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PHYSIC-CHEMICAL QUALITY OF SECOND CROP CORN AS A FUNCTION OF TIME BETWEEN HARVEST AND DRYING

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ABSTRACT: The gap in the storage industry has brought a series of problems for the agro industrial market today, as its ability to directly infer the quality of newly collected material. The present study was carried out with the objective of evaluating the quality of second crop corn harvested with different water contents depending on the period until drying. The corn grains were harvested with moisture contents of approximately 28.5; 22.4; 21 and 19%, and subjected to temporary storage for ten days, simulating the time between harvest and drying. In the period, every two days the quality was evaluated by determining the specific mass, electrical conductivity, color, crude protein content, ethereal extract, ashes and carbohydrates. Based on the obtained results it is concluded that: the increase in the harvest water content negatively influenced the quality of the produced corn in the second harvest, being this effect worsened with time. The harvest moisture content of 19% is the least that affected the quality of the grains during 10 days of temporary storage.

KEY WORDS: *Zea mays* L., grain quality, post-harvest.

INTRODUCTION

Currently in Brazil corn is the second most cultivated plant species being only behind soybean (Môro & Fritsche Neto, 2015). However, even with increasing productivity rates and a heated market, a number of drawbacks are present in the production chain. The post-harvest area and its lag in the storage sector can be seen as one of the main problems once the implications promoted by this affect cost / benefit balance (Kolling et al., 2012; Kussano & Batalha, 2012).

An example of this is the increasing qualitative and quantitative losses from year to year, since the newly harvested material is temporarily stored in the trucks' bodies, subject to deteriorating potentiation due to the uncontrolled environmental conditions and the temperature and relative humidity to infer directly in this process (Coradi et al., 2014; Del Campo et al., 2014).

In Brazil given the difficult interaction between the field and the commercial sector, the static capacity becomes insufficient to meet the production (Oliveira Neto et al., 2015; Nascimento et al., 2016). For the 2016/2017 harvest it is estimated that the amount of second crop corn requires approximately 39% of the national storage capacity, however, because it is already occupied by about 69% of soybeans, 19% of first-crop corn and 8% of rice, its capacity will be exceeded (CONAB, 2017).

In this context, estimating the possible losses between harvesting and drying are extremely important. Therefore, factors such as time and the harvest moisture content become relevant, once both have influence on some of the main qualitative attributes, such as the physic-chemical (Surki et al., 2012; Jyoti & Malik, 2013).

The objective of this study was to evaluate the quality of the second crop corn harvested with different moisture contents as a function of time until drying.

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MATERIAL AND METHODS

The present study was developed in two stages being the first one constituted by the grain production phase and the second by the temporary packaging and the quality evaluation of the same.

The production occurred between February and July 2014 at São José Farm, located at 22° 41'27.88"S, 54°49'02.40"W, and altitude of 409 meters in the municipality of Caarapó, MS. Temporary packaging was also carried out at the farm level, but the qualitative evaluation was carried out at the Laboratories of Pre-Processing and Storage of Agricultural Products and of Physical Properties of Agricultural Products, both belonging to the Faculty of Agricultural Sciences (FCA) of the Federal University of Grande Dourados (UFGD), located in the municipality of Dourados, MS.

The hybrid corn cultivated to obtain the material was BG 7061H (simple hybrid) which was cultivated under no-tillage system. The area preparation involved only desiccation actions, using 1,680 g a.i. ha^{-1} of glyphosate herbicide seven days before sowing. The fertilization process was carried out in two phases, simultaneously with sowing, using 300 kg ha^{-1} of formulated fertilizer 08-20-20 (N-P-K) and 30 days after seedlings emergence, applying 150 kg ha^{-1} of urea.

Before sowing the seeds were treated with insecticide (Thiametoxan - 3 g kg of seed^{-1}) and fungicide (Thiram - 3 ml kg of seed^{-1}), only then mechanically seeded with a spacing of 0.50 m between the sowing lines and density of 3 (three) seeds m^{-1} resulting in a final population of 60,000 plants ha^{-1}.

The grains were harvested mechanically, using an automotive model TC 57, whose platform had eight lines. Harvest time was established in order to obtain four different moisture contents which were approximately 28.5; 22.4; 21 and 19% ± 0.4%, on a wet basis (w.b.).

For the simulation of transport time between harvest and drying, each batch of grains, with their respective moisture content was packed in a wooden-box which was covered with plastic canvas of Vinilona brand, simulating the truck body. Temporary storage lasted ten days with all quality tests performed immediately after harvest and every two subsequent days (0, 2, 4, 6, 8 and 10 days), which totaled six evaluation periods.

Each box is one meter wide, one meter high and two meters long, which totaled 2 m^3. In addition, about 1,500 kg of corn was packed in each one.

During the pre-established intervals were determined the values of temperature and relative humidity of the air by means of a meteorological station near the place.

In order to evaluate the quality of the grains were performed analyzes on the apparent specific mass, electrical conductivity, coloring, crude protein, ethereal extract, ashes and carbohydrates. In addition, the behavior of the moisture content of each batch was determined during the temporary storage using the gravimetric method, through oven at 105 ± 3°C for 24 hours in two replicates (MAPA, 2009), and the behavior of the grain mass temperature which was measured with maximum thermometer connected to a sensor placed at four points on the box during 5 minutes for each point.

