining a good robusta natural blend EC was 92°C.

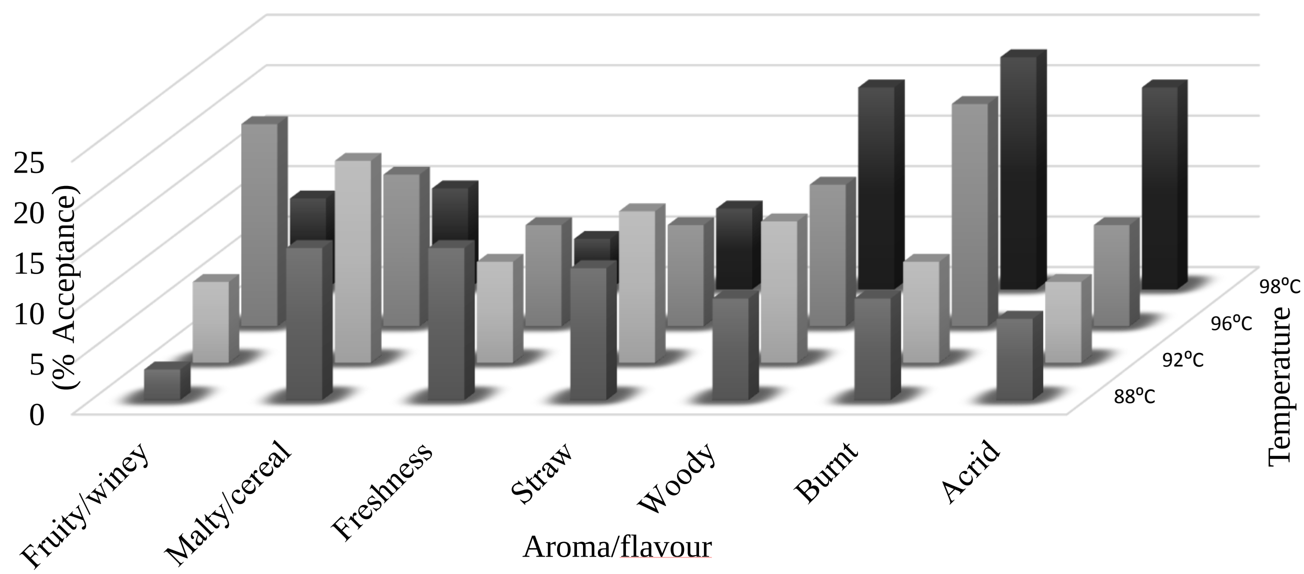

Figure 1: Influence of water temperature on flavour characteristics of Arabica espresso coffee samples

In EC prepared using robusta torrefacto blend also there were similar findings. A torrefacto roasting process is usually applied to increase the body and mask the low quality of some robusta coffees. But, the flavour sensory profile observed in robusta torrefacto blend EC was worse than that found in Robusta natural blend EC. The lowest percentage of negative

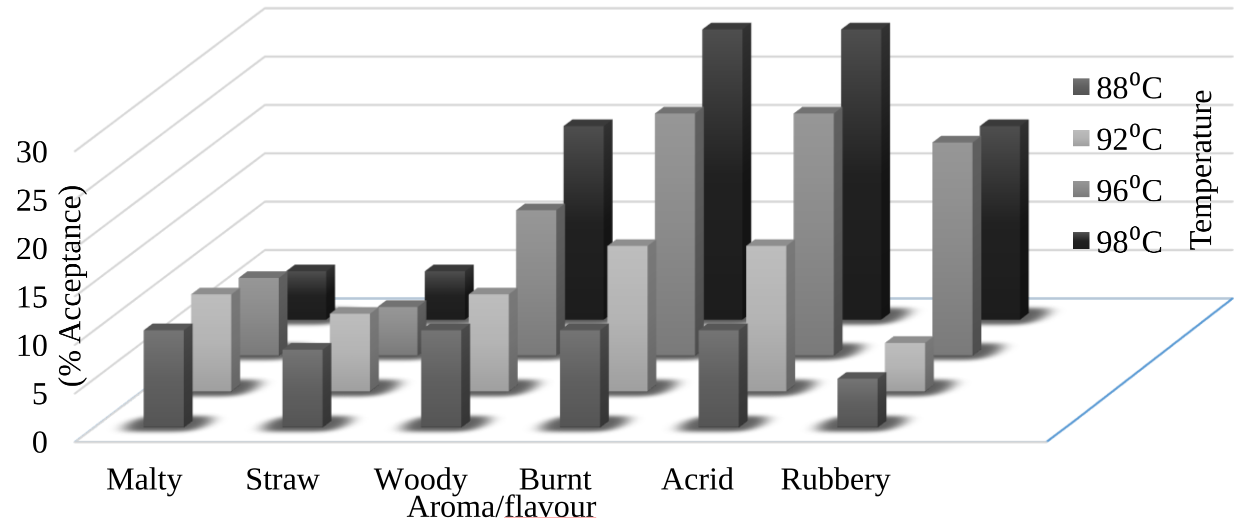

Figure 2: Influence of water temperature on flavour characteristics of robusta natural blend coffee samples

