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THE QUALITY OF ROASTED COFFEE AGROFORESTRY SYSTEM: SPECIAL AND TRADITIONAL

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ABSTRACT

The processing of the coffee agroforestry system in the Baturité Massif is done by hand, allowing the production of special and traditional coffee without strict production control, and in some cases there may be adulterations. The twenty-five samples of coffee agroforestry were purchased in the period from June2018 to March 2019, in the form of powder and roasted grains, in traditional and special managements, in four coffee agroforestry producing cities in the Baturité Massif. Grain and powder samples were standardized in their granulometry in0.60 mm. The determinations of the physical-chemical parameters of moisture (%, m m^{-1}), caffeine (%, m m^{-1}), mineral residue (%, m m^{-1}), aqueous extract (%, m m^{-1}) and ether extract (%, m m^{-1}) were performed in triplicates. The average values of the parameters were: moisture 3% $\pm$ 1 with coefficient of variation of 39%; ashes 4.9% $\pm$ 0.7 with coefficient of variation 15%; ether extract 19% $\pm$ 2 with coefficient of variation 10%; aqueous extract 27% $\pm$ 6 with coefficient of variation 22% and caffeine 1.6% $\pm$ 0.3 with coefficient of variation of 19%. It was possible to verify in the studied samples that the chemical quality varies a lot among the producers; however, when evaluated in general, expressing the average values of the parameters, we can say that they have quality within the quality parameters expected by the Brazilian legislation.

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INTRODUCTION

Agro forestry systems are agricultural production systems accompanied by woody plants with a great diversity of species and ecological interactions. Due to these characteristics, the agroforestry system is an alternative for the production of crop variations with less human intervention, imitating the natural environment. It is an affordable and manageable system for the farmers, andit can be incorporated into the low input farming systems of smallholder farmers while ensuring sustainable management of soil fertility, landresources, and ecosystem services (Bado, Whitbread and Manzo, 2021). The Baturité Massif is one of the regions with the highest rainfall in the State of Ceará, which favorsmaking agricultural production feasible. These environmental characteristics were essential for the insertion of coffee culture in the mountain area of Baturité and, consequently, for the triggering of urban centers, through agribusiness that has geopolitical, historical and economic relevance for the country (Ribeiro E Rufino, 2018). Coffee agroforestry system from Baturité Massif is seen as a quality production alternative, and this is not only because of its center of origin, since it originated in African tropical forests, but also because it increases incomes to the producer through other products of economic interest (Mancuso *et al.,* 2013). It is true that, throughout its history, it went through golden and critical periods as a reflection of the political and economic measures adopted by the government, however it overcame all these bad weather and, even today, it survives, with less expressiveness, but with signs of a new rise (Ribeiro E Rufino, 2018). In the Baturité Massif, coffee agroforestry system is produced under the shade of walnut trees (Inga ingoides), banana trees (usa ssp.) and camunzé (Pithecellobiumpolycephalum) guaranteeing the recovery of coffee plantations, and consequently the soil (SILVA, 2015). Considering the above, it is possible to verify that the shaded coffee culture in the mountain region favored the harmonious coexistence between man and nature, one of the principles of agro biodiversity (RIBEIRO e RUFINO, 2018). The interest in organic products, produced with agroforestry management, has contributed to the exponential growth of the alternative market. The coffee produced in BaturitéMassif has been gaining a consumer market in the State of Ceará, standing out in the tourist sector in the mountainous region ofBaturité Massif. The commercial value of this coffee grown in the shade of large trees can reach up to 10 times more than coffee grown in full sun, sold in supermarkets. The processing of coffee agroforestry system is done by hand, allowing the production of Special type coffee (without the use of pesticides, with the selection of the best beans and roasting control, resulting in a product of excellent quality and with high commercial value) and the Traditional type (without strict production control, and in some cases there may be adulterations). Before roasting, it is possible that impurities are introduced into the coffee, and so that it is not noticeable to the naked eye, the oven temperature can be raised by increasing the level of the roasting.

