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EFFECT OF STORAGE CONDITIONS ON THE PHYSICAL PROPERTIES OF COFFEE BEANS WITH DIFFERENT QUALITIES

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Abstract

The quality of coffee starts in the field, and goes through the harvesting and post-harvesting processes, and continues to storage and transportation. The storage of coffee beans aims to stock a product for a certain period of time. However, factors such as quality and metabolism of the grain, water content, environmental conditions of the warehouse, type of packaging, and storage time influence the maintenance of these characteristics, and may negatively affect sensory aspects of the beverage. The use of high-barrier packaging or refrigerated storage practices are alternatives that can ensure grain quality during storage. Thus, the objective of the present study was to evaluate the behavior of raw coffee beans, of different processing and quality levels, packed in impermeable packages and stored in a refrigerated environment. The specialty coffees were previously sampled and characterized as to the drink, with two lots (one of natural coffee and the other of pulped natural coffee) evaluated with a score of 82 points, and another lot of natural coffee evaluated with a score of 84 points. They were packed in two types of packaging: moisture and gas permeable, and gas, moisture, and light impermeable. The beans were stored in ambient conditions without temperature control and in refrigerated environments. The CO_2 concentration inside the packaging was measured, and the physical analyses – water content, color, and apparent specific mass – were performed. According to the results there is less variation in the water content and coloration of the grains stored in high barrier packages. The storage of the beans in refrigerated condition and in high barrier packing is efficient in the retarding of the loss of quality of the coffees during the nine months of the experiment.

Keywords: refrigeration, jute packaging, high barrier packaging, carbon dioxide, specific mass.

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1. Introduction

Coffee is an important product in Brazilian agribusiness, in the crop year 2019/20 more than 40 million 60 kg bags were exported by Brazil and the foreign exchange revenue was more than

6.5 billion USD [1]. The growing consumption and new trends in coffee consumer behavior make the market experience many changes. This challenge is an opportunity for specialty coffee producers to change their social and economic conditions, and for researchers to find increasingly effective techniques to produce and preserve the qualitative attributes of differentiated coffees.

The characteristics of green coffee beans depend on environmental factors, genetics, and the level of technology adopted from the formation of crops to the post-harvest processes [2]. However, chemical, physical, biochemical and sensorial transformations that occur in coffee depending on storage conditions may compromise the maintenance of the initial quality, impacting the commercialization as specialty coffees. These changes are more pronounced in specialty coffees stored conventionally in jute bags, when compared to the losses noted in commodity coffees [3–5]. There is also a tendency that dry-processed coffees show a more intense quality reduction when compared to pulped natural coffees [6].

The color of the green coffee bean is a characteristic that changes a lot according to the processing adopted. In the literature, it has been reported that wet-processed coffee beans have a higher intensity of green (lower values of the a-coordinate) and blue (lower values of the b-coordinate) colors, which corresponds to the characteristic of better quality coffee beans [7, 8], when compared to dry-processed coffees. Besides this, during storage, a greater variation in the coloration of dry-processed coffees was found when compared to wet-processed coffees stored for up to eight months [7].

Recently, studies have been conducted to ensure the preservation of desirable sensory attributes during storage. In this context, studies evaluated the use of plastic packaging impermeable to moisture and gases such as oxygen and carbon dioxide in the preservation of green coffee beans, during the storage period and when exporting them [3, 4, 9–11]. Due to its impermeability and the respiration of the beans, the high-barrier packaging promotes the alteration of the atmosphere inside the packaging, increasing the concentration of carbon dioxide (CO_2) and, consequently, reducing the respiratory activity of the beans [10].

Cellular respiration is a phenomenon that occurs in all living cells and consists of the oxidation of high energy compounds, such as glucose ($C_6H_{12}O_6$), and the consequent formation of lower energy substances, such as carbon dioxide (CO_2) and water (H_2O). In other words, it is a process that naturally occurs in the cells of the coffee beans, causing the dry matter to decrease, the water content to increase, and the carbon dioxide concentration to rise. Thus, when the metabolic activity of the stored beans is intense, there is a reduction in the specific mass, an increase in the water content and changes in the chemical composition and sensorial quality.

Coffee beans stored in an environment with high temperature and relative humidity have their metabolic processes accelerated, so some studies applied the concept of artificial atmosphere, controlling temperature and relative humidity. These studies concluded the technical viability of storing beans in a refrigerated environment and for differentiated coffees, it is favorable to employ the technique regardless of the processing method [12]. In addition to the environment, high-barrier packaging for specialty coffees, are efficient to decrease the speed of deterioration, maintaining the initial characteristics for longer periods [3, 4, 13, 14].

However, even with the advances found in the literature on the use of high-barrier packaging or refrigerated storage practices, these being, employed in different ways in the search for alternatives that ensured grain quality during storage, no type of packaging in use has the capacity to maintain the initial quality of the grains [3, 4, 10, 15].