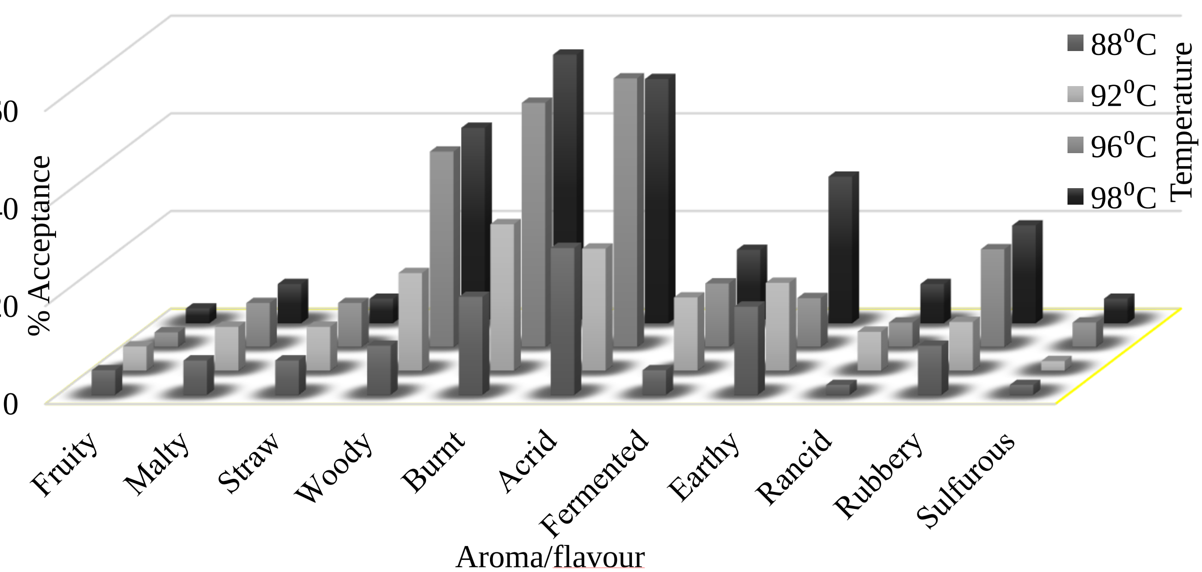

Figure 3: Influence of water temperature on flavour characteristics of robusta torrefacto blend samples

flavour notes and the highest overall acceptability might lead to the selection of 88°C as the ideal water temperature. However, the low body, flavour and odour intensities, the high percentages of key odorants related to roasty and earthy/musty flavours (Fig. 3) and the 'not hot enough' perception dictated the selection of 92°C as the optimal temperature for making the most acceptable robusta torrefacto blend EC like in arabica and robusta natural blend. Thus, it can be concluded that, the best temperature for preparation of espresso coffee is 92^{0}C.

4.2. Coffee-water ratio

The physico-chemical and sensory characteristics of an espresso coffee obviously depend on both the selection of ground roasted coffee and the technical conditions of the percolation process, which should be adjusted according to the coffee type (Petracco, 2005). The coffee/water ratio is another factor that could influence the extraction and quality of the coffee compounds. An excessive amount of coffee would not allow sufficient expansion during wetting, thus causing over-compaction, which disturbs the percolation and results in deposition of solids in the cup. In contrast, too little coffee could result in a brew that will be over-extracted and will have a bitter flavour (Lingle, 1996). Based on his commercial and technical experience, Petracco (2005) proposed a range between 5 g and 8 g of ground coffee for preparing one cup of espresso, depending on the coffee blend.

In a work conducted by Andueza *et* al. (2007), during each sample preparation, the foam index increased significantly with coffee/water ratio but all espresso coffees had a sufficient amount of consistent, persistent and hazelnut foam. Thus, the coffee/water ratio in the proposed range seems to have less influence on the amount and quality of the foam than other technical parameters. On the other hand, robusta blend espresso coffee had higher foam indices than arabica, may be because of the presence of unknown tensioactive substances which increased the foam (Petracco, 2005).

4.2.1 Influence of coffee-water ratio on chemical characteristics and taste

The extraction of caffeine and chlorogenic acid, compounds related to bitterness and astringency, increased when the coffee/water ratio was higher. However, among the samples *viz*., EC made from pure arabica, arabica-robusta 20:80 blend and arabica-robusta 20:80 blend with 50% torrefacto coffee, significant increase in bitterness and astringency were perceived only in robusta blend espresso coffee, and mainly in torrefacto coffee. This could be partially due to the higher amount of caffeine and trigonelline in the robusta variety (Petracco, 2005) and, consequently, higher extraction in espresso coffees. Furthermore, the formation of other unidentified bitter compounds derived from Maillard reactions and caramelisation during roasting of robusta coffee, and mainly in torrefacto roast, could also contribute to the greater bitterness and astringency of robusta blend espresso coffee. A bitterness intensity higher than 7.5 on a 10-scale was proposed to reject 8.5 g/40ml in both robusta blend espresso coffee and also 7.5 g/40ml in torrefacto coffee (Andueza *et al*., 2007).

4.2.2 Influence of coffee-water ratio on aroma/flavour

Andueza *et al*., (2007) conducted a work on three types of samples of EC prepared using pure arabica coffee, arabica-robusta 20:80 blend and arabica-robusta 20:80 blend with 50% torrefacto coffee which were prepared at three coffee water ratios *viz*., 6.5, 7.5 and 8.5g per 40ml water. He found that, in EC with 100% arabica (A100), the key odourants were almost similar in three coffee/water ratios (Fig. 4) but negative flavour profile like burnt/roasty, acrid and fermented flavours was observed on increasing coffee quantity. Freshness was found to decrease with high coffee-water ratio. Similar observations were found in EC with arabica-robusta blend of 20:80 ratio (Fig. 5). Therefore, quantity of 6.5g and 6.5-7.5g was found best for conventional roasted coffee and torrefacto roasted coffee (Fig. 6) respectively.