The apparent specific mass was determined using a cylindrical container of 1000 ml volume with a height equal to the diameter in ten subsamples. At each measurement the grain mass that filled the container volume was determined on a 0.01 g resolution scale being the apparent specific mass results expressed in kg m^{-3}.

In the evaluation of the electrical conductivity four subsamples of 50 seeds, for each treatment, were weighed and placed to soak in 75 ml of distilled water and deionized for 24 hours at 25°C in plastic cups with capacity of 200 ml. After this period the electrical conductivity of the imbibition solution was carried out by means of a digital conductivity meter of the brand Gehaka, model CG 1800. From the results obtained in the readings, those in μS cm^{-1} was performed the division of each one by its respective mass, and the final result for the test was expressed as μS cm^{-1} g^{-1} (Vieira & Krzyzanowski, 1999).

Color monitoring was carried out by direct reading of reflectance of the corn grains in a trichrome colorimeter (illuminant 10°/D65), using the Hunter color system obtaining the values of the coordinates "L" (luminosity), "a" (tonality green - red) and "b" (tonality blue - yellow). For each treatment the average of ten determinations was used to evaluate the color of the analyzed product.

Crude protein content was obtained by determining the percentage of total nitrogen from three previously milled sub samples of 100 mg according to the Kejldahl method described by AOAC (1984). After the determination of the percentage of total nitrogen the obtained value was multiplied by the average factor of 6.25, and therefore found the crude protein content.

The ethereal extract was determined according to the INCT-CA G-004/1 method (Detmann et al., 2012), using three corn bran subsamples with 2 g each. The extractive apparatus used was the soxhlet which remains in operation for six hours and used ethyl ether as the solvent.

The ash content was determined by the INCT-CA M-001/1 method (Detmann et al., 2012), being the results obtained, by percentage, through incineration at high temperatures (500-600 ° C), and total combustion of organic matter.

In addition, the carbohydrate content was obtained by proximal analysis, subtracting from 100% contents the crude protein, ethereal extract and ash (Detmann et al., 2012).

The experiment was set up in a scheme of subdivided plots 4 x 6, with four levels of harvest moisture in the plots and six evaluation periods, referring to the transport time between harvest and drying, in the subplots, in a completely randomized design. In order to evaluate the latent effect of harvest moisture contents the data were submitted to polynomial regression analysis. The models were selected considering the magnitude of the determination coefficient (R^2), the significance of the regression by the F test, and the biological phenomenon under study.

RESULTS AND DISCUSSION

Figure 1 shows the thermal and relative humidity variations measured throughout the experiment. Thus, due to such illustrated situation it was possible to verify that the average temperature observed during the temporary storage was 17.7 ° C with the maximum and minimum recorded at 31 and 6°C, respectively. Regarding the relative humidity mean value observed was 72.3% with the maximum recorded at 87%, and the minimum at 38%.

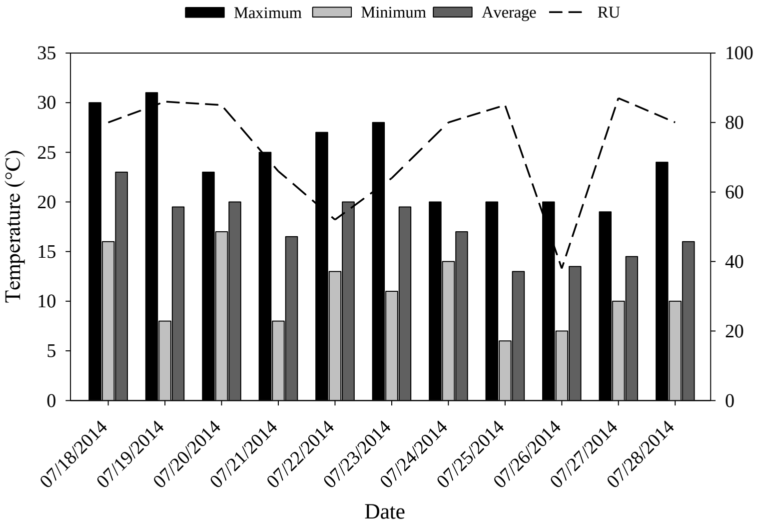


FIGURE 1. Daily mean of air relative humidity and temperature, during 10 days of temporary storage of corn in a non-controlled environment.

Table 1 shows that there were increases in moisture contents of corn grains during the temporary storage, mainly due to the uncontrolled temperature and relative humidity conditions (Figure 1), besides the sorption phenomena the occurrence of oxidative and fermentative phenomena which through successive chemical reactions promoted the consumption of dry matter of the grains and the formation of water which was released as vapor and reabsorbed (Bessa et al., 2015; Brito et al., 2015). Thus, elevations of approximately 9.7; 5.5; 5.7 and 5 percentage points were verified for corn grains harvested with moisture contents of 28.5; 22.4; 21 and 19%, respectively.

TABLE 1. Mean moisture content (% w.b.) of corn according to harvest moisture content and temporary storage.

