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Flax seeds produced in the brazilian midwest: chemical and physical quality

Laís Chancare Garcia
laisgarcianutri@gmail.com
http://orcid.org/0000-0001-9064-0279
Universidade Federal da Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brasil.

Joyce Castro Xavier
joyxcastro@gmail.com
http://orcid.org/0000-0002-0993-6740
Universidade Federal da Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brasil.

Fernanda Rosan Fortunato Seixas
fernanda@ufgd.edu.br
http://orcid.org/0000-0002-1995-2250
Universidade Federal da Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brasil.

Vanderleia Schoeninger
vschoeninger@ufgd.edu.br
http://orcid.org/0000-0001-7308-4709
Universidade Federal da Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brasil.

Claudia Andrea Lima Cardoso
claudiacardosouems1@gmail.com
http://orcid.org/0000-0002-4907-0056
Universidade Estadual do Mato Grosso do Sul (UEMS), Mato Grosso do Sul.

Carla Eloize Carducci
elocarducci@gmail.com
http://orcid.org/0000-0001-5736-3775
Universidade Federal da Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brasil.

ABSTRACT

Chemical and physical flaxseed properties can be altered by Brazilian edaphoclimatic and soil management conditions. The study aimed to evaluate the physical and chemical quality of reddish-brown and golden-yellow flaxseeds produced in a conservation management system (i.e., with low agricultural inputs) in Dourados, MS, Midwest region, Brazil. The experiment design was carried out in random blocks, with three repetitions. Significance in difference between two groups were tested by Student t test at 5%. The reddish-brown and golden-yellow flaxseed from Midwest, cultivated under a conservation management system, exhibited similar physical and chemical patterns. However, the reddish-brown flaxseed had a higher hundred seed mass, width, length, color parameters (luminosity, chromaticity, and color angle), neutral detergent fiber contents, phenolic compounds, and stearic and oleic acids than the golden-yellow flaxseed. The flaxseeds produced in the conservationist management system showed the same grain physical and chemical quality as the international and national grains produced in the conventional management system, described in the literature. Our results corroborate the future incentives for increasingly sustainable production while searching for greater eco-efficiency and food security. Thus, the flaxseed cultivated in a conservationist management system has potential to be an economical alternative for all farmers.

KEY-WORDS: *Linum usitatissimum* L..; soil conservationist management; physical chemical attributes.

INTRODUCTION

Flaxseed (*Linum usitatissimum* L.), is cultivated in many countries worldwide, including Canada, the United States, and Argentina (Americas); China, India, and Kazakhstan (Asia); and Belgium, Russia, and Ukraine (Europe) (FAOSTAT, 2020). In Brazil, flaxseed is grown mainly in regions with a subtropical climate, such as the south states (IBGE, 2020), and employing conventional management systems or through no-tillage systems (STANCK *et al.*, 2017). The flaxseeds are multi-utility, as they can be consumed either fresh or processed into flour for use in baking or mixed with other foods in their raw form. Although flaxseeds were present in the human diet for millennia, most of the flaxseeds cultivated are still destined for oil, dyeing, animal feed, textiles, biodiesel, and biomaterials industries (COSMO *et al.*, 2014; GU *et al.*, 2018; VIEIRA *et al.*, 2015).

Flaxseeds have high potential as a functional food because they possess chemical compounds beneficial to health, such as preventing or reducing the risk of chronic non-communicable diseases and low-density lipoprotein cholesterol (TAVARINI *et al.*, 2021). Several compounds present in flaxseed, especially the lignans, alpha-linolenic acid (ALA), and fibers, affect physiological functions. In addition, the bioactive compounds possess strong antioxidant properties, which reduce lipid oxidation, while the lignans are biologically active phytochemicals that exhibit potential anticarcinogenic and anti-inflammatory properties (EBRAHIMI *et al.*, 2021).

Two flaxseed varieties, reddish-brown and golden-yellow, and their varieties, are used for human consumption (STANCK *et al.*, 2017). According to the Dietary Reference Intake (2006), a daily intake of approximately 4 g of golden-yellow or reddish-brown flaxseed oil for men, and 3 g for women, would be sufficient to fulfill the nutritional requirements of ALA. Evidence shows that reddish-brown and gold flaxseeds have similar chemical compositions, suggesting the possibility that both have similar bioactivity (THOMPSON & CUNNANE, 2003; BARROSO *et al.*, 2014). It is worth mentioning that the higher concentration of the constituent chemical compounds and the physical properties of the seeds, such as color, moisture, and size, are directly related to the edaphoclimatic and soil management conditions in which they are grown (CARDUCCI *et al.*, 2018; BARROSO *et al.*, 2014; SINGH *et al.*, 2012; TROSHCHYNSKA *et al.*, 2019).

Comparative studies between varieties are scarce in the Brazilian literature, especially regarding the seed physicochemical attributes. Thus, evaluating flaxseed varieties can contribute to a greater appreciation of this food, especially reddish-brown flaxseed, which is the most produced flaxseed in Brazil (IBGE, 2020). Most international and national scientific studies on flaxseeds either do not know the seed origin, or evaluated seeds produced in conventional agricultural management systems. However, it is not known whether soil conservation management systems (i.e., low agricultural input) can increase the physical and chemical quality of flaxseeds (STANCK *et al.*, 2017; CARDUCCI *et al.*, 2018; SINGH *et al.*, 2012).