In view of the above, the present research was made possible by a partnership among Universidade Federal de Lavras (UFLA), Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), Cool Seed – Tecnologia em Pos-Colheita, GrainPro – Storing The Future, Syngenta – Nucoffee and Logística Integrada Varginha (LIV), with the objective of evaluating the behavior of green coffee beans of different processing and quality levels, packed in impermeable packages and stored in a refrigerated environment through the physical properties of carbon dioxide (CO_2) concentration, water content, color and specific mass.

2. Material and methods

The experiment was set up according to an entirely randomized design, with three repetitions, in a 2×3×2 factorial scheme (two storage environments, three lots of coffee with differentiated quality and processing, and two types of packaging). The effect of the treatments was studied throughout the nine months of storage, with sampling at 0, 6 and 9 months after the installation of the experiment. **Table 1** shows the summary of the experimental design.

The specialty coffees (Coffea arabica L.) came from commercial lots supplied by Syngenta – NuCoffee. The lots of natural coffee and pulped natural cherry were previously sampled and characterized as to the beverage, one lot with a score of 82 points, the other with a score of 84 points, according to the Specialty Coffee Association (SCA) scale.

The coffee beans were packed in two types of packaging: packaging permeable to moisture and gases (jute-J); and structured packaging of high barrier to gases, moisture and light (high barrier-HB). The packages used have a capacity of 10 kg.

The coffee beans were stored in ambient conditions without temperature control and in a refrigerated environment, in the Armazem Logistica Integrada Varginha, in Varginha – MG. In order to avoid external effects, a pile was assembled for each sampling time, consisting of seventy 60 kg bags of coffee. All the piles were properly spaced from each other. The experimental samples were placed in the center of the piles, creating a border, both in ambient and refrigerated conditions. The refrigerated piles were mounted inside a Coocon Lite 005, which delimited the refrigerated space.

The refrigeration was obtained by an artificial aerator of the Cool Seed Company, which maintained the temperature of the grain mass between 15 and 18 °C. The ambient temperature and relative humidity values were recorded daily, by means of thermohygrographs installed in the experimental area.

Three samples were taken, the first at the beginning of storage, another at six months of storage and finally at nine months of storage.

The CO_2 concentration inside the packages was measured at the time of sampling, using a UEI gas analyzer, model C20. The results were expressed as a percentage of CO_2.

The water content of green coffee beans was determined in an oven at 105 °C±1 °C for 16 hours±0.5 h, according to the international standard method of ISO 6673 [16]. The grains were placed in the oven in duplicate and by difference of the initial and final mass of the product the amount of water present in the grains was obtained.

The color evaluation was carried out using a Minolta® CR 310 colorimeter (C illuminant and 10° angle), in which the parameters *L* (brightness), *a* and *b* (chromaticity coordinates) were measured. In this system, *L* indicates the luminosity, which varies from zero 0, (corresponding to the black color). The coordinates *a* and *b* indicate the directions that color can assume, positive values of *a*, corresponding to red and negative values, to green. Similarly, positive values of *b* correspond to yellow and negative values, to blue.

The apparent specific mass was given using a hectoliter weight scale with a capacity of one liter. The result represents the average of three repetitions for each sample, expressed in $kg{\cdot}m^{-3}$.

The results obtained from the physical analyses were submitted to variance analysis and when significant differences were detected in the F test, the Scott Knott test was applied at 5 % significance level for the treatments.

Table 1
Experimental design

Storage condition	Beverage quality	Processing	Packaging
Ambient (A)	82	Wet (DC)	High barrier (HB)
			Jute (J)
		Dry (N)	High barrier (HB)
			Jute (J)
	84	Dry (N)	High barrier (HB)
			Jute (J)
Refrigerated (R)	82	Wet (DC)	High barrier (HB)
			Jute (J)
		Dry (N)	High barrier (HB)
			Jute (J)
	84	Dry (N)	High barrier (HB)
			Jute (J)

3. Results and Discussion

3. 1. Temperature and relative humidity monitoring

The mean temperature values and the mean relative humidity values for refrigerated storage and for storage under ambient condition for nine months are presented in **Fig. 1**.

The mean temperature in the refrigerated storage was 18 °C and the mean relative humidity was 60 %, while for the storage in ambient condition the mean temperature was 22.5 °C and the mean relative humidity was 58 %.

Initially in the refrigerated storage there was a fast decrease in temperature values, but after this initial period it was difficult to reach even milder temperatures in the center of the pile (**Fig. 1, *a***). In the refrigerated environment there was also a greater variation of relative humidity in the center of the pile, with values above 60 % during the long storage period (**Fig. 1, *b***). In equilibrium with these values of relative humidity, green coffee beans can reach water content of up to 13.5 % when packed in packages permeable to water vapor, a water content not recommended for storage [13].