Harvest moisture content (%w.b.)	Temporary storage (days)					
	0	2	4	6	8	10
28.5	28.5	30.7	31.4	31.5	34.3	38.2
22.4	22.4	22.5	24.4	24.7	25.4	27.9
21.0	21.0	22.3	22.4	23.4	25.2	26.7
19.0	19.0	20.4	21.3	22.0	22.0	24.0

It was also possible to verify from Table 1 that the higher the harvest moisture content, the higher the moisture content reached at the end of ten days of temporary storage. Therefore, this fact suggested that because the material with higher moisture content has a higher metabolic activity, mainly related to the respiratory process, the greater its interaction with the environment and more intense its oxidative and fermentative reaction, therefore greater the moisture absorption by part of the material (Jyoti & Malik, 2013; Mahjabin & Abidi, 2015). In addition, because high moisture content in the material intensifies its respiratory activity, and this produces water as a product, most probably this has helped to raise the moisture content in the grains, once it is reabsorbed.

Another factor that may have contributed to the increase the final moisture content in grains, according to the increase on the harvest moisture content was the fact that corn grains harvested with high moisture content generally present a higher percentage of impurities, and this material has a high moisture retention capacity raising the values of the moisture content in the sample (Marques et al., 2012).

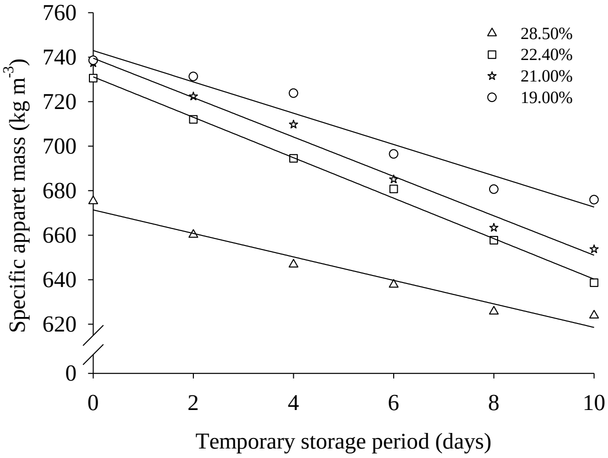
Regarding the grain mass temperature, it was observed that it had an increase according to the increase in the values related to the moisture content on harvest, as well as in the time of temporary storage (Table 2). Therefore, the fact that the harvested grains with higher moisture contents have a high metabolic activity could be confirmed given that in addition to the increase in moisture content, the heating of the grain mass is one of the main characteristics of products with high respiratory activity (Suleiman et al., 2013).

TABLE 2. Mean temperature (°C) of corn according to harvest moisture content and temporary storage.

Harvest moisture content (%w.b.)	Temporary storage (days)					
	0	2	4	6	8	10
28.5	38.0	40.0	46.0	50.0	50.0	50.0
22.4	34.0	36.0	40.0	41.0	44.0	44.0
21.0	34.0	35.0	38.0	40.0	40.0	42.0
19.0	34.0	35.0	36.0	36.0	37.0	37.0

Therefore, since the respiratory process involves the consumption of reserves and oxygen, and produce water and CO_2 as by-products, it was possible to conjecture that one of the forms on energy dissipation of the system was the heat production which promoted the temperature rise in the mass of the stored grains. This fact was more incisive in the grains harvested with higher moisture contents, once these presented a greater heating in their mass according to the temporary storage. An example of this was the elevations of 12, 10, 8 and 3°C at the end of the 10 days, of the harvested grains with moisture contents of 28.5; 22.4; 21 and 19%, respectively (Table 2).

In relation to the apparent specific mass of corn a decreasing behavior was verified according to the increase of the moisture content, and a linear deleterious behavior observed during the temporary storage (Figure 2).



$SAM_{28,50\%} = 671.3638 - 5.2774\ TS$ $(R^2 = 0.9557)$
$SAM_{22.40\%} = 731.1686 - 9.0887\ TS$ $(R^2 = 0.9953)$
$SAM_{21.00\%} = 739.5410 - 8.8539\ TS$ $(R^2 = 0{,}9833)$
$SAM_{19.00\%} = 742.9467 - 7.0310\ TS$ $(R^2 = 0.9411)$

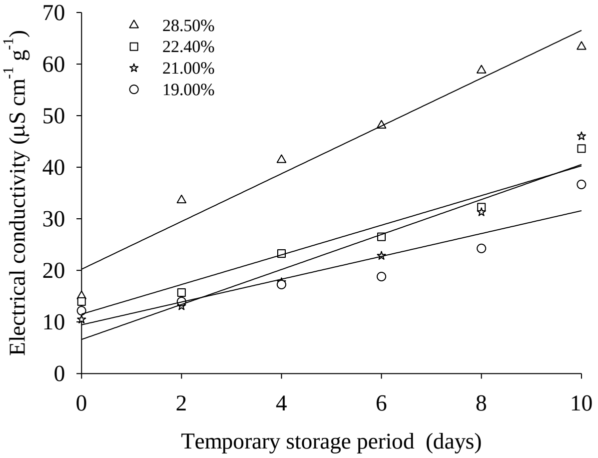
FIGURE 2. Result of the specific apparent mass of corn grains according to harvest moisture content and temporary storage period (TS).