With the underproduction of coffee and the devaluation of its value, some producers opted for differentiated coffees with high quality. The quality of the coffee is evaluated mainly through the physical aspects of the coffee beans, such as the color of the beans, size, density and percentage of physical defects, taking into account their handling at planting, harvest and post-harvest, which greatly contributes to its quality. Another peculiarity to be evidenced is that the harvests are made manually and selectively, where only the mature grains are harvested. It is called “finger picking” or “picking”. In this practice, product quality is gained, as the grains are more uniform and impurities are avoided (RIBEIRO e RUFINO, 2018). In this way, the quality of the coffee drink, which is characterized by its flavor and aroma, is influenced by several pre- and post-harvest factors that guarantee the final expression of product quality. It is important to note that the species evaluated in this study is the Arabica type (Coffeaarabica), commonly found in the Massif de Baturité region, following the agroforestry bias, characterized by being totally shaded, helping to maintain the soil's climate and humidity, in addition to being intercropped with other crops such as banana, orange, beans, among others. In this context, we decided to evaluate the quality of roasted coffees (powder and grain), produced in Massif de Baturité, by determining the physical-chemical parameters of moisture, ash, ether extract, aqueous extract and caffeine, in order to verify the quality of the samples for purposes of comparison with Brazilian legislation. In addition to making use of principal component analysis to check the different physical-chemical pattern between the types of traditional and special coffee agroforestry produced.

MATERIALS AND METHODS

Sample set: The samples of coffee agroforestry system were purchased from June 2018 to March 2019, in the form of roasted powder and grains, in traditional and special managements, in the cities of Pacoti, Baturité, Mulungu and Guaramiranga, producers of agroforestry coffee in the of Baturité Massif/Ceará. A mix containing ten brands of ground coffee, commonly sold in supermarkets in the region, was prepared to verify the approximation of the values of the physical-chemical parameters that have quality established by the Brazilian Coffee Association (ABIC). Table 1 presents the description and coding of the 25 coffee samples used in this study: 24 samples of coffee agroforestry system and 1 mix of commercial coffees. The difference between traditional and special type in some samples is evident (Figure 1), as it is possible to verify the homogeneity of the grains and in the roasting, since the level of roasting and appearance of the grains are the most noticeable aspects in the distinction of the handling.

Granulometry standardization: The grain and powder samples were standardized in their granulometry using sieve28 Mesh, with an opening of 0.60 mm (Figure 2), whose objective is to maintain homogeneity between the grains. The grain samples were previously ground using a Cadence coffee grinder and 150W power.

Table 1. Legend of 25 samples: 24 samples of coffee agroforestry system and 1 sample mixture of ten different coffee sold in supermarkets

N°	SAMPLES	DESCRIPTION
1	A_S_G	Sample A, Special type, Grain
2	A_S_P	Sample A, Special type, Powder
3	B_S_G	Sample B, Special type, Grain
4	B_S_P	Sample B, Special type, Powder
5	C_S_P	Sample C, Special type, Powder
6	D_S_G	Sample D, Special type, Grain
7	D_S_P	Sample D, Special type, Powder
8	E_T_P	Sample E, Traditional type, Powder
9	F_S_G	Sample F, Special type, Grain
10	F_E_P	Sample F, Special type, Powder
11	G_T_G	Sample G, Traditional type, Grain
12	G_T_P	Sample G, Traditional type, Powder
13	H_T_G	Sample H, Traditional type, Grain
14	H_T_P	Sample H, Traditional type, Powder
15	I_S_G	Sample I, Special type, Grain
16	I_S_P	Sample I, Special type, Powder
17	J_T_G	Sample J, Traditional type, Grain
18	J_T_P	Sample J, Special type, Powder
19	L_S_G	Sample L, Special type, Grain
20	L_S_P	Sample L, Special type, Powder
21	M_T_P	Sample M, Traditional type, Powder
22	N_T_G	Sample N, Traditional type, Grain
23	N_T_P	Sample N, Traditional type, Powder
24	O_S_P	Sample O, Special type, Powder
25	MIX	Mixture of 10 different brands of coffee sold supermarket.

Determination of physical chemical parameters: The determinations of the physical chemical parameters of moisture (%, m m^{-1}), caffeine content (%, m m^{-1}), ash content (%, m m^{-1}), aqueous extract content (%, m m^{-1}) and ethereal extract content (%, m m^{-1}) were carried out in triplicates following the analytical standards of the Adolfo Lutz Institute (2008).

Data analysis and software: Principal component analysis (PCA) was used to recognize classes of coffee agroforestry system.PCA was performed using The Unscrambler 10.4X software with the data centred on the mean and self-scaled to eliminate the effect of the magnitude of the parameter values. The validation was carried out by full cross-validation.