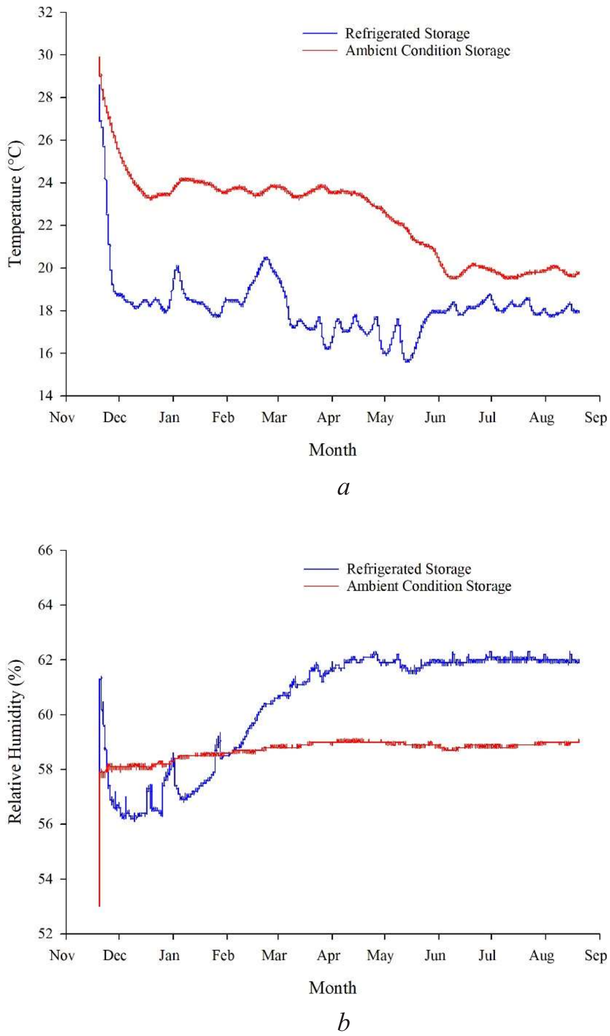


Fig. 1. Storage conditions for ambient and refrigerated storage:
a – temperature; *b* – relative humidity

For the storage in ambient condition it was noted that with the arrival of winter there was a decrease in temperature, previously the values were close to 24 °C (**Fig. 1, *a***). However, the humidity values had a minimum variation during storage (**Fig. 1, *b***).

3. 2. CO_2 concentration inside the packages

The values for the CO_2 concentration inside the packages are shown in **Table 2**.

The results show that the different packages and storage time had a significant interaction, and that the CO_2 concentration inside the high-barrier packages even in a refrigerated environment resulted in similar values when compared to coffee beans stored at room temperature. The CO_2 concentrations, over time, in the wet and dry processed coffees are shown in **Fig. 2**.

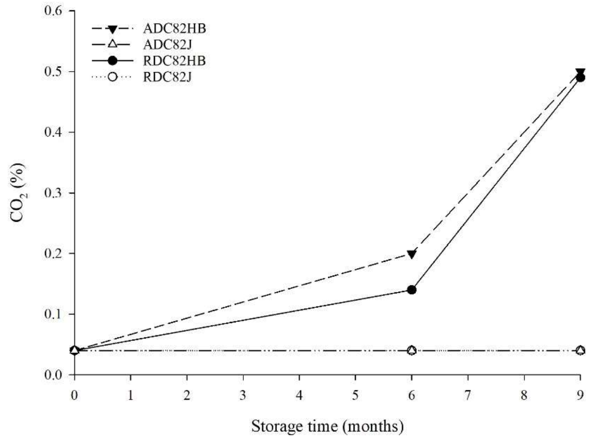
The results show that the high-barrier packages presented higher CO_2 concentrations over 6 and 9 months compared to the concentrations present in the samples stored in jute packaging. Furthermore, it is noted that for all the treatments studied, the permeable jute packaging presented stability of CO_2 concentrations. The increase in CO_2 concentration in high-barrier packages may be related to the respiration of the grains, but also suggests the impermeability of the package to gas exchange, which may reflect in greater conservation of the quality of the grains over time [11].