Soon after harvesting the specific apparent masses verified were 671.4; 731.2; 739.5 and 742.9 kg m^{-3} for the harvest moisture contents of 28.5; 22.4; 21 and 19%, respectively. However, due to the latent behavior enunciated at the end of ten days the verified values for the variable with reference to the same moisture contents were 618.6; 640.3; 651.0 and 672.6 kg m^{-3} (Figure 2).

This conduct occurred immediately upon harvest due to the high moisture content to hamper the arrangement of the material in the container, since for most agricultural products the apparent specific mass is elevated as the moisture content is reduced due to better product accommodation in the container, given the reduced porosity, as well as the surface area of the grain (Oliveira et al., 2014; Araujo et al., 2015). However, in general, this behavior was potentiated during the temporary storage not only by increasing the moisture content of the product (Table 1), but also by the worsening of the deterioration processes, since this variable is related to the dry matter loss of the material and, consequently, with its quality (Coradi et al., 2015).

The loss of dry matter is directly responsive to the storage conditions and the moisture content of the material, because of these factors being able to infer in the respiratory process of the grain mass, increasing its metabolic activity, increasing consumption of the reserves components in the material and the deteriorating intensity (Del Campo et al., 2014; Polat, 2015).

Through the electrical conductivity test it was possible to confirm that the elevation on the harvest moisture content was determinant on grain quality reduction, as well as the aggravation of this situation with the temporary storage, since the obtained results by the test are already increasing at the harvest and, over time, behave in a positive and progressive linear manner for all treatments (Figure 3).



$EC_{28.50\%} = 20.2194 + 4.6294\ TS$ ($R^2 = 0.9492$)
$EC_{22.40\%} = 11.5076 + 2.8747\ TS$ ($R^2 = 0.9383$)
$EC_{21.00\%} = 6.3667 + 3.4057\ TS$ ($R^2 = 0.8187$)

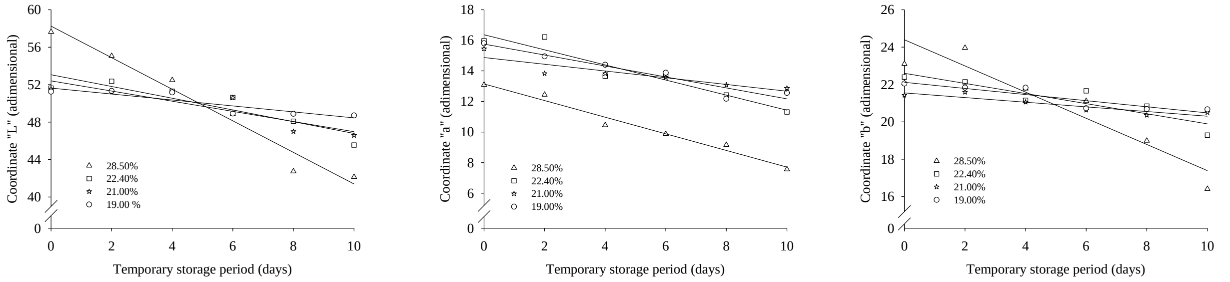
FIGURE 3. Result of electrical conductivity of the soaking solution of the corn grains, according to harvest moisture content and temporary storage period (TS).

Very likely, with the elevation on harvest moisture content the kneading damages to the grains intensifies as well as the electrical conductivity values increases. In addition, due to the fact that the values of the terms of the adjusted equations were elevated as a function of the increment on both factors, it was allowed to attest higher level of deterioration in the harvested plots with higher moisture contents evidencing a greater susceptibility of kneading grains to the loss of their quality according to the time. According to Marques et al. (2011) when harvested with high moisture contents corn grains are more vulnerable to kneading damage which usually breaks their pericarp and exposes their cellular material. In addition, the more damaged, the more exposed the product gets to deteriorating processes which implies in aggravation of qualitative and quantitative losses from day to day after the harvest (Camolese et al., 2015).

The electrical conductivity test provides information regarding to integrity of the material, especially that relating to its cell membranes (Marcos Filho, 2015). Therefore, through the results it was possible to certify that the interaction between the factors caused physical-structural cellular disarray in grains which may have contributed to the profuse leaching of a series of important solutes for the preservation and qualitative maintenance of the product.

The cellular integrity commitment and product deterioration facilitate the leaching of solutes, since cell membranes do not perform efficiently their selective barrier function at the beginning of the imbibition process which increases the values of the electrical conductivity of the solution (Resende et al., 2012). This fact is common when the agricultural product is stored under extreme conditions, since its integrity is gradually compromised (Bezerra et al., 2015).

Similarly to the other variables, the color of the corn grains was also altered according to the imposition of the studied factors, and this behavior was more incisive in relation to the increase of the harvest moisture content in relation to the period (Figure 4).