RESULTS AND DISCUSSION

Determination of physical chemical parameters: The results of the physical chemical parameters obtained for the coffee samples are shown in Table 2. The values found in each parameter were compared with the values established by the current Brazilian legislation (Resolutions N° 19, N° 30 and N° 31 of the Secretariat of Agriculture and Supply of the State of São Paulo (SAASP, 2007) and Ordinance N° 377, of April 26, 1999 of the National Health Surveillance Agency of the Ministry of Health/Brazil). The smaller and bigger values found for the moisture content of coffees agroforestry were 0.92% $\pm$ 0.06 and 5.39% $\pm$ 0.06, respectively, where the highest value corresponds to the single sample (L_S_P) above the maximum limit allowed. The average value of the samples was 3% $\pm$ 1 and the coefficient of variation was 39%.

The MIX also had moisture content above that allowed by law, with 6.10% $\pm$ 0.21, which is an important fact of verification. Moisture represents an important fact, as coffee samples with high water percentages favour the development of microorganisms and color change, which can affect the price and quality of the product. In addition, adequate drying and temperature prevent the creation of favourable conditions for the growth of microorganisms in the samples, ensuring greater stability in them, also avoiding losses of micro and macro nutrients (SOUSA et al., 2018).

Figure 1. Different qualities of coffee agroforestry beans collected in the Baturité Massif: Special coffee beans and Traditional coffee beans

Figure 2. Granulometric standardization of all samples with sieve 28 mesh, (0.6 mm) size

Table 2. Results of the quality parameters agroflorestry coffee produced in Baturité Massif (mean + sd, n=3)

Sample	Moisture(%)	Ash (%)	EtherExtract (%)	AqueosExtract (%)	Caffeine (%)
A_S_G	5.07 ± 0.04	4.69 ± 0.01	18.68 ± 1.22	28.5 ± 2.4	1.50 ± 0.19
A_S_P	4.46 ± 0.19	4.08 ± 0.03	19.88 ± 0.72	28.3 ± 0.4	1.66 ± 0.04
B_S_G	2.80 ± 0.14	5.12 ± 0.67*	20.70 ± 0.67	25.6 ± 2.0	1.57 ± 0.22
B_S_P	3.10 ± 0.13	5.45 ± 0.02*	16.37 ± 0.77	25.8 ± 1.0	1.38 ± 0.09
C_S_P	0.92 ± 0.06	5.72 ± 0.31*	18.43 ± 1.97	24.6 ± 0.7	1.39 ± 0.13
D_S_G	2.14 ± 0.19	4.54 ± 0.03	18.79 ± 0.22	20.3 + 0.4*	1.22 ± 0.03
D_S_P	4.20 ± 0.47	4.40 ± 0.47	18.74 ± 0.95	22.2 ± 2.0*	1.49 ± 0.07
E_T_P	2.64 ± 0.31	5.79 ± 0.07*	19.61 ± 0.63	29.9 ± 2.0	2.07 ± 0.28
F_S_G	2.88 ± 0.07	4.11 ± 0.06	19.21 ± 0.31	25.8 ± 1.5	1.37 ± 0.02
F_S_P	4.31 ± 0.16	3.84 ± 0.02	18.25 ± 1.96	24.2 ± 1.2*	1.49 ± 0.07
G_S_G	2.01 ± 0.20	4.71 ± 0.15	20.93 ± 0.64	20.6 ± 0.7*	1.48 ± 0.04
G_S_P	2.88 ± 0.07	4.67 ± 0.19	20.10 ± 0.60	16.8 ± 0.2*	0.93 ± 0.11
H_T_G	2.20 ± 0.12	5.84 ± 0.05*	21.50 ± 0.55	22.1 ± 1.0*	1.71 ± 0.12
H_T_P	2.72 ± 0.12	5.56 ± 0.08*	19.30 ± 0.93	21.9 ± 0.3*	1.56 ± 0.20
I_S_G	2.93 ± 0.35	4.19 ± 0.03	19.07 ± 0.39	21.5 ± 0.7*	1.76 ± 0.21
I_S_P	3.20 ± 0.16	4.95 ± 0.03	20.22 ± 0.08	23.0 ± 0.6*	1.66 ± 0.09
J_T_G	2.41 ± 0.20	4.69 ± 0.07	20.84 ± 0.37	40.1 ± 0.3	1.49 ± 0.33
J_T_P	2.58 ± 0.06	5.86 ± 0.02*	13.61 ± 0.15	37.0 ± 1.3	2.69 ± 0.34
L_S_G	3.59 ± 0.16	4.21 ± 0.04	18.61 ± 0.63	24.2 ± 1.2*	1.48 ± 0.14
L_S_P	5.39 ± 0.06*	3.88 ± 0.03	19.39 ± 0.39	21.8 ± 1.0	1.41 ± 0.16
M_T_P	2.91 ± 0.19	5.02 ± 0.04	18.57 ± 0.17	28.0 ± 0.6	1.88 ± 0.17
N_T_G	1.17 ± 0.12	6.38 ± 0.08*	17.98 ± 0.74	34.3 ± 1.2	1.73 ± 0.13
N_T_P	2.21 ± 0.18	5.63 ± 0.13*	22. 85 ± 0.36	33.6 ± 0.3	1.55 ± 0.14
O_S_P	3.72 ± 0.12	4.33 ± 0.04	20.20 ± 1.32	23.3 ± 0.5*	1.37 ± 0.04
MIX	6.10 ± 0.21*	4.03 ± 0.10	19.10 ± 0.92	22.6 ± 0.6*	1.64 ± 0.12
mediaCAF	3%	5,0%	19%	27%	1,6%
standard desvition	1	0,7	2	6	0,3
coefficient of variation	33%	14%	10%	22%	19%
BrasilianLegislation	<5%	< 5%	>8%	> 25%	> 0,7%

