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# Effect of Mixing Coffee with Some Therapeutic Potential Plants on Some Quality Indicators of the End Product: A Case Study

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***Abstract***

The paper proposes a new direction of preparing the coffee „*dark roast*" [originating from the Asia-Pacific (marine-like granulation)], mixed with condiment/aromatic plants (***thyme***, ***mint***, ***lavender***). Method of preparation: *French press* – patented by Italian designers *Attilio Calimani* and *Giulio Moneta* in ***1929*** [14]. The recipe was adapted, by integrating aromatic plants: ***18 g*** of coffee; ***2 g*** of aromatic plant; ***330 mL*** water, t°C ≈***100***; infusion time of ***5 minutes***. The products obtained were ***physical-chemical***: *polyphenols* [maximum coffee „*dark roast*" (***101.68 μg/mL***), minimum with mint (***90.18μg/mL***)]; *pH* [minimum (***5.64***), coffee „dark roast", maximum (***5.82***), with lavender]; grade *Brix* [maximum with thyme (***0.8%***)], *free acidity* [maximum coffee „dark roast" (***0.14 mg NaOH/g***), minimum with thyme (***0.06 mg NaOH/g***)], *humidity* [maximum coffee „dark roast" (***57.79%***), minimum with mint (***18.68%***)] and sensory support with the help of 15 respondents. From a sensory point of view, the mint infusion is ranked 1st (***17.6*** points), even if the physical-chemical analysis classifies it as average. It can be argued that for the introduction of new products or product improvement it is recommended to study in detail the raw materials, the auxiliary raw materials, the influence induced by the operations performed (special thermal and mass transfer), on the cultivation-harvest processing- compared to sensory analysis.

***Keywords***: coffee, dark roast, aromatic/spicy plants, French press, quality indicators, sensory analysis.

## 1.Introduction

Coffee ranks second after oil, traded on the global market in greater quantities than cotton, wheat, maize, or sugar [15]. The plant, currently cultivated in many parts of the globe (acclimatization), has its origins in the Ethiopian plateau (Corn of Africa (Ethiopia)). The word "*coffee*" appeared in English in ***1582***, derived from the Dutch word "*koffie*", borrowed from the Turkish language ("*kahve*"), which, in turn, is picked from Arabic ("*qahwah*") [16]. Currently, there are three global coffee tree cultivation regions: *East Africa-Arab Peninsula*, *Southeast Asia (Pacific)* and *Latin America*.

The area, altitude, variety, climate, and method of cultivation, separately prints the physical-chemical-sensory characters of the fruit, with a decisive role in the "*fingerprint*" of the aroma and taste of coffee [17]. From a commercial point of view, *Coffea arabica Linneo* (also known as *Arabica* or *Arabiga*) and *Coffea canephora Pierre Ex-Froehner* (known as Robusta) are important [18]. *Arabica*, native to the mountain areas of southwestern Ethiopia, accounts for between 70÷75% of the world production [19]. *Robusta*, originating in the sub-Saharan area of central and western Africa, is easier to maintain, produces a higher yield with a high amount of caffeine and antioxidants, and less susceptible to disease compared to *Arabica* [20]. The chemical compounds present can be classified as ***soluble*** and ***insoluble*** in water.

*Soluble* compounds are represented by caffeine, trigonelline, nicotinic acid (niacin), at least 18 chloric cyanic acids, mono-, di- and oligosaccharides, some proteins and minerals, and carboxylic acids. Water *insoluble* components

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include cellulose, polysaccharides, lignin and hemicellulose, as well as some proteins, minerals and lipids. Both volatile and non-volatile compounds contribute to the *formation/fingerprint* of the flavour at the final roasting. Non-volatile nitrogen compounds (alkaloids, trigonelline, free proteins, and amino acids), as well as carbohydrates, are of major importance for the formation of the complete aroma of roasted coffee and for its subsequent biological activity. Table 1 shows the chemical composition, compared, of *green coffee* for the two types: *Arabica* and *Robusta*.