(a) **(b)** **(c)**

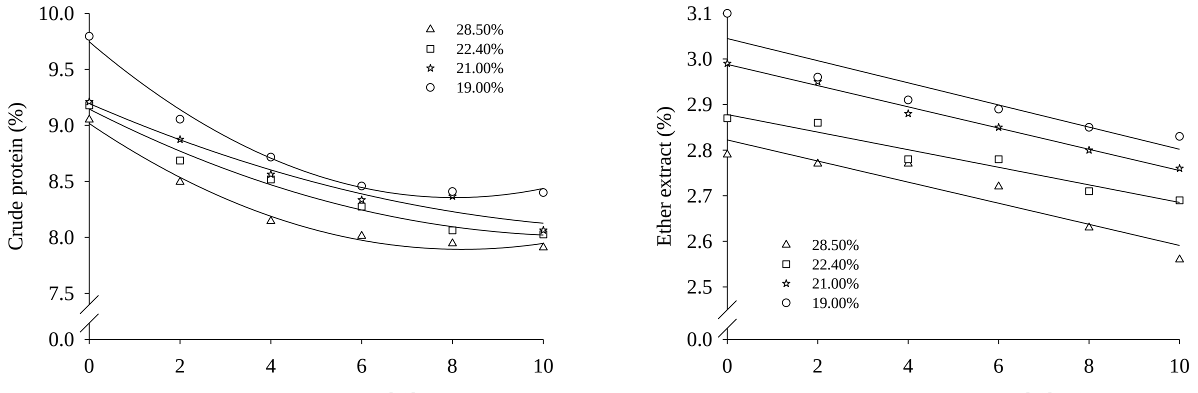
$L_{28.50\%} = 58.2510 – 1.6859\ TS$ $(R^2 = 0.9600)$ $a_{28.50\%} = 13.1476 – 0.5439\ TS$ $(R^2 = 0.9662)$ $b_{28.50\%} = 24.3938 – 0.7004\ TS$ $(R^2 = 0.8555)$
$L_{22.40\%} = 53.0600 – 0.6270\ TS$ $(R^2 = 0.7702)$ $a_{22.40\%} = 16.3652 – 0.4937\ TS$ $(R^2 = 0.8946)$ $b_{22.40\%} = 22.5995 – 0.2706\ TS$ $(R^2 = 0.7663)$
$L_{21.00\%} = 52.4029 – 0.5426\ TS$ $(R^2 = 0.7527)$ $a_{21.00\%} = 14.8733 – 0.3162\ TS$ $(R^2 = 0.7701)$ $b_{21.00\%} = 21.5495 – 0.1246\ TS$ $(R^2 = 0.8007)$
$L_{19.00\%} = 51.6357 – 0.3181\ TS$ $(R^2 = 0.7621)$ $a_{19.00\%} = 15.,7548 – 0.3583\ TS$ $(R^2 = 0.9043)$ $b_{19.00\%} = 22.1162 – 0.1636\ TS$ $(R^2 = 0.7996)$

FIGURE 4. Result of color coordinates “L” (a); “a” (b); and “b” (c) of corn grains, according to harvest moisture content and temporary storage period (TS).

The change in color occurred due to the darkening of the grains, behavior evidenced by decreasing in the values related to the coordinates “L”, “a” and “b” (Figure 4). In this way, because the product presents values tending to approach darker tonality, such as black rather than white (Figure 4a), green rather than red (Figure 4b), and blue rather than yellow (Figure 4c) it can be noticed the darkening.

The high water content of the material and uncontrolled relative temperatures and humidity conditions raised the metabolic rate of the product, and eventually interfered directly in its appearance darkening it. As this behavior was influenced by the time the situation was aggravated by the prolongation of temporary storage, since it has the capacity to interfere in situations such as this one. As already recommended by Elias et al. (2016) the grains can undergo darkening according to storage conditions however, the storage time is determinant for the potentialization of their behavior. In addition, the corn grains during the storage when undergoing deterioration processes due to temperature and relative humidity fluctuations may have some degraded constituents, such as carotenoids, and because of this their appearance may be darkened (Ortiz et al., 2016).

In the evaluations of crude protein and ethereal extract we observed decrease in the values according to the increment of the studied factors (Figure 5).



(a) **(b)**

$CP_{28.50\%} = 9.0164 – 0.2736\ TS + 0.0167\ TS^2$ $(R^2 = 0.9825)$ $EE_{28.50\%} = 2.8224 – 0.0231\ TS$ $(R^2 = 0.8518)$
$CP_{22.40\%} = 9.1456 – 0.2067\ TS + 0.0094\ TS^2$ $(R^2 = 0.9783)$ $EE_{22.40\%} = 2.8781 – 0.0193\ TS$ $(R^2 = 0.9342)$
$CP_{21,00\%} = 9.1952 – 0.1758\ TS + 0.0069\ TS^2$ $(R^2 = 0.9463)$ $EE_{21.00\%} = 2.9881 – 0.0233\ TS$ $(R^2 = 0.9893)$
$CP_{19.00\%} = 9.7467 – 0.3459\ TS + 0.0215\ TS^2$ $(R^2 = 0.9840)$ $EE_{19.00\%} = 3.0448 – 0.0243\ TS$ $(R^2 = 0.8266)$