CAF –Coffee Agroforestry; * values off-limits by low (SAASP, 2007).

Thus, the time, form, and place of storage of the grains must be taken into account and done in an appropriate way to guarantee the quality of the final product. The ash content was the parameter studied that had the highest number of samples outside the legal specifications: 3 samples of Special coffee (B_S_G; B_S_P; C_S_P) and 6 samples of Traditional coffee (E_T_P; H_T_G; H_T_P; J_T_P; N_T_G; and N_T_P). The smaller and bigger values obtained were 3.84% ± 0.02 and 6.38% ± 0.08, respectively, for coffees agroforestry.

The N_T_G sample had the highest ash content due to its high amount of inorganic matter, above expectations. The average value of the A_F_C samples was 4.9% ± 0.7 (close to the maximum allowed limit) with a coefficient of variation 15%. Ash is the residue obtained by heating a product at a temperature close to 550-570 °C. This residue does not always represent all the inorganic substances present in the sample (LUTZ, 2008). The ether extract presented all values above 8%, the minimum required value, thus being all samples (agroforestry coffee and mix) in compliance with the current legislation. The average value of the samples was 19% ± 2 and the variation coefficient was 10%, the smallest variation being obtained among the studied parameters. The J_T_P sample, which has the darkest coloration of the sample set, presented the lowest percentage of ether extract 13.6% + 0.1, suggesting that there was a higher level of roasting of its grains, resulting in the loss of organic matter by carbonization. The aqueous extract was the parameter that most presented values below the minimum regulated limit. Of the 24 samples of agroforestry coffee, 10 had values below 25%, together with the mix sample. However, two samples (J_T_G and J_T_P) showed high levels, expanding the range from 16.8% ± 0.2 to 40.1% ±0.3. Thus, the average value of aqueous extract from coffees agroforestry was 27 ± 6%, with a variation coefficient of 22%. All samples had caffeine levels above 0.7%, which is the minimum required, indicating that the entire sample set is within the standard established by law. Caffeine levels ranged from 0.93% ± 0.11 to 2.69% ± 0.34, with an average value of 1.6% ± 0.3 and a variation coefficient of 19%. The J_T_P sample had high caffeine content (2.69%) and also suffered greater carbonization. Samples that are subjected to longer roasting time lose organic compound content and, in this case, caffeine stands out in percentage terms for having thermal resistance to pyrolysis. These three parameters together, that is, less ether extract, high aqueous extract and higher caffeine content, prove that the sample has very high roasting level. The taste and aroma of the coffee drink are complex, resulting from the combined presence of various volatile and non-volatile chemical constituents, including acids, aldehydes, ketones, sugars, proteins, amino acids, fatty acids, phenolic compounds, including also the action of enzymes in some of these constituents, giving reaction products, compounds that will interfere with the taste of the cup tasting. Therefore, the determination of the physical-chemical parameters is essential for assessing the quality standard of the coffee.