***Table 1.*** Chemical composition, compared, of *Arabica* and *Robust* beans (g/100 g) [1, 2].

| ***Structural components*** | | ***Arabica*** | ***Robusta*** |
|---|---|---|---|
| ***Carbohydrates and fibres*** | | | |
| | *Saccharose* | 6.0÷9.0 | 0.9-4.0 |
| | *Reducing sugars* | 0.1 | 0.4 |
| | *Polysaccharides* | 34÷44 | 48-55 |
| | *Lignin* | 3.0 | 3.0 |
| | *Pectin* | 2.0 | 2.0 |
| ***Nitrate compounds*** | | | |
| | *Proteins/Peptides* | 10.0-11.0 | 11.0-15.0 |
| | *Free amino acids* | 0.5 | 0.8-1.0 |
| | *Caffein* | 0.9-1.3 | 1.5-2.5 |
| | *Triglycerides* | 0.6-2.0 | 0.6-0.7 |
| ***Lipids*** | | | |
| | *Coffee oil* | 15.0-17.0 | 7.0-10.0 |
| | *Diterpenes (free and esterified)* | 0.5-1.2 | 0.2-0.8 |
| | *Minerals* | 3.0-4.2 | 4.4-4.5 |
| ***Acids and esters*** | | | |
| | *Chlorogenic acids* | 4.1-7.9 | 6.1-11.3 |
| | *Aliphatic acids* | 1.0 | 1.0 |
| | *Quinic acid* | 0.4 | 0.4 |

*Caffeine* (amino acid) (1,3,7-trimethyl-xanthin) (Fig. 1), the most present alkaloid (1.0% and 2.5% by weight of dried green coffee beans), whose solubility in water is accentuated by the presence of chlorogenic, citric or tartaric acids in relation to temperature. For example, 1 g of caffeine dissolves in 46 mL of water at room temperature and in 5.5 mL at 80°C [21].

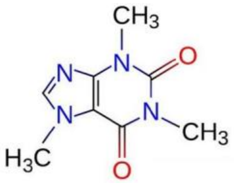


***Figure 1.*** Chemical structure of caffeine [22].

The caffeine content at ***240 mL*** coffee can range from ***30÷300 mg***, the average on is ***≈90÷100 mg***. At the cerebral level, it inhibits the function of *andesine* (neurotransmitter hormone), causing increased brain activity and releasing other neurotransmitters (norepinephrine and dopamine), reducing the feeling of fatigue.

Coffee beans are rich in nutrients, so ***240 mL*** of coffee can contain 11% riboflavin (B2), 6% pantothenic acid (B5), 2% niacin (B3), 1% folate, 3% manganese, 3% potassium, 2% magnesium, and 1% phosphorus [1, 23]. *In general*, the grinding process/method *plays an important role in choosing how to brew coffee*. By grinding, the grains release the oils and flavours encapsulated inside the plant matrix [24]. Table 2 shows the dependence between the degree of grinding and the recommended method of preparation. The particle size (*granularity*) conditions *the time of release of the flavour* (the passage of the water-soluble substances), but also *the way the drink is prepared*, which is why *espresso coffee* is finely ground and *espresso coffee prepared with the French press* is coarse (similar to cornflour) [25]. Specialized studies (Table 3) show that this drinking is an important source of antioxidants, with a role in controlling free radicals, being a protective factor in the premature onset of cell aging and many associated conditions that are partly caused by oxidative stress, including cancer [27].

Coffee can be served as such or in a multitude of associations such as with milk, alcohol, ice, cakes, sugar, tea, natural juices, nuts or peanuts, or ice cream. *This paper proposes mixing the resulting drink using the French Press method with aromatic/spiced plants (with therapeutic role*

***Table 2.*** Grinding grade and method of preparation [26].

| ***Grain size*** | ***Preparation method*** |
|---|---|
| *Extra-coarse* | Cold Brew Coffee, Cowboy Coffee |
| *Coarse* | *French press* |
| *Medium-coarse* | Chemex |
| *Medium* | AeroPress (preparation time 3 minutes). Paper filter. Metal filter. |
| *Medium-fine* | AeroPress (preparation time 2-3 minutes) |
| *Fine* | Espresso, Mocha pot, AeroPress (preparation time 1 minute) |
| *Extra fine* | Turkish |