Table 2

CO_2 concentration of the samples packed in different packages and different temperature conditions at 0, 6 and 9 months

Treatment	Time (months)	CO_2 (%)
ADC82HB	0	0.035^c
	6	0.200^b
	9	0.500^a
ADC82J	0	0.035^a
	6	0.035^a
	9	0.035^a
RDC82HB	0	0.035^c
	6	0.140^b
	9	0.490^a
RDC82J	0	0.035^a
	6	0.035^a
	9	0.035^a
AN82HB	0	0.035^b
	6	0.170^b
	9	0.440^a
AN82J	0	0.035^a
	6	0.035^a
	9	0.035^a
RN82HB	0	0.035^b
	6	0.170^b
	9	0.470^a
RN82J	0	0.035^a
	6	0.035^a
	9	0.035^a
AN84HB	0	0.035^b
	6	0.170^b
	9	0.500^a
AN84J	0	0.035^a
	6	0.035^a
	9	0.035^a
RN84HB	0	0.035^c
	6	0.240^b
	9	0.540^a
RN84J	0	0.035^a
	6	0.035^a
	9	0.035^a

*Note: A – ambient storage; R – refrigerated storage; N – dry processing; DC – wet processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging; * – treatment means followed by the same letter in the column do not differ by the Scott Knott test at 5 %*



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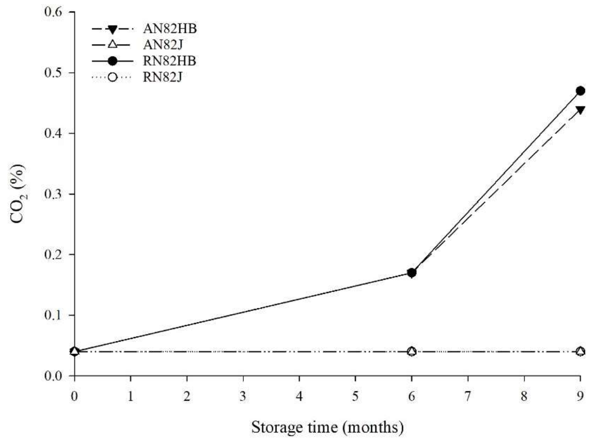

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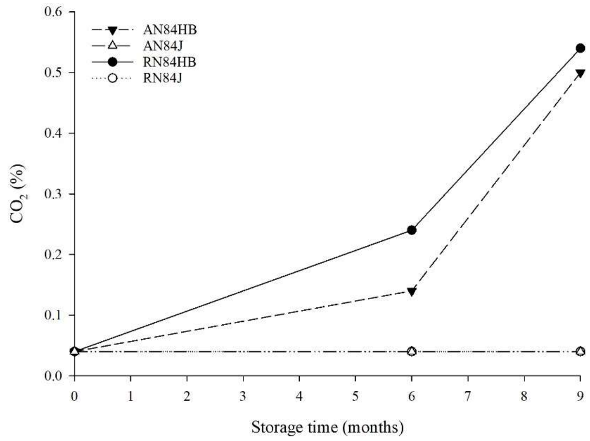


c

Fig. 2. CO_2 concentration for green coffee beans storage in different packages and temperatures at 0, 6 and 9 months: *a* – wet processed grains evaluated in 82 points; *b* – dry processed grains evaluated in 82 points; c – dry processed grains evaluated in 84 points; A – ambient condition storage; R – refrigerated storage; DC – wet processing; N – dry processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging

The CO_2 can concentrate in the atmosphere inside the packages from the breathing of the grains or be injected, which modifies the internal atmosphere of the package. Carbon dioxide concentrations higher than 0.03 % (atmospheric values) suggest good impermeability of the packages to exchanges with the environment. In addition, high concentrations of CO_2 inside packages have the positive effect on the preservation of grain quality because they reduce the respiration rate of the grains [17].

3. 3. Water content

The values for water content of stored coffee beans are shown in **Table 3**. Only the DC82 treatments had no significant variation in water content under the conditions studied, indicating that these coffees showed greater stability during the 9 months of storage.

The water content of the other samples changed over time, and this change was more significant for the refrigerated samples and those packed in jute packaging, regardless of the quality level, as shown in **Table 3**. In this way, **Fig. 3** shows the variation of water content in the treatments of natural coffees stored in different conditions, with 82 and 84 quality points.

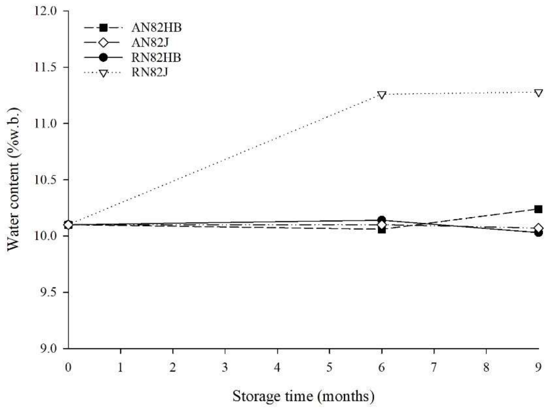
Table 3

Water content of samples packed in different packages and different temperature conditions at 0, 6 and 9 months