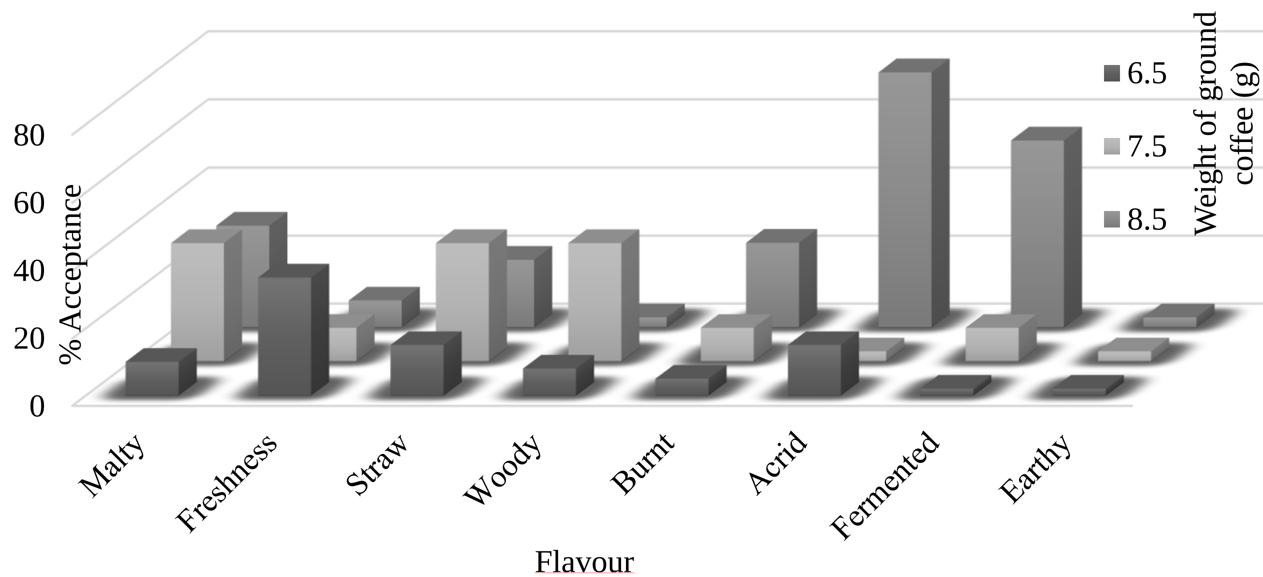

Figure 4: Influence of coffee quantity on flavour of pure arabica espresso coffee

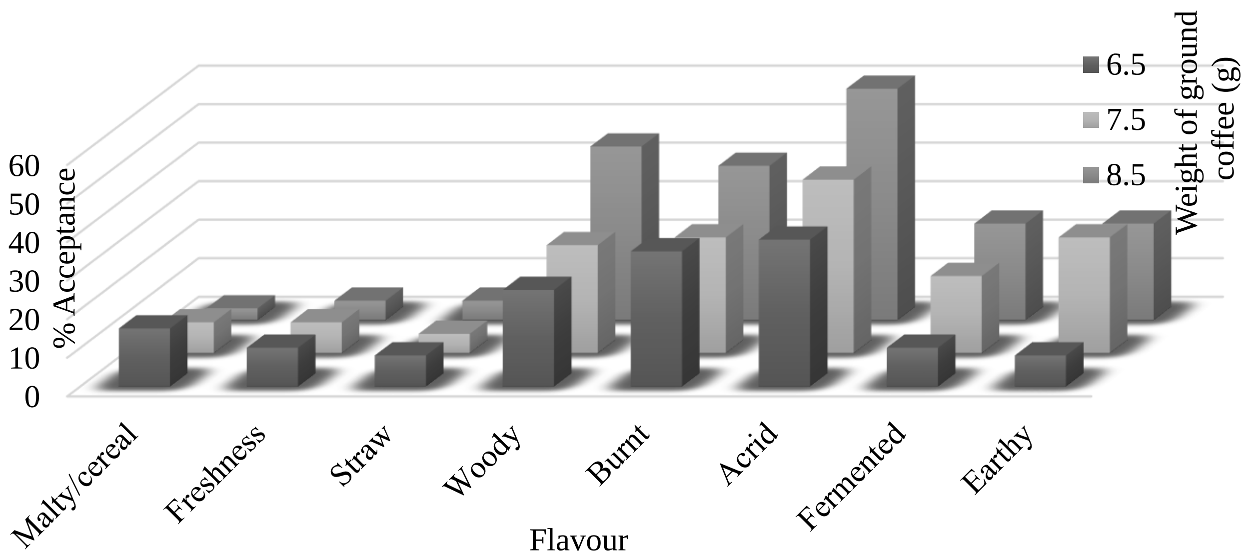

Figure 5: Influence of coffee quantity on flavour of arabica/robusta 20:80 blend espresso coffee (A20:R80)