Principal Component Analysis (PCA): The PCA was used as a tool for multivariate analysis of the results of the physical-chemical parameters (Table 1), to verify whether the samples have similarities regarding the type of traditional or special management. In addition, in PCA we can also verify differences between samples from the same producer, acquired in the form of grain and powder, which can help in the identification of alleged adulterations or high level of roasting, which compromises the quality of the coffee. The data were centred on the mean and self-scaled to eliminate the effect of the magnitude of the parameter values. The PCA result is present in the bi-plot graph (Figure 3) with the scores and weights for each variable. The bi-plot graph sample scores and variable weights elucidated which parameters influenced the projection of the samples in the score graph. In Figure 3 it can be seen that the Special coffee samples are closer to the physical-chemical quality of the Mix of commercial coffees, the positive axis of the first main component, however there are 2 samples that were declared by the producer as being of the Special type, but that have physical-chemical quality of the Traditional type.

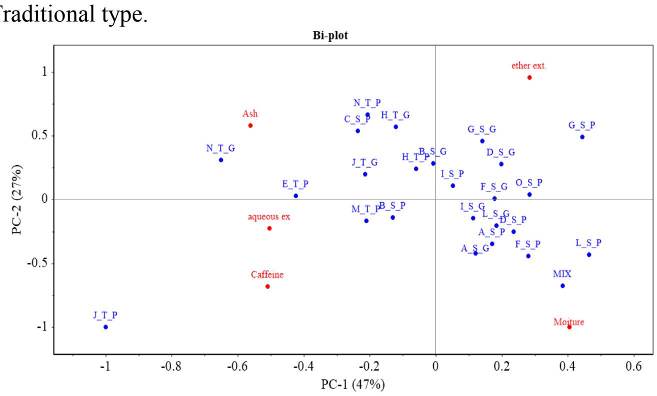

Figure 3. Bi-plot graphic PC-1 (47%) x PC-2(27%) of 25 coffee samples, and loading plot

It was also observed that there is a sample of Traditional handling (outlier) that presents a very different behaviour from the others, located at the end of the negative axis of the first main component, verified by the Hotelling T^2 statistical test with 95% confidence (Figure 4). According to the bi-plot graph, Special type samples have the highest levels of moisture and ether extract, the positive axis of the first main component. However, the B_S_P and C_S_P samples are not on the same axis due to the influence of the high ash content that is more prevalent in Traditional management samples. According to Table 1, samples B and C are samples of the Special handling type that showed values above 5% of ash, confirming the influence of this parameter on the projection of the PCA.

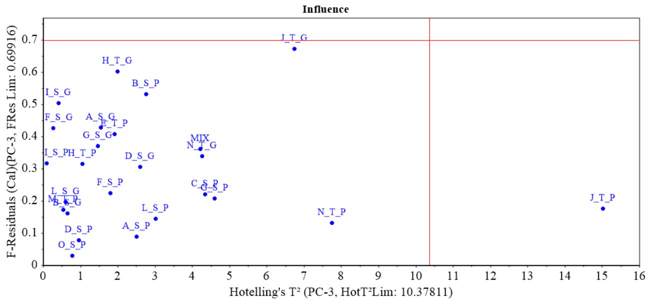

Figure 4. Influence samples based in Hotelling T^2 statistical test with 95% confidence

The samples that have the highest concentrations of ash, caffeine and aqueous extract are traditionally managed, with the J_T_P sample having the greatest influence on the projection on the negative axis of the first main component, as it has the lowest ether extract content and highest content of caffeine. The contents of ether extract and ashes agglomerated in most samples in the direction of the positive axis of the second main component (at the top of the graph). This means that most samples have values closer to the maximum value of the parameters. It was possible to verify the divergence of the physical-chemical quality of the samples belonging to the same producer. The sample J acquired in the form of grain (J_T_G) is closer to the other samples of Traditional handling, however the sample J acquired in the form of powder (J_T_P) has a strong difference in the physical-chemical quality. In Hotelling T^2 statistical test, J_T_P was indicated as outlier, mainly due to the levels of caffeine and aqueous extract. Thus, PCA of coffee quality parameters can be a powerful tool to identify the lack of adjustment in the quality control of the product sold to the final consumer, because products with high-quality control are positioned in the same quadrant as the PCA.

CONCLUSION

The studied samples of coffee agro forestry system produced in the Baturité Massif region have varied physical-chemical quality among producers of Special and Traditional management, however when evaluated in general, expressing the average values of the physical-chemical parameters, we can say that have a quality standard that meets Brazilian legislation. Principal Component Analysis was presented as a multivariate tool capable of identifying the standard of physical-chemical quality of samples from different types of management, as well as contributing to the identification of divergence between samples produced by the same producer.

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