Treatment	Time (months)	Water content (% b.u.)
ADC82HB	0	10.16[a]
	6	10.00[a]
	9	10.19[a]
ADC82J	0	10.16[a]
	6	10.14[a]
	9	10.18[a]
RDC82HB	0	10.16[a]
	6	10.15[a]
	9	10.16[a]
RDC82J	0	10.16[a]
	6	10.21[a]
	9	10.82[a]
AN82HB	0	10.10[a]
	6	10.06[a]
	9	10.24[a]
AN82J	0	10.10[a]
	6	10.10[a]
	9	10.07[a]
RN82HB	0	10.10[a]
	6	10.14[a]
	9	10.03[a]
RN82J	0	10.10[b]
	6	11.26[a]
	9	11.28[a]
AN84HB	0	9.32[a]
	6	9.56[a]
	9	9.44[a]
AN84J	0	9.32[c]
	6	10.2[a]
	9	9.94[b]
RN84HB	0	9.32[a]
	6	9.43[a]
	9	9.37[a]
RN84J	0	9.32[b]
	6	10.04[b]
	9	11.07[a]

*Note: A – ambient storage; R – refrigerated storage; N – dry processing; DC – wet processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging; * – treatment means followed by the same letter in the column do not differ by the Scott Knott test at 5 %*

This difference in water content, especially for the samples stored in jute packaging in refrigerated environment evidences the permeability offered by the material, which allows more exchanges of the grains with the environment. In contrast, in the treatments with the use of high barrier packaging, the gases and humidity did not present significant difference in the variation of the water content during the 9 months of storage, even in refrigerated storage environment where cold air can have high relative humidity (**Fig. 1**). High water contents may be related to greater loss of quality over time, since these high values influence oxidation reactions, enzymatic and respiratory activity inducing the consumption of dry matter and accelerating the deterioration of grains [11].



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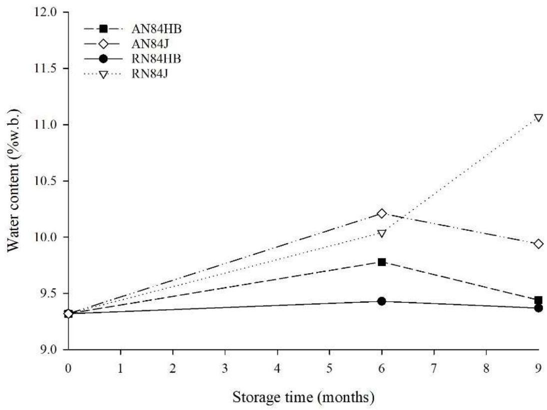


b

Fig. 3. Water content for green coffee beans storage in different packages and temperatures at 0, 6 and 9 months: *a* – dry processed grains evaluated in 82 points; *b* – dry processed grains evaluated in 84 points; A – ambient condition storage; R – refrigerated storage; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging

3. 4. Luminosity and coordinates a and b values

The values of the CIE coordinates *L*, *a* and *b* are shown in **Table 4**.

The results described in **Table 4** show that there was variation in luminosity in all treatments with wet processed coffees over time. The samples RDC82HB and RN84HB showed less variation in relation to this parameter at the end of the 9 months of storage, indicating that there is a positive interaction of high barrier packaging in a refrigerated environment. However, when jute packaging was combined with refrigerated environment the luminosity values were higher, the highest luminosity value was observed for sample RN84J after nine months of storage. Thus, it is possible to state that the samples packed in jute presented greater whitening over time. This fact suggests that the packaging was the factor with the greatest impact on the whitening of the grains, when compared to the storage temperature.

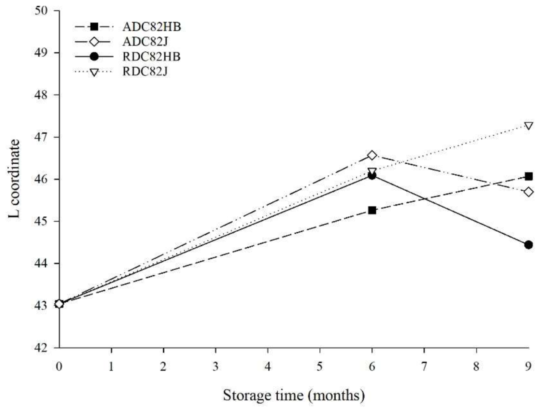
The color changes can be a result of biochemical degradation during the respiration of the beans, which contributes to the reduction of quality. These results corroborate with other research found in the literature [3, 18], in which they discuss that jute packaging is not suitable for storing specialty coffees and maintaining their quality. **Fig. 4** shows the variation of the color coordinates *a*, *b* and L in the treatments of coffees stored in different conditions.

Table 4
L, *a* and *b* coordinates of the samples packed in different packages and different temperature conditions at times 0, 6 and 9 months.