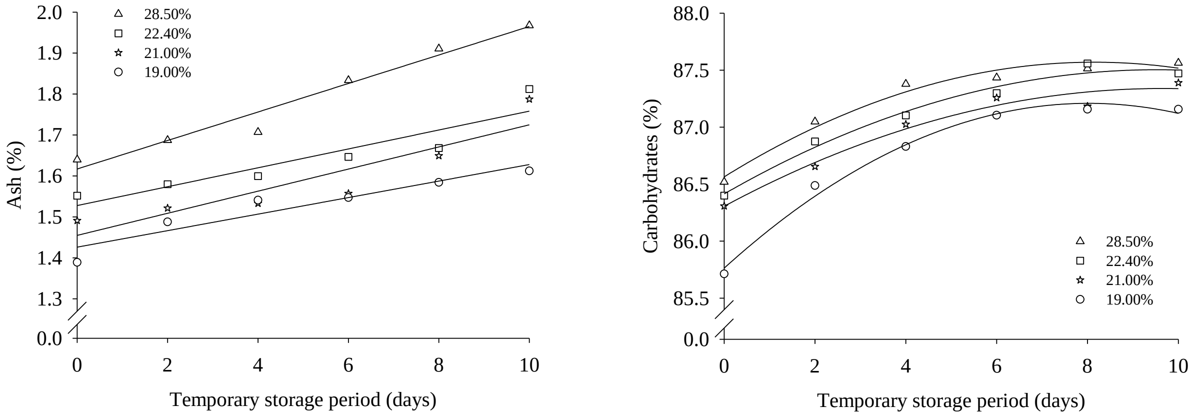
FIGURE 5. Result of crude protein (a) and ether extract contents (b) of corn grains, according to harvest moisture content and temporary storage period (TS).

Immediately harvesting the crude protein contents checked for water contents of 28.5; 22.4; 21 and 19%, were 9.02; 9.15; 9.19 and 9.75%, respectively (Figure 5a). However, because the deteriorating effect promoted a reduction of approximately 1% in crude protein content for all treatments at the end of the 10 days the final observed values for the variable were 7.95; 8.01; 8.13 and 8.44%.

For the ethereal extract the verified values immediately after harvest for the water contents of 28.5; 22.4; 21 and 19% were 2.82; 2.88; 3.00 and 3.04%, respectively (Figure 5b). However, because the latent reduction during ten days was approximately 0.2% for all treatments, the obtained values at the end of the temporary storage period were 2.60; 2.70; 2.75 and 2.80%.

As a consequence of these behaviors it was possible to conjecture that the reduction on both variables contributed to the decreasing behavior relative to the apparent specific mass (Figure 2), since proteins and lipids are important constituents of corn and interfere directly in related aspects with the loss of dry matter. According to Tiecker Junior et al. (2014) the centesimal composition of a grain may directly reflect its condition, and therefore, it is possible to admit relations between constituent character variables with qualitative-quantitative variables. In addition, as suggested by Suleiman et al. (2013), both components protein and lipids can be affected by the characteristics that the product has in its pre-storage stage by conditions of the environment and by the time, since the levels of these factors dictate the deterioration, increasing or reducing the consumption of the material structural components, in particular by respiration.

There was an increase on ash content values according to the increment of both factors. Immediately after harvest the obtained values were 1.62; 1.53; 1.45 and 1.43% for the harvest moisture contents of 28.5; 22.4; 21 and 19%, respectively. However, due to linear potentiation during the temporary storage for all treatments at the end of the 10 days the observed values were 1.96; 1.76; 1.72 and 1.51% (Figure 6a).



(a)

$AS_{28.50\%} = 1.6170 + 0.0348\ TS$ ($R^2 = 0.9540$)

$AS_{22.40\%} = 1.5277 + 0.0231\ TS$ ($R^2 = 0.8205$)

$AS_{21.00\%} = 1.4549 + 0.0270\ TS$ ($R^2 = 0.7902$)

$AS_{19.00\%} = 1.4261 + 0.0084\ TS$ ($R^2 = 0.8202$)

(b)

$CO_{28.50\%} = 86.5641 + 0.2471\ TS - 0.0152\ TS^2$ ($R^2 = 0.9605$)

$CO_{22.40\%} = 86.4144 + 0.2287\ TS - 0.0120\ TS^2$ ($R^2 = 0.9733$)

$CO_{21.00\%} = 86.3059 + 0.2141\ TS - 0.0111\ TS^2$ ($R^2 = 0.9495$)

$CO_{19.00\%} = 85.7632 + 0.3605\ TS - 0.0225\ TS^2$ ($R^2 = 0.9838$)

FIGURE 6. Result of ash (a) and carbohydrates contents (b) of corn grains, according to harvest moisture content and temporary storage period (TS).

The metabolic activity of grains consumes organic matter metabolizing CO_2, water and other products, and releasing heat. Because of this, structurally the mineral composition of the material is transformed without changing its total content. Thus, the determination of the ash content takes proportionally higher values as the organic matter is consumed (Muir et al., 2000). Thus, what could be observed in this study was the increase of the organic matter consumption of the stored product in relation to the increase of the harvest moisture content and the time, since determined ash content has increased, thus evidencing a higher content of mineral material (Figure 6a).