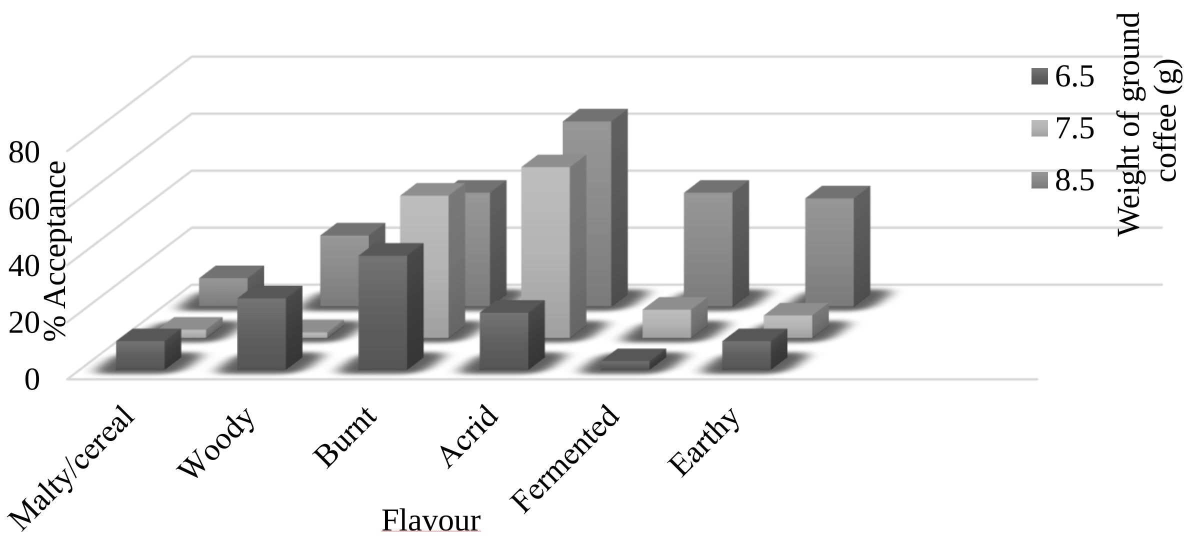

Figure 6: Influence of coffee quantity on flavour in blend of A20:R80 with 50% of torrefacto blend espresso coffee

4.3. Espresso crema

Freshly brewed espresso coffee displays a thick layer of dense, reddish-brown foam of small gas bubbles, which is commonly known as “crema” (Illy and Viani, 2005). A layer of crema persisting for few minutes is very important since it is a characteristic quality of an espresso coffee. In general, coffee connoisseurs expect crema to typically occupy at least 10% of the volume of an espresso, and it must survive at least 2 min before breaking up to reveal the underlying liquid phase. The formation of crema foam is mediated by protein and protein-derived melanoidins present in the brew, while the persistence of the crema is mainly determined by the extracted polysaccharides, mainly galactomannans and arabinogalactan, that provide the viscoelastic interfacial properties of the lamella liquid films. Crema is less stable and after crema formation, the entrapped water flows down due to gravity and the stress of lamellar structure has to bear by surfactant molecules. Since its elasticity is less, the molecules rupture by releasing the entrapped gas (Illy and Navarini 2011; Illy and Viani 2005).

4.3.1 Effect of particle size and basket size on espresso crema

Crema volume and its stability are influenced by the particle size of coffee and the size of basket used for coffee preparation. The size of baskets used for EC preparation varies from single shot to double and triple shot baskets, which determines the quantity of shots used for coffee preparation. In a work conducted by Wang *et al*. (2019), the maximum crema volume for single shot, double shot and triple shot baskets were found to be 10.6, 20.0 and 20.0 ml, respectively (Fig. 7). This observation could be associated with the less number of holes in the single-shot (253 holes) than the double-shot and triple-shot baskets (~583 and ~716 holes respectively), thus less number of sites available for pressure-drop that induced foaming. In addition, the higher crema volume for double and triple baskets than the single counterpart could be explained by the higher amounts of coffee used for brewing, resulting in greater quantities of dissolved CO_2 and foaming agents being extracted into the cup.

Plate 3: Brew baskets used for percolation

Crema fading time was shorter for brews from single basket than double and triple baskets (Fig. 8). The increased foam stability of brews from larger baskets can be partially because of higher total solids with higher foam stabilizing agents like galactomannan and arabinogalactan. It could also be due to the higher elution of finer particles in large baskets with higher perforated surface area. On the other hand, within the particle size range investigated, the crema remained stable for espresso samples brewed from both double- and triple-shot baskets.