Treatment	Time (months)	*L*	*a*	*b*
	0	43.04^{b}	2.14^{a}	14.01^{b}
ADC82HB	6	45.26^{ab}	2.26^{a}	16.67^{a}
	9	46.07^{a}	1.79^{a}	16.73^{a}
	0	43.04^{b}	2.14^{a}	14.01^{b}
ADC82J	6	46.57^{a}	1.60^{b}	16.84^{a}
	9	45.70^{ab}	1.59^{b}	16.51^{a}
	0	43.04^{b}	2.14^{a}	14.01^{b}
RDC82HB	6	46.09^{a}	1.67^{a}	16.37^{a}
	9	44.44^{ab}	1.69^{a}	17.04^{a}
	0	43.04^{b}	2.14^{a}	14.01^{b}
RDC82J	6	46.20^{a}	1.67^{a}	16.23^{a}
	9	47.29^{a}	1.68^{a}	17.84^{a}
	0	43.92^{b}	2.03^{a}	15.48^{b}
AN82HB	6	47.43^{a}	1.24^{b}	18.41^{a}
	9	45.09^{ab}	1.85^{ab}	18.20^{a}
	0	43.92^{b}	2.03^{a}	15.48^{b}
AN82J	6	46.53^{a}	2.16^{a}	18.43^{a}
	9	46.82^{a}	1.40^{b}	18.62^{a}
	0	43.92^{a}	2.03^{a}	15.48^{b}
RN82HB	6	46.29^{a}	1.88^{a}	18.10^{a}
	9	46.20^{a}	1.92^{a}	18.85^{a}
	0	43.92^{a}	2.03^{a}	15.48^{b}
RN82J	6	46.30^{a}	1.33^{b}	18.35^{a}
	9	46.98^{a}	1.34^{b}	18.74^{a}
	0	45.20^{b}	1.79^{a}	16.07^{b}
AN84HB	6	48.70^{a}	1.88^{a}	19.11^{a}
	9	47.84^{a}	1.49^{a}	18.62^{a}
	0	45.20^{a}	1.79^{a}	16.07^{b}
AN84J	6	47.61^{a}	1.35^{a}	18.18^{a}
	9	46.06^{a}	1.41^{a}	18.77^{a}
	0	45.20^{a}	1.79^{a}	16.07^{b}
RN84HB	6	46.12^{a}	1.72^{a}	18.18^{a}
	9	45.83^{a}	1.64^{a}	18.32^{a}
	0	45.20^{b}	1.79^{a}	16.07^{b}
RN84J	6	48.30^{a}	1.49^{b}	18.78^{a}
	9	48.96^{a}	1.34^{b}	18.86^{a}

*Note: A – ambient storage; R – refrigerated storage; N – dry processing; DC – wet processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging; * – treatment means followed by the same letter in the column do not differ by the Scott Knott test at 5 %*

The results for the a-coordinate are shown in **Table 4** and **Fig. 5**. The difference in the DC82 treatments was not substantial over time, being significant only for the ADC82J treatment; however, for the other treatments, there was a decrease in the a-coordinate values, showing an approximation of the green coloration in relation to the red one. The decrease in a value for N82 treatments was also observed throughout the 9 months, with a slight increase after 6 months of storage. Lesser variations in a value were observed for samples RN82HB and AN82HB, showing that the high barrier packages represented greater protection against the variation of this variable over time. Similar behavior was observed for samples RN84HB and AN84HB.



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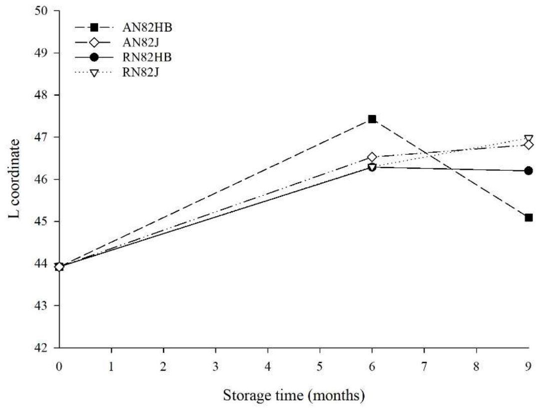

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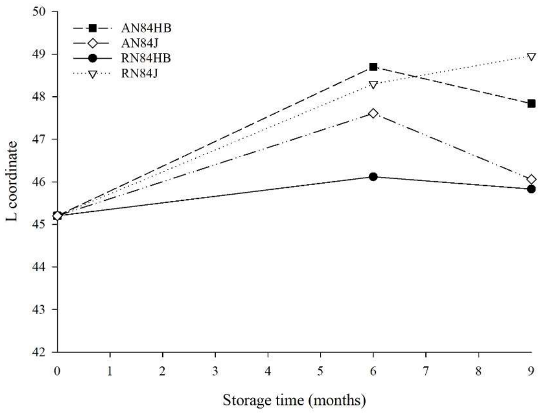

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Fig. 4. Luminosity for green coffee beans storage in different packages and temperatures at 0, 6 and 9 months: *a* – wet processed grains evaluated in 82 points; *b* – dry processed grains evaluated in 82 points; *c* – dry processed grains evaluated in 84 points; A – ambient storage; R – refrigerated storage; N – dry processing; DC – wet processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging

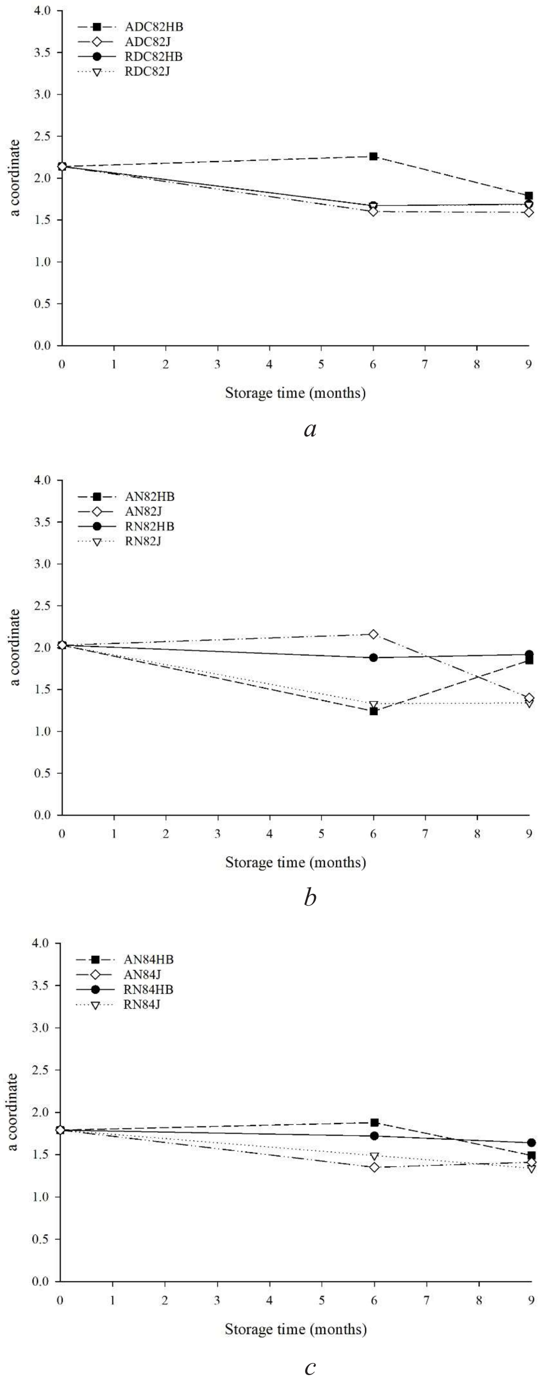
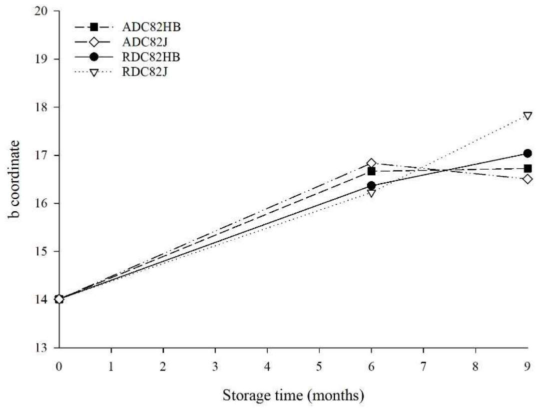


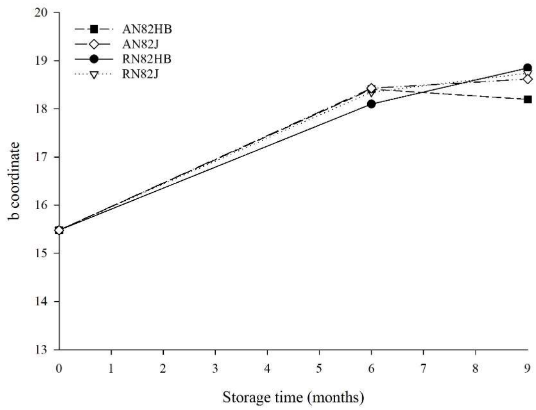
Fig. 5. *a* coordinate for green coffee beans storage in different packages and temperatures at 0, 6 and 9 months: *a* – wet processed grains evaluated in 82 points; *b* – dry processed grains evaluated in 82 points; *c* – dry processed grains evaluated in 84 points; A – ambient storage; R – refrigerated storage; N – dry processing; DC – wet processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging

The results for the b - coordinate are shown in **Table 4** and **Fig. 6**. There was no significant difference in b values between the different treatments, but the difference was significant over storage time.