As already evidenced by Tiecker Junior et al. (2014) increase in the ash content may be a deteriorating indicator once the mineralization of the organic matter expresses the consumption of reserve material via metabolic activity. As suggested by the same authors this behavior is accelerated in cereals when it presents water contents higher than 14%, and specifically for stored corn when the initial water content is close to 29%.

The carbohydrate content, as well as the ash content, showed an increasing behavior when the harvest moisture content was high and the storage time was over (Figure 6b). Soon after harvesting the verified values for the variable related to water contents of 28.5; 22.4; 21 and 19% were 86.56; 86.41; 86.31 and 85.8%, respectively. However, at the end of ten days they were brought to 87.51; 87.50; 87.34 and 87.12%.

It can be deduced that when reducing the levels of crude protein and ethereal extract there is an increase on values related to carbohydrates. This is due to the fact that the carbohydrate content is inversely proportional to the other compounds when determined by proximal analysis, the greater relative proportion of this constituent in the grains and also the loss of crude protein and ethereal extract were more intense during the temporary storage period (Schuh et al., 2011).

The tendency of this increase, therefore, is a virtual increase, apparent or relative, since it occurs as a function of the decrease on crude protein and fat fractions during storage. This variation in apparent increments of the carbohydrate fraction reflects therefore a proportional relationship, due to the requirement of constituents, such as lipids and proteins in the intrinsic metabolism of the grains, associated microorganisms and pests, besides the fact that these constituents are quite susceptible to enzymatic and non-enzymatic chemical transformations during storage, as already verified by Tiecker Junior et al. (2014) evaluating the physical-chemical quality of corn grains stored with different moisture.

Due to the fact that practically all the treatments showed increases of approximately 1% in the carbohydrate content at the end of ten days it was verified that independently of the chosen harvest moisture content, the corn grains were affected during the temporary storage, since the deteriorative processes occur under all tested conditions.

In view of this, even the product being harvested with relatively lower water content, such as 19% its ability to undergo deteriorating processes is still present when temporarily stored in an unsuitable environment, since the variations of temperature and relative humidity dictate the deteriorating intensity, the water content allows the respiratory process to occur, and the period has the ability to accentuate such deleterious activity (Coradi et al., 2016).

CONCLUSIONS

The increase in the harvest moisture content negatively influenced the quality of the corn grains produced in the second harvest, being this effect potentiated with the temporary storage time.

In the range of harvested moisture content, 19% is the one that least affects the quality of produced corn in the second harvest during the ten days of temporary storage period.

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REFERENCES

Araujo WD, Goneli ALD, Orlando RC, Martins EAS, Hartmann Filho CP (2015) Propriedades físicas dos frutos de amendoim durante a secagem. Revista Caatinga 28(4):170-180.

AOAC - Association Of Official Analytical Chemists (1984) Official methods of analysis of the Association of Official Analytical Chemists. AOAC, 1141p.

Bessa JFV, Donadon JR, Resende O, Alves RMV, Sales JF, Costa LM (2015) Armazenamento do crambe em diferentes embalagens e ambientes: parte I - qualidade fisiológica. Revista Brasileira de Engenharia Agrícola e Ambiental 19(3):224-230.

Bezerra PHS, Biaggioni MAM, Silva MAP, Sperotto FCS, Brandão FJB (2015) Efeito do armazenamento na qualidade dos grãos e do óleo de crambe para a produção de biodiesel. Revista Energia na Agricultura 30(3):310-318.

Brito JG, Queiroz AJM, Figueirêdo RMF, Oliveira AS (2015) Armazenamento de grãos residuais de urucum sob atmosfera controlada. Revista Brasileira de Engenharia Agrícola e Ambiental 19 (12):1185-1191.

MAPA - Ministério da Agricultura, Pecuária e Abastecimento (2009) Regras para análise de sementes. Secretaria de Defesa Agrícola. Brasília, DF: MAPA/ACS. 399p.

Camolese HS, Baio FHR, Alves CZ (2015) Perdas quantitativas e qualitativas de colhedoras com trilha radial e axial em função da umidade do grão. Brazilian Journal of Biosystems Engineering 9(1):21-29.

CONAB - Companhia Nacional de Abastecimento (2017). Acompanhamento da Safra Brasileira-Grãos 2016/2017 (sétimo levantamento) 4(7). Available: http://www.conab.gov.br/OlalaCMS/uploads/arquivos/17_04_17_17_20_55_boletim_graos_abr_2017.pdf . Accessed: May 1, 2017.

Coradi PC, Camilo LJ, Cunha FF, Pereira TLL, Alves CZ (2016) Alternatives os storage of corn grains for the conditions of the brazilian cerrado. Bioscience Journal 32(1):29-40.

Coradi PC, Chaves JBP, Lacerda Filho AF, Mota ATO (2014) Quality of stored grain of corn in diferente conditions. Científica 42(2):118-133.

Coradi PC, Milane LV, Camilo LJ, Prado RLF, Fernandes TC (2015) Qualidade de grãos de soja armazenados em baixas temperaturas. Brazilian Journal of Biosystems Engineering 9(3):197-208.

Del Campo BG, Brumm TJ, Bern CJ, Nyendu GC (2014) Corn cob dry matter loss in storage as affected by temperature and moisture contente. Transactions of the American Society of Agricultural and Biological Engineers 52(2):573-578.