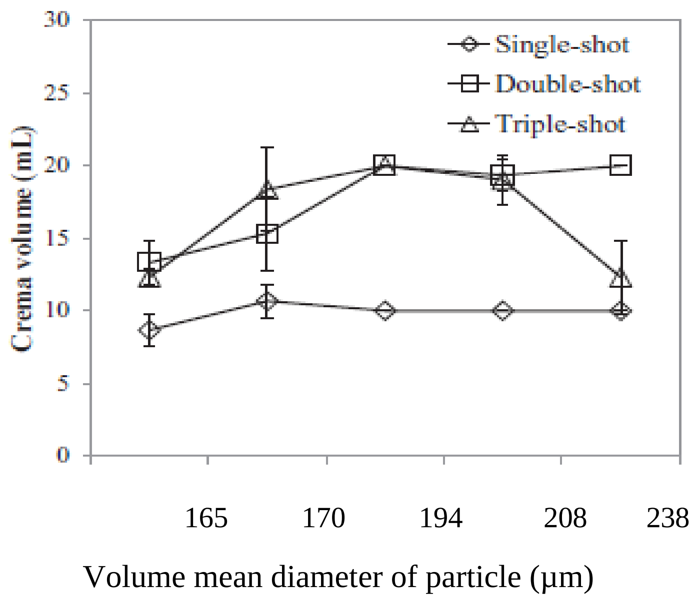

Figure 7: Effect of basket type and particle size on crema volume

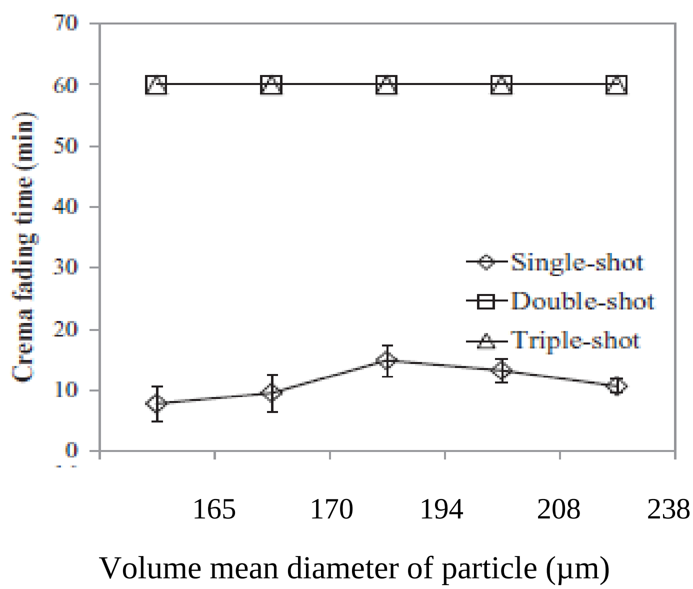

Figure 8: Effect of basket type and particle size on crema stability

4.3.2 Effect of coffee freshness on crema volume, stability and carbon dioxide content

An amount of carbon dioxide formed during coffee roasting is trapped in the roasted coffee beans and released slowly during storage (Anderson *et al*., 2003; Wang, 2014). As shown in Fig. 9, the residual CO_2 content of roasted beans, immediately after roasting, was 10.9 mg/g. The CO_2 content decreased to 8.05 mg/g after one day, and rapidly dropped to 4.5 mg/g after one week of storage under the experimental conditions applied. Thereafter, the CO_2 releasing rate was reduced, i.e., from 4.5 to 2.9 mg/g during the subsequent four weeks of storage. The crema volume followed a similar trend as CO_2 content, showing a rapid decrease during the first week of storage. It is noteworthy that no significant change in crema volume was observed between the freshly roasted and one-day old coffees, despite a significant decrease in CO_2 content in the latter. Beyond one week, further storage did not result in significant changes in crema volume. As for the crema stability, the fading time was all longer than 60 minutes. Thus, while CO_2 content is correlated strongly with the crema volume, this parameter is not the main contributor to crema stability (Wang *et al*., 2019).

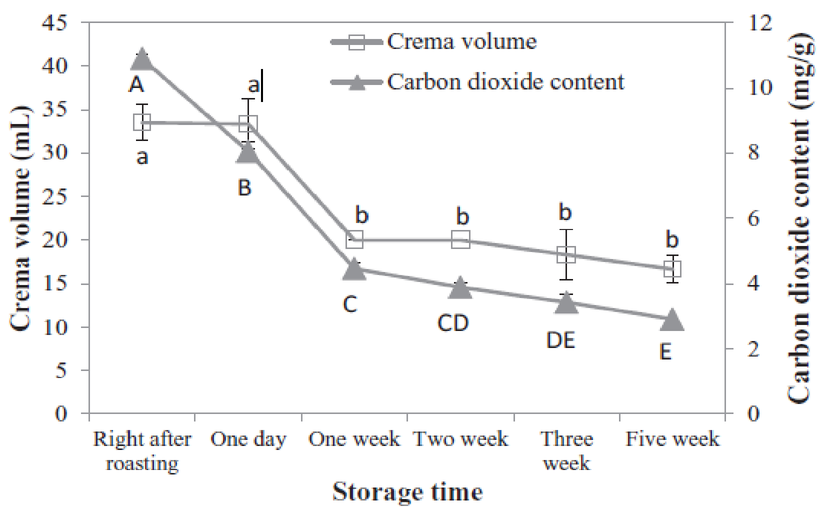

Fig 9: Effect of coffee freshness on crema volume and CO_2 content

4.3.3 Effect of coffee variety and degree of roast on crema volume and stability

The effect of coffee variety and roast degree on crema properties is summarized in Table 2 which was based on a work conducted by Wang *et al*. (2019). Espresso brewed from robusta beans had more crema volume but lower stability than Arabica coffee. On an average, the pure arabica coffee contain higher total lipid contents than robusta beans (Illy and Viani 2005; Wang, 2014). Since lipid is an anti-foam agent, the lower crema volumes observed for arabica espresso could be attributed to the higher amount of lipids being extracted. In addition, the protein and protein-derived melanoidins related to the foaming could be different for arabica and robusta due to the different chemical compositions. But an opposite trend was observed with the crema fading time. Overall, arabica crema foams lasted longer than those from robusta beans. The higher interfacial tension of robusta brew than arabica reinforced the above observation. The higher crema stability for arabica coffee than robusta could be attributed to the lipid contents as well. As for the degree of roast, dark roast samples for both arabica and robusta coffees tended to exhibit higher crema volume than the medium roast counterparts which was attributed to the higher melanoidins (foaming agent) content, as well as the greater residual CO_2 in the dark roasted coffee (Wang and Lim, 2014).

Table 2: Effect of coffee variety and degree of roast on crema volume and stability

Brew	**Degree of roast**	**Crema volume (ml)**	**Crema fading time (min)**
Single-shot basket			
Arabica	Medium	11.3	19.0
	Dark	13.3	8.3
Robusta	Medium	12.7	9.4
	Dark	20.0	21.7
Double shot basket			
Arabica	Medium	28.3	60.0
	Dark	34.3	60.0
Robusta	Medium	60.0	13.7
	Dark	62.7	24.0

4.4. Water quality

Water is another important ingredient for espresso coffee preparation since percolation or brewing is done using hot water. Hence, quality of water is yet another factor that influences the quality of espresso coffee. Electrolytes in water adversely affect the quality of beverage (Pangborn *et al*., 1971). In particular the carbonates are the worst offenders, resulting in a bitter, flat coffee.