The biggest difference between the treatments over time was observed for sample RDC82J. In the other treatments, the increase occurred similarly among the samples. The increase in b values shows yellowing of the samples over time, but in this case the packaging and storage temperature had no significant influence on this process.



a



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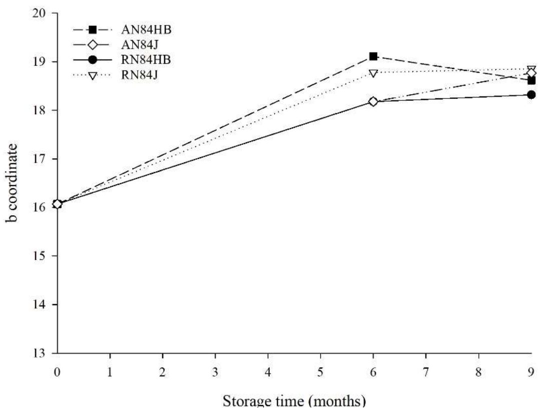

c

Fig. 6. *b* coordinate for green coffee beans storage in different packages and temperatures at 0, 6 and 9 months: *a* – wet processed grains evaluated in 82 points; *b* – dry processed grains evaluated in 82 points; *c* – dry processed grains evaluated in 84 points; A – ambient storage; R – refrigerated storage; N – dry processing; DC – wet processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging

3. 5. Apparent specific mass

The results of apparent specific mass of green coffee beans stored in different packages and temperatures are shown in **Table 5**. No significant differences were found over storage time for specific mass of wet and dry beans stored in different packages.

When analyzing processed coffee beans with different water contents, researchers observed no change in the specific mass of the beans [19]. These results corroborate those found in this research, that despite the variation in the water content of coffee beans throughout storage, the apparent specific mass did not show a significant difference.

Table 5

Apparent specific mass (ρ, kg.m^{-3}) of grains packed in different packages and temperatures

Treatment	Time (months)	ρ (kg.m^{3-})
ADC82HB	0	629.64^{a}
	6	595.35^{a}
	9	608.36^{a}
ADC82J	0	629.64^{a}
	6	604.87^{a}
	9	605.42^{a}
RDC82HB	0	629.64^{a}
	6	604.06^{a}
	9	601.07^{a}
RDC82J	0	629.64^{a}
	6	587.32^{a}
	9	597.07^{a}
AN82HB	0	614.17^{a}
	6	615.72^{a}
	9	617.69^{a}
AN82J	0	614.17^{a}
	6	616.72^{a}
	9	610.84^{a}
RN82HB	0	614.17^{a}
	6	612.78^{a}
	9	614.40^{a}
RN82J	0	614.17^{a}
	6	598.78^{a}
	9	603.56^{a}
AN84HB	0	642.22^{a}
	6	640.69^{a}
	9	635.11^{a}
AN84J	0	642.22^{a}
	6	628.29^{a}
	9	624.62^{a}
RN84HB	0	642.22^{a}
	6	629.30^{a}
	9	624.62^{a}
RN84J	0	642.22^{a}
	6	611.03^{a}
	9	618.22^{a}

*Note: A – ambient storage; R – refrigerated storage; N – dry processing; DC – wet processing; 82 – 82 beverage quality points; 84 – 84 beverage quality points; HB – high barrier impermeable packaging; J – jute permeable packaging; * – treatment means followed by the same letter in the column do not differ by the Scott Knott test at 5 %*

Although the reductions in the values of the apparent specific mass of the grains were not significant, a decrease in the values occurred, mainly between 0 to 6 months. The grains conditioned in jute packing and refrigerated presented the lowest values of apparent specific mass, mainly for the RDC82J treatment. The loss of apparent specific mass in the treatments conditioned in jute can be related to the increase of the water content and availability of oxygen, resulting in the increase of the respiratory rate of the grains, which leads to the degradation and consumption of chemical compounds of the same. Researchers [20] suggest that the stress caused by wet processing leads to losses in coffee beans. These losses are associated with increased free fatty acids, loss of phospholipids, and antioxidants such as ascorbic acid and glutathione reductase. With the growing demand for coffee storage worldwide, studies are needed to complement studies with chemical and sensory analyzes of the material for a better understanding of the phenomenon.

4. Conclusions

The high-barrier packages presented higher CO_2 concentrations over 9 months compared to the concentrations present in the samples stored in jute packaging. The increase in CO_2 concentration in high-barrier packages suggests the impermeability of the package to gas exchange, which may reflect in greater conservation of the quality of the grains over time.

The change water content was more significant for the refrigerated samples and those packed in jute packaging, regardless of the quality level.

Lesser variations in color values were observed for samples stored at high barrier regardless of initial quality score, showing that the high barrier packages represented greater protection against the variation of this variable over time.

No significant differences were found over storage time for the specific mass of the processed wet and dry grains stored in different packages.

The storage of beans in refrigerated condition and in high barrier packages is efficient in delaying the loss of quality of the coffees throughout the nine months of the experiment.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Manuscript has no associated data.

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