## 2. Material and Methods

**a) *Materials*: a$_1$)** *raw material*: ***dark roast*** (*coquam tenebris*) (*Arabica*) – the beans are roasted (*dark*), in the range 240-250°C, characteristic taste of tar and coal [30]; **a$_2$)** *auxiliaries*: flavoured and/or seasoning plants containing taste-enhanced substances, a pleasant smell for food, a food craving and digestion stimulant. *In this paper, after preliminary tests (obtaining and sensory analysis), the following spice plants were selected*: ***mint*** (*Mentha piperita* L, Lamiaceae family) [(1÷2.5% volatile oils, 30÷50% menthol and ketones, mint and lemon, increased amounts of polyphenols), (anti-inflammatory, regenerative action of liver cells, gastrointestinal transit disorders (nausea, vomiting, diarrhoea, cramps, flatulence, and dyspepsia))], ***lavender*** (*Lavandula*) [contains volatile substances with sedative effects, used to combat anxiety, anxiety, insomnia, depression and headache, have antiseptic and anti-inflammatory properties], ***thyme*** (*Thymus serpyllum*) [0.5÷1.2% volatile oils (cymol, terminalol, cineol, carvacrol, timol), 5% tannins, bitter substances, albumin, saponins, limestone salts, etc.; antiseptic properties, beneficial effect on the digestive system, anthelmintic action, antispasmodic, carminative, diaphoretic, disinfectant, expectorant, sedative, tonic, administered in the treatment of flatulent indigestion, dysmenorrhea, colic and "hangover"] [3, 4, 31, 32, 33, 34]; **a$_3$)** *reagents* (*Sigma-Aldrich*, *Merck*) *of analytical purity*; **a$_4$)** *machine/equipment*: *French Press* (Fig. 2), consisting of a cylindrical glass fitted with a metal cover and piston of the inner diameter of the glass provided at the bottom with a stainless steel filter [5, 6]; analytical balance; spectrophotometer 210; Brix saccharometer (°Brix); pH-meter.

**Figure 2.** French Press.

**b) *Method*: b$_1$)** *French Press standard method* (***54 g*** coffee/***1000 mL*** water ≈90°C): the grinder is placed at the base of the machine, over which water is poured and mixed; put the lid on, set the timer to ***4 minutes*** for the infusion operation (extraction of hydro soluble components); after the expiry of the infusion time, a slight pressure is exerted on the pressing device, at which point the separation of the two components takes place: **1.** *liquid* – coffee (drink); **2.** *solid* – solid exhausted. **b$_2$)** *French Press proposed method* (recipe) (***flavoured coffee***): blend coffee with herbs (**a$_2$**) in dry and ground state; the determination (by repeated tests) of the mixing masses (*coffee/plant/water*) in relation to the standard recipe, finally reaching a ratio of ***2 g*** plant (constant for all mixtures)/***18 g*** coffee/***330 mL*** water, with a maintenance time of ***5 minutes***. The quality of the resulting samples was quantified *physical-chemically* (polyphenols, pH, total sugar (°***Bx***), free acidity) and *sensorially* (score method) [7, 8, 9, 10, 11, 12, 13, 35].

## 3. Results and Discussion

Based on the bibliographical study, preliminary attempts to discover new combinations of flavours and tastes of such a well-known energy drink came off (Fig. 3). It has been observed that the final recipe does not significantly alter the taste, but influences the flavour and colour (Fig. 4): **1. *+mint (P2)*** is characterized as an aromatic, refreshing and refreshing drink; **2. *+lavender (P2)*** – floral smell and refreshing taste; **3. *+thyme (P3)*** – similar to a tea, with a pleasant smell.