Moreover, although a certain degree of acidity is characteristic of brewed coffee, the sourness of coffee prepared from distilled water has been found to be excessive (Pangborn *et al*., 1971).

In an experiment conducted by Navarini and Rivetti (2010), they used bottled mineral water and Milli Q water for comparing the foam quality. Milli Q water is an ultra-pure reagent grade water produced by Milli Q system developed by Millipore, Italy. The calcium, magnesium and bicarbonate content in the samples are given in the Table 3.

It is clear from the Table 4 that the espresso coffee sample prepared with Milli-Q ultra-pure reagent grade water, virtually lacking of any solute, is characterised by the lower foam volume in comparison with other mineral water samples A, B, C and D. The foam volume increased from Milli Q to D water which may be due to the bicarbonate content since it provides CO_2 for the foam formation.

Table 3: Properties of water samples used for preparation of espresso coffee

Water	Ca^{2+}(mg/l)	Mg^{2+}(mg/l)	HCO^{3-} (mg/l)
Milli Q	-	-	-
A	32.9	6.5	106
B	55	12	198
C	80	26	360
D	171	27.8	574

Table 4: Foam volume of Espresso coffee samples as a function of water type

Water	Foam volume (ml)
Milli Q	3.79 ± 0.62
A	4.40 ± 0.46
B	4.38 ± 0.24
C	6.24 ± 0.57
D	9.48 ± 1.09

In the case of foam persistency, water rich in bicarbonate ions led to an evanescent foam collapsing very quickly. But in the espresso sample prepared using Milli Q water, fading of foam was slower.

Even the foam texture is affected by quality of water. As a matter of fact, water poor in bicarbonate ions like Milli Q, samples A and B permit to prepare an espresso coffee with a foam layer characterised by a desired fine texture whereas water rich in bicarbonate ions, like sample D, led to a foam characterised by non-desired large bubbles unacceptable for consumers. This indicated that the quality of espresso is also influenced by the type of water used for extraction. More studies are needed in this area to scientifically define the best quality water for espresso coffee preparation.

4.5. Pressure

The espresso method is a beverage preparation technique based on pressure-induced percolation of a limited amount of hot water through a ground coffee cake, where the energy of water pressure is spent within the cake itself (Petracco, 2001). Thus pressure is a yet another factor that contributes to the overall quality of espresso coffee.

According to a work conducted by Andueza *et al.* (2002), among ECs prepared at three different pressures *viz.*, 7 atm, 9 atm and 11 atm, the best flavour and odour profiles with maximum acceptance was found for the EC prepared at 9 atm (Fig. 10). Also coffees prepared at 9 atm showed a consistent foam and a high percentage of key odorants related to freshness, fruity, malty and buttery flavour. Thus, the universally accepted water pressure for a good EC is 9 atm.

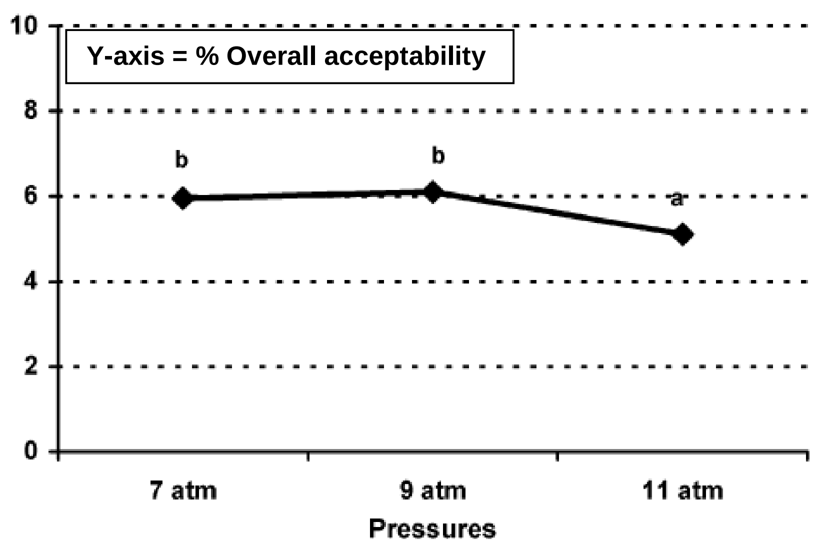

Figure 10: Influence of water pressure on overall acceptability of the EC samples

4.6. Percolation time

Percolation time is the time in which the hot water extraction through compacted coffee powder or coffee cake take place. It is important because it affects the flavor of coffee. If the percolation is done for 10 seconds, it leads to an under extracted coffee that tastes very dull and diluted. If percolation happens for more than 60 seconds, over extraction takes place and the coffee becomes very bitter and astringent in taste. Percolation time depends on people's demand. Those who need highly extracted coffee with more astringency, will prefer for a long percolation time. The average percolation time for a good cup of espresso coffee was found to be 30 ± 5 seconds (Petracco, 2005).

5. Conclusion

Espresso coffee is the base for most of the specialized coffee beverages like cappuccino, caffe latte, macchiato *etc*., which means preparation of an espresso shot should be perfectly done. The important parameters that plays a key role in quality espresso coffee preparation are temperature, pressure, coffee-water ratio, water quality and percolation time. Even nutritionally it is found better than normal coffee with good extracts of minerals and vitamins (USDA, 2019).

6. Discussion

1. Why should we go for tamping before percolation?

Tamping is done to avoid settlement of finer particles at the bottom of portafilter which may block the filter during percolation.