Detmann E, Souza MA, Valadares Filho SC, Queiroz AC, Berchielli TT, Saliba EOS, Cabral LS, Pina DS, Ladeira MM, Azevedo JAG (2012) Métodos para análise de alimentos. Instituto Nacional de Ciência e Tecnologia - Ciência Animal. Visconde do Rio Branco, Suprema. 214p.

Elias MC, Ziegler V, Romano CM, Alves GH, Paraginski RT, Oliveira M (2016) Physicochemical properties and enzymatic bean grains dried at different temperatures and stored for 225 days. Semina: Ciências Agrárias 37(3):1295-1306.

Jyoti U, Malik CP (2013) Seed deterioration: A review. International Journal of Life Sciences Biotechnology & Pharma Research 2(3):373-386.

Kolling EM, Trogello E, Modolo AJ (2012) Perda econômicas vinculadas às etapas de beneficiamento de milho e trigo, em unidade cooperativa do norte do Paraná. Revista Agroambiente On-line 6(3):268-274.

Kussano MR, Batalha MO (2012) Custos logísticos agroindustriais: avaliação do escoamento da soja em grão do Mato Grosso para o mercado externo. Gestão & Produção 19(3):619-632.

Mahjabin SB, Abidi AB (2015) Physiological and biochemical changes during seed deterioration: a review. International Journal of Recent Scientific Research 6(4):3416-3422.

Marcos Filho J (2015) Fisiologia de sementes de plantas cultivadas. Londrina, ABRATES, 2ed. 660p.

Marques OJ, Dalpasquale VA, Vidigal Filho PS, Scapim CA, Reche DL (2011) Danos mecânicos em grãos de híbridos comerciais de milho em função da umidade de colheita. Semina: Ciências Agrárias 32(2):565-576.

Marques OJ, Vidigal Filho PS, Scapim CA, Reche DL, Pricinotto LF, Okumura RS (2012) Qualidade comercial de diferentes híbridos de milho em função do teor de água nos grãos durante a colheita. Semina: Ciências Agrárias 33(3):911-920.

Môro GV, Fritsche Neto R (2015) Importância e usos do milho no Brasil. In: Borém, A.; Galvão, J.C.C.; Pimentel, M.A. (eds). Milho do plantio a colheita. Viçosa, Editora UFV. p9-25.

Muir WE, Jayas DS, White NDG (2000) Controlled atmosphere storage. In: MUIR, W.E. (Ed.) Grain preservation biosystems. University of Monitoba, 20p.

Nascimento Q, Marques JC, Miranda LM, Zambra EM (2016) Perdas quantitativas no transporte curto de grãos de milho (*Zea mays* L.) em função de aspectos gerais de pós-colheita no norte do estado de Mato Grosso. Navus: Revista de Gestão e Tecnologia 6(1):60-71.

Oliveira Neto MS, Reis AC, Stender GHC, Costa WO, Souza CG (2015) Avaliação dos critérios de seleção de transportador e modais para o escoamento da safra de soja brasileira. Revista Produção e Desenvolvimento 1(1):14-30.

Oliveira DEC, Santos MNS, Rufatto S (2014) Forma e tamanho dos grãos de milho da cultivar p3646 submetidos a diferentes condições de ar de secagem. Nativa 2(3):162-165.

Ortiz D, Rocheford T, Ferruzzi MG (2016) Influence of temperature and humidity on the stability of carotenoids in biofortified maize (zea mays l.) genotypes during controlled postharvest storage. Journal of Agricultural and Food Chemistry 64(13):2727-2736.

Polat HE (2015) Effects of different storage conditions on the nutritional qualities of barley and maize. Journal of Agricultural Sciences 21(2):246-255.

Resende O, Almeida DP, Costa LM, Mendes UC, Sales JF (2012) Adzuki beans (*Vigna angularis*) seed quality under several drying conditions. Ciência e Tecnologia de Alimentos 32(1):151-155.

Schuh G, Gottardi R, Ferrari Filho E, Antunes LEG, Dionello RG (2011) Efeitos de dois métodos de secagem sobre a qualidade físico-química de grãos de milho safrinha-RS, armazenados por 6 meses. Semina: Ciências Agrárias 32(1):235-244.

Suleiman RA, Rosentrater KA, Bern CJ (2013) Effects of deterioration parameters on storage of maize. ASABE Paper No 131593351.

Surki AA, Sharifzadeh F, Afshari RT (2012) Effect of drying conditions and harvest time on soybean seed viability and deterioration under different storage temperature. African Journal of Agricultural Research 7(36):5118-5127.

Tiecker Junior A, Guimarães LE, Ferrari Filho E, Castro B, Del Ponte EM, Dionello RG (2014) Qualidade físico-química de grãos de milho armazenados com diferentes umidades em ambientes hermético e não hermético. Revista Brasileira de Milho e Sorgo 13(2):174-186.

Vieira RD, Krzyzanowski FC (1999) Teste de condutividade elétrica. In: Krzyzanowski FC, Vieira RD, França Neto JB (eds). Vigor de sementes: conceitos e testes. ABRATES, p4-1 a 4-26.