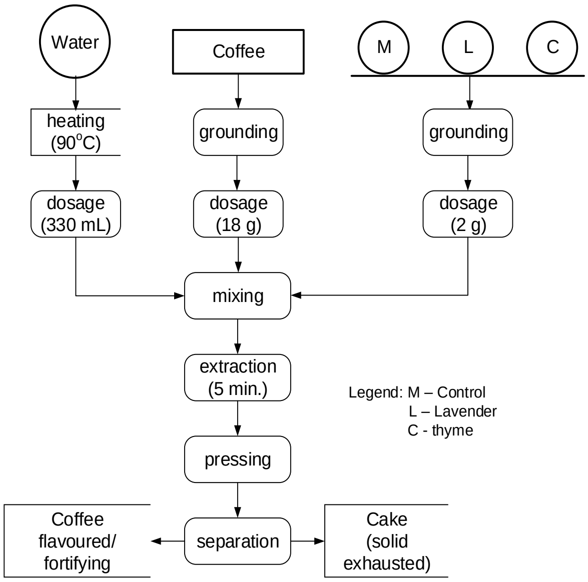


***Figure 3.*** Block diagram of obtaining flavoured coffee.


***Figure 4.*** Coffee samples: P1 (control); P2 (mint); P3 (lavender); P4 (thyme).

• ***polyphenols*** (Folin-Ciocâlteu method) (Fig. 5). In the plant kingdom, *phenolic compounds* are the most present antioxidant substances, the phenolic content being the benchmark of total antioxidant capacities in food and beverages.

Coffee is a major source of food antioxidants. Expert studies show that coffee consumption has beneficial effects on health, generated by the high share of antioxidant compounds that rank this drink among the top foods. Some (poly) phenolic components are formed during the development of the fruit (their nature and quantity depending on soil and climate conditions and variety), while others are generated during the roasting operation. In this paper, the antioxidant capacity of the extracts was evaluated comparatively: the control sample (drink coffee (control)) and the flavoured mixtures. Figure 5 show a maximum (***101.68 g/mL***) for the control sample and a minimum (***90.18 g/mL***) for the mint sample. When referring strictly to flavoured mixtures, a close value (***99.03 g/mL***) is observed for the lavender mixture compared to the *control* sample. Therefore, the decreasing evolution of polyphenols confirms their sensitivity to thermal treatments. Thermodynamically, different interactions are possible from the different types of molecules characteristic of each plant being worked on. It can be said that the antioxidant capacity of coffee and, implicitly, of mixtures, is conditioned by the degree of roasting.

| ***Sample*** | ***Polyphenols (ug/mL)*** |
|---|---|
| *Control* | 101,68 |
| *+ mint* | 90,18 |
| *+ lavender* | 99,03 |
| *+ thyme* | 93,57 |

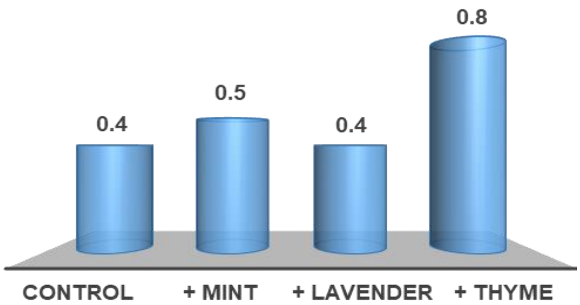


***Figure 5.*** Compared evolution of polyphenols.

• ***pH*** (Fig. 6). The *pH* values of the samples analysed are comparable in the range of values ***5.64÷5.82***. It is noted that the control sample has the lowest (most acidic) value, having higher concentrations in titratable total acids, in line with the highest antioxidant activity (***101.68 g/mL***), compared to flavoured derivatives, which exhibit a relative balance.

This shows that the heat treatment of preparation, coupled with the exposure time (***5 minutes***), causes the passage of a significant amount of acids responsible for antagonism towards antioxidant activity in the case of the control sample. In other cases, the results confirm a slight tendency of "*mitigation*" in antioxidant activity in relation to, the complexity of hot-extracted acids. Data show that the action of plants is one of reducing the final acidity of the drink, more beneficial to the needs of the body.

| ***Sample*** | ***pH*** |
|---|---|
| *Control* | 5.64 |
| *+ mint* | 5.74 |
| *+ lavender* | 5.82 |
| *+ thyme* | 5.71 |