2. Which is the most expensive coffee?

Kopi Luwak is one of the expensive coffes in world because its coffee beans is collected from the dung of Asian civets. Its cost range from 100-600 dollars. Another costliest coffee is Black Ivory coffee where the coffee beans is fed to elephants and the beans from their dung is used for coffee preparation. It costs around 50-100 dollars.

3. What happens when percolation time is extended?

When percolation time is more, hot water will be in contact with the coffee powder for a long time which results in over extraction that makes the coffee more bitter and astringent.

4. Is there any consumer preference for highly astringent espresso coffee?

Yes, some consumers prefer highly astringent and highly flavoured espresso coffees. In case of percolation time general preference is around for 25±5 seconds, but there are people who like espresso coffees prepared with a percolation time of 60 to 120 seconds.

5. Do you think that these highly priced coffee can thrive in our market where a normal coffee is available at a very cheap rate?

First of all there is a huge difference between normal coffee and espresso coffee. Café coffee day (CCD) is the main outlet for these type of special coffees. The tremendous increase in the number of outlets of CCD itself shows that these types of coffee thrived easily in Indian market. At present there are around 1700 outlets of CCD in India.

6. How cappuccino is prepared?

For cappuccino and other type of coffees like café latte, café Americano, *etc*. espresso coffee forms the base. A cappuccino is an approximately 150 ml beverage, with 25 ml of espresso and 85 ml of fresh milk. The foaming action creates the additional volume. Cappuccino is prepared by adding steamed frothy milk to a shot of espresso in a cappuccino cup.

7. References

Anderson, B. A., Shimoni, E., Liardon, R., and Labuza, T. P. 2003. The diffusion kinetics of carbon dioxide in fresh roasted and ground coffee. *J. of Food Eng*. 59: 71–78.

Andueza, S., Maeztu, L. Dean, B., de Pena, M. P., Bello, J., and Cid, C. 2002. Influence of water pressure on the final quality of arabica espresso coffee. Application of multivariate analysis. *J. Agri. Food Chem*. 50: 7426-7431.

Andueza, S. Maeztu, L., Pascual, L., Ibanez, C., Paz de Pena, M., and Cid, C. 2003. Influence of extraction temperature on the final quality of espresso coffee. *J. Sci. Food Agri*. 83:240–248.

Andueza, S., Vila, M. A., Paz de Pena, M., and Cid, C. 2007. Influence of coffee/water ratio on the final quality of espresso coffee. *J. Sci. Food Agri.* 87:586–592.

Bersten, I. 1993. *Coffee Floats, Tea Sinks: Through History and Technology to a Complete Understanding*. Helian books. 284p. ISBN: 0646091808, 9780646091808.

Blank, I., Sen, A., and Grosch, W. 1991. Aroma impact compounds of Arabica and Robusta coffee. Qualitative and quantitative investigations. In: *Proceedings of the 14th International Scientific Colloquium on Coffee*, San Francisco, CA, pp. 117–129.

Cappelletti, S., Piacentino, D., Daria, P., Sania, G., and Aromatrio, M. 2015. Caffeine: Cognitive and physical performance enhancer or psychoactive drug? Current Neuropharmacology. 13(1):71-88. Doi: 10.2174/1570159X13666141210215655PMC4462044.

Cipolla, M. 1999. Today’s espresso bar: common problems and relative solutions. *Tea Coffee Trade J*. 171:32–39.

Coffee Board of India. 2018. Coffee statistics [on-line]. Available: https://www.indiacoffee.org/coffee-statistics.html [02 Oct. 2019].

Illy, A. and Viani, R. (eds.) 1995. *Espresso Coffee: the Chemistry of Quality*. Academic Press, London. pp. 331-335.

Illy, A. 2005. Quality. In: Illy, A. and Viani, R. (eds). *Espresso Coffee: The Science of Quality* [E-book]. https://books.google.co.in/books/about/Espresso_Coffee.html. [15 Oct.2019].

Illy, E. and Navarini, L. 2011. Neglected Food Bubbles: The Espresso Coffee Foam. *Food Biophysics* 6: 335–348.

Lingle, T.R. 1996. Coffee brewing control chart. In: Lingle, T.R. (Ed.), *The Coffee Brewing Handbook: A Systematic Guide to Coffee Preparation*. Specialty Coffee Association of America, Long Beach, CA, pp. 3–5.

Maeztu, L., Sanz, C., Andueza, S., de Pena, M. P., Bello, J., and Cid, C. 2001. Characterization of espresso coffee aroma by HS–GC–MS and sensory flavor profile. *J. Agri. Food Chem.* 49: 5437–5444.

Pangborn, R. M., Trabue, I. M., and Little, A. C. 1971. Analysis of coffee, tea and artificially flavoured drinks prepared from mineralized waters. *J. Food Sci.* 36: 355–362.

Perren, R., Geiger, R., and Escher, F. 2001. Mechanism of volume expansion in coffee beans during roasting. *Proceedings 19th ASIC Colloquium*, Trieste, Italy, pp. 197-205.

Petracco, M. 1989. Physico-chemical and structural characterisation of espresso coffee brew. In: *Proceedings 13th ASIC Coll*oquium, Paipa, Colombia, Paris, pp. 246–261.

Petracco, M. 2005. The Cup. In: Illy, A. and Viani, R. (eds*). Espresso Coffee: The Science of Quality* [E-book]. https://books.google.co.in/books/about/Espresso_Coffee.html. [15 Oct.2019].

Petracco, M. 2005. Percolation. In: Illy, A. and Viani, R. (eds.) *Espresso Coffee: The Science of Quality*. [E-book]. https://books.google.co.in/books/about/Espresso_Coffee.html. [15 Oct.2019].

Semmelroch, P. and Grosch, W. 1995. Analysis of roasted coffee powders and brews by gas chromatography–olfactometry of headspace samples. *Lebensm Wiss Technol*. 28:310–313.

Semmelroch, P. and Grosch, W. 1996. Studies on character impact odorants of coffee brews. *J. Agri. Food Chem*. 44:537–543.

USDA [U.S. Department of Agriculture]. 2019. USDA Food search page [on-line]. Available: https://fdc.nal.usda.gov/fdc-app.html#/food-details/171891/nutrients [30 Oct. 2019].

Wang, X. 2014. Understanding the formation of CO_2 and its degassing behaviours in coffee. University of Guelph.

Wang, X. and Lim, L.T. 2014. Effect of roasting conditions on carbon dioxide degassing behavior in coffee. *Food Res. Int.* 61: 144–151.

Wang, X., Lim, L.T., Tan, S., and Fu, Y. 2019. Investigation of the factors that affect the volume and stability of espresso crema. *Food Res. Int.* 116: 668-675.

8. Abstract

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COLLEGE OF HORTICULTURE, VELLANIKKARA

Department of Post Harvest Technology

PHT: 591 Masters Seminar

Student : Sharon Jacob		Venue : Seminar Hall
Admission no. : 2018-12-027		Date : 01-11-2019
Major Advisor : Dr. A. Sobhana		Time : 11.30 am

'Espresso coffee: The science of quality'

Abstract

Coffee is one of the most popular beverages in the world and it is widely consumed next to water. Change in the lifestyle and economic status changed the food consumption pattern of the people. In the case of beverages, increase in coffee consumption is a notable one. Special types of coffee served in designated coffee shops like Cafe Coffee Day, Starbucks *etc*. are gaining more attention. Coffee types like Cappuccino, Caffe Latte, Caffe Americano *etc*. got popularized in India, only in the near past but it was a common drink in Italy and English speaking countries from 17^{th} century onwards. Espresso coffee forms the base for all these types.

Espresso coffee (EC) is a beverage prepared on request from roasted and ground coffee beans. In the espresso preparation technique, pressure induces percolation of a limited quantity of hot water through a ground coffee cake in a short time to yield a small cup of a concentrated foamy elixir known as 'shot of coffee' (Petracco, 2001).

As in common coffee, for espresso also, the beans are roasted and ground before percolation. During roasting heat is applied to the beans and it result in change of colour, flavour and aroma profile. This is due to the reactions during roasting, like removal of water, pyrolysis, non-enzymatic browning etc. (Illy, 2005). Grinding is the process of comminution associated with the fineness of ground coffee and it changes the physical structure of beans along with increase in surface area, which helps in better percolation. For a good espresso coffee, the ground coffee powder should have a plurimodal surface which contain both finer and coarser particles. The final step is percolation of hot water through tightly tamped coffee cake in a portafilter at 9 atmospheric pressure (Petracco, 2005). This type of percolation extracts most of the water-soluble substances and emulsifies the insoluble coffee oils.

There are many factors that influence the quality of espresso coffee. Among those, the most important are temperature, pressure, coffee-water ratio during percolation and espresso crema. Quality of water used for preparation of coffee is also an important parameter.

In a study conducted by Andueza *et al*., (2003), the overall acceptability and good aroma due to the presence of positive flavours like methanethiol, acetaldehyde, propanal *etc*. were obtained when water at a temperature of 92°C was used during percolation. When 6.5 ± 1.5g of ground coffee powder was mixed with 25-30ml water, the quality of espresso coffee was found best (Andueza *et al*., 2007). Espresso crema or the foam phase above the liquid phase of coffee makes espresso special. Minimum 10% of the total volume of coffee should be occupied by the crema and it should persist for at least 2 minutes after percolation (Illy, 2005).

As per the USDA report 2019, espresso coffee is better than normally brewed coffee due to the presence of minerals. Since espresso coffee forms the base for different types of coffee, the quality of espresso coffee is an important area for research and study.

References

Andueza, S. Maeztu, L., Pascual, L., Ibanez, C., Paz de Pena, M., and Cid, C. 2003. Influence of extraction temperature on the final quality of espresso coffee. *J. Sci. Food Agri*. 83:240–248.

Andueza, S., Vila, M. A., Paz de Pena, M., and Cid, C. 2007. Influence of coffee/water ratio on the final quality of espresso coffee. *J. Sci. Food Agri.* 87:586–592.

Illy, A. 2005. Quality. In: Illy, A. and Viani, R. (eds). *Espresso Coffee: The Science of Quality* [E-book]. https://books.google.co.in/books/about/Espresso_Coffee.html. [15 Oct.2019].

Petracco, M. 2001. Technology IV: Beverage preparation: brewing trends for the new millenium in Coffee, Recent developments. In: Clarke, R. J. and Vitzthum, O. G. (eds.), Coffee: Recent Developments. pp: 140–164. https://doi.org/10.1002/9780470690499.ch7. [20 Oct. 2019].

Petracco, M. 2005. The Cup. In: Illy, A. and Viani, R. (eds). Espresso Coffee: The Science of Quality [E-book]. https://books.google.co.in/books/about/Espresso_Coffee.html. [15 Oct.2019].

USDA [U.S. Department of Agriculture]. 2019. USDA Food search page [online]. Available: https://fdc.nal.usda.gov/fdc-app.html#/food-details/171891/nutrients [30 Oct. 2019].