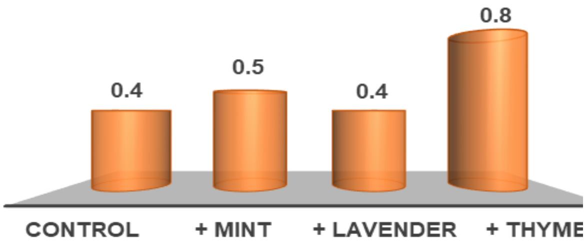


***Figure 6***. Compared evolution of pH.

• *free acidity* (***acidity index (AI)*** (Fig. 7). Free acidity can be a criterion of appreciation of both physical-chemical and sensory (dry, casting forms foam). The acidity of coffee is conditioned by the presence and nature of organic acids (e.g. acetic, formic, malic, citric, lactic, quinic, and chlorogenic). Depending on type (*Arabica*, *Robusta*), green coffee beans contain different acids, but roasting induces quantitative changes, ratio, but also depending on nature, generating new acids, even if of low level. These water-soluble compounds are later found in coffee (drink). The degree of acidity is also conditioned by the area of cultivation (climate, altitude, soil quality). Literature shows that a simple coffee can have a degree of acidity on the pH scale around ***4.7*** [48]. In this paper, the control pH is ***5.64*** relative to a high acidity of ***0.14 mg NaOH/g***. The same may be said for coffee mixed with lavender (pH=***5.82***→AI=***0.13 mg NaOH/g***). For some consumers, this parameter would be an alarm signal, as it would associate the drink with negative health effects (astringent sensation, with gastritis setting).

Advanced roasting (*dark roasting*) *can reduce acidity, but also hide the origin of the product*.

It would, therefore, be important to know the indicators of the quality of green coffee (raw material) before further processing, contributing to the choice and correction of technological process parameters, with a focus on the roasting operation. *If we follow sensory analysis, we can observe a correlation of the aroma with the evolution of pH and free acidity*.

| ***Sample*** | ***AI (mg NaOH/g)*** |
|---|---|
| *Control* | 0.14 |
| *+ mint* | 0.11 |
| *+ lavender* | 0.13 |
| *+ thyme* | 0.06 |

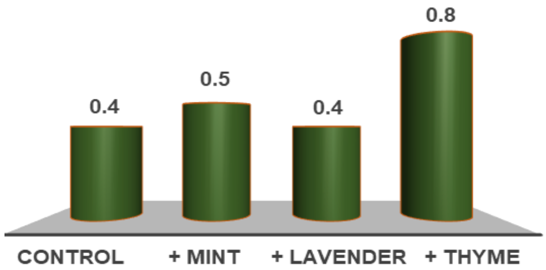


***Figure 7.*** Comparative evolution of acidity index (***AI***).

• *total sugar* (Fig. 8) expressed in *Brix* degrees (°***Bx***). The evolution of the data shows an increase in the weight of sugar in the thyme-flavoured sample (***0.8%***), probably due to a high level of extractable sugars present in the plant. Minimum value of ***0.4%*** is recorded in the control and flavoured with lavender samples.

| ***Sample*** | ***°Bx (%)*** |
|---|---|
| *Control* | 0.4 |
| *+ mint* | 0.5 |
| *+ lavender* | 0.4 |
| *+ thyme* | 0.8 |

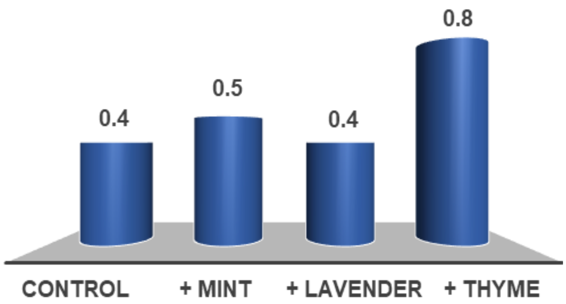


***Figure 8.*** Compared evolution of total sugars.

• *sensory analysis*. In human behaviour, sensory qualities such as taste, smell, colour, and consistency have a special affective tone, which determines the orientation in the choice of food and drink.

They constitute the consumer's first contact with the product and determine purchasing decision. In view of this important aspect of food quality, it is necessary to objectively assess the quality of the sensory. In order for the analysis to be effective, the following must be ensured: **1.** developing a correct score that adequately assesses the quality criteria according to their importance in assessing quality; **2.** determining the weighting of each criterion in the overall assessment of quality; **3.** drawing up the scale must so that the difference in score reflects a reproducible variation in the criteria; **4.** analysing the scoring system statistically.

In general, a single variant for the evaluation of all foodstuffs cannot be mastered because of the difference and the variable importance of the different criteria for each of the products assessed.

Therefore, the scoring scheme must be developed first, each time, only for a specific product assortment or for each product (Table 4).

Sensory analysis data were quantified and presented centrally as an arithmetic mean (table 5).

The score reveals that the mint mixture ranks first, even if the physical-chemical analysis ranks it as mean.

***Table 4.*** Adapted sensory beverage appreciation sheet. Score scale.

| *Sensory feature* | *Score scale* | *Feature description* | *Score* |
|---|---|---|---|
| *Colour* | **0-3** | intensely coloured infusion in brown | **3** |
| | | less intensely coloured infusion | **2** |
| | | weak brown coloration | **1** |
| | | inappropriate colour | **0** |
| *Clarity* | **0-3** | clear liquid | **3** |
| | | clear liquid without particulate matter | **2** |
| | | liquid with small particulate matter | **1** |
| | | cloudy liquid with sediment particles | **0** |
| *Aroma* | **0-6** | excellent, very well pronounced | **6** |
| | | smooth, well-pronounced | **4** |
| | | weak, no foreign smell | **2** |
| | | inappropriate with foreign shades | **0** |
| *Taste* | **0-6** | excellent taste, fine, without astringency | **6** |
| | | well pronounced, slightly astringent | **3** |
| | | improper | **0** |
| *Smell* | **0-2** | excellent, characteristic | **2** |
| | | well pronounced, slightly astringent | **1** |
| | | uncharacteristic | **0** |

The analysis was supported with the help of 15 respondents. In general, respondents characterized the samples as follows:

| ***control:*** | ***+mint:*** | ***+lavender:*** | ***+thyme:*** |
|---|---|---|---|
| ***colour**: intensely coloured infusion in brown;*<br>***clarity**: clear liquid, free of particulate matter;*<br>***aroma**: good, well pronounced;*<br>***taste**: tends towards excellent taste, fine, without astringency;*<br>***smell**: excellent, characteristic.* | **colour**: intensely coloured infusion in brown;<br>**clarity**: clear liquid, free of particulate matter;<br>**aroma**: excellent, very well pronounced;<br>**taste**: excellent taste, fine, without astringency;<br>**smell**: excellent, characteristic. | **colour**: faintly brown coloration;<br>**clarity**: clear liquid, free of particulate matter;<br>**aroma**: good, well pronounced;<br>**taste**: tends to taste excellent, fine, without astringency;<br>**smell**: excellent, characteristic. | **colour**: less intensely coloured infusion;<br>**clarity**: clear liquid, free of particulate matter;<br>**aroma**: tends towards good, well pronounced;<br>**taste**: well pronounced, slightly astringent;<br>**smell**: well pronounced, slightly astringent. |

***Table 5.*** Sensory analysis summary.

| *Feature* | *control* | *+mint* | *+lavender* | *+thyme* |
|---|---|---|---|---|
| *colour* | 3 | 2.6 | 1.3 | 2 |
| *clarity* | 2.3 | 2 | 2 | 2 |
| *aroma* | 4.3 | 5.5 | 4.3 | 3.5 |
| *taste* | 5 | 5.5 | 5 | 3.5 |
| *smell* | 2 | 2 | 1.8 | 1.4 |

## 4. Conclusions

For the introduction of new products or product improvement, it is recommended to study in detail raw material, auxiliaries, influence induced by operations carried out (especially thermal and mass transfer ones) along the cultivation-harvest-processing-consumption chain. Subsequently, the results obtained should be compared and analysed with sensory results. Because, even if the sensory product is considered as a consumer good, it may be that, from the perspective of quality physical-chemical indicators, it may have a negative (over time) impact on health. In order to better understand the conditional effect of temperature/chemical structure on the resulting product, advanced analysis of specific compounds for the extracts obtained is necessary. Thermodynamically, classes of compounds can be formed, which can subsequently cause sensory differences observed in coffee and formed mixtures. A possible class of compounds that can influence antioxidant activity, pH levels, and free acidity are melanoidins, potentially toxic compounds as a result of the Maillard's reaction between amino acids and reducing sugars.

**Compliance with Ethics Requirements.** Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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