In this context, our study aimed to evaluate the physical and chemical attributes of reddish-brown and golden-yellow flaxseeds produced in a conservationist soil management system, in the Dourados, Mato Grosso do Sul (MS), Midwest Region, Brazil. For this, the following hypothesis was tested: The flaxseed produced in the Midwest, in a conservationist soil management system, would have a good pattern of physicochemical profiles, such as, acidity, water activity, moisture, ash, fiber, total phenolic compound and fatty acid profile?

MATERIALS AND METHODS

DESCRIPTION OF THE STUDY AREA

The evaluations were performed on flaxseeds produced at the experimental farm of the Federal University of Grande Dourados (UFGD), Dourados City, MS (Figure 1-A), in the Midwest Region of Brazil (22°13′16″S, 54°48′20″W; 430 m altitude). The climate of this region is *Cwa* according to the Köppen classification. The soil was classified as Rodic Haplustox – Soil Taxonomy, with a very clayey texture (656 g kg^{-1} clay, 205 g kg^{-1} silt, and 138 g kg^{-1} sand).

Flax has been cultivated in the Dourados, MS since 2017 in a conservationist soil management system; that is, soil protection practices are employed, such as the substitution of chemical inputs for organic ones, no-tillage, and the maintenance of residues from the previous crop, which in turn make the production system environmentally sustainable (XAVIER *et al.*, 2018; CARDUCCI *et al.*, 2018).

We used two flaxseed landrace varieties, that is, the reddish-brown color flaxseeds, were acquired from the Federal University of Santa Catarina (UFSC) – campi Curitibanos, Santa Catarina (SC) (Figure 1-B), Brazil, where they have been cultivated in a soil conservation management system since 2014 (STANCK *et al.*, 2017).

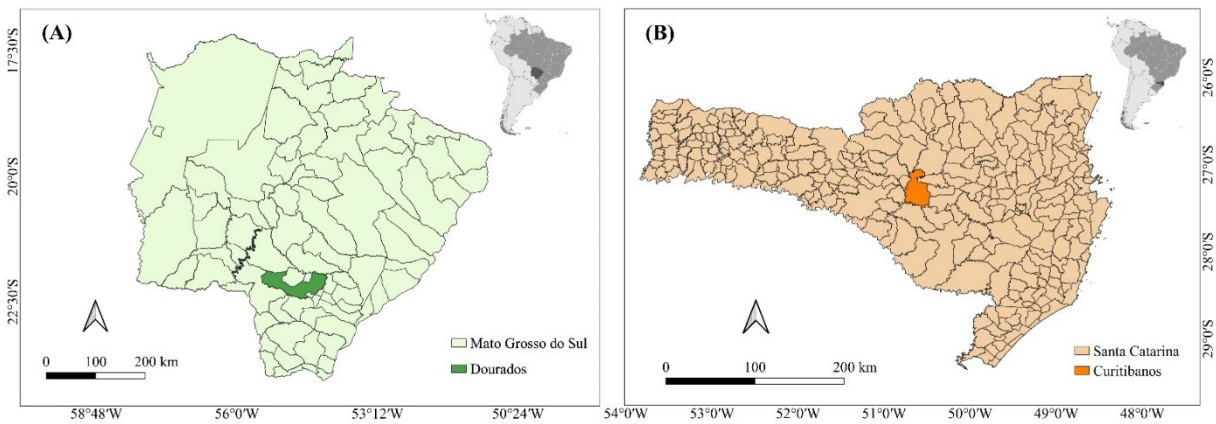

Figure 1. Location of linseed cultivation (A) and of linseed origin (B).

The golden-yellow color flaxseeds were obtained from the Agricultural Research and Rural Extension Company of Santa Catarina (Epagri), Campos Novos, SC, and cultivated in an agroecological system since 2010 (PARIZOTO *et al.*, 2013) (Figure 2). Following harvest, the seeds were cleaned by removing dirt, dust, residues, and damaged seeds, and then sorted using sieves by 50 mesh.

CHEMICAL AND PHYSICAL ANALYSES OF FLAXSEEDS

The acidity index in oleic acid (AOA) were estimated according to the titrimetric method 325/IV (IAL, 2008). The content expressed as *(g)* acidity in oleic acid *(*AOA*)*/100g of flaxseed flour was calculated.

The seeds were milled in an industrial processor and hermetically stored in a refrigerator at 10°C, following which they were used to analyze the water activity, cold-extracted lipids, proteins (5.75 conversion factor), and contents of ash and the neutral detergent fiber (NDF), according to the American Oil Chemists' Society—American Open Currency Standard (AOAC, 1993). The total caloric value was calculated as the sum of calories (kcal) provided by carbohydrates, lipids, and protein, by multiplying their values in grams with the respective conversion of 4, 9, and 4 kcal g^{-1} using Atwater general factor (FAO, 2003). The total carbohydrate content was calculated by subtracting the protein, lipid, ash, and moisture contents from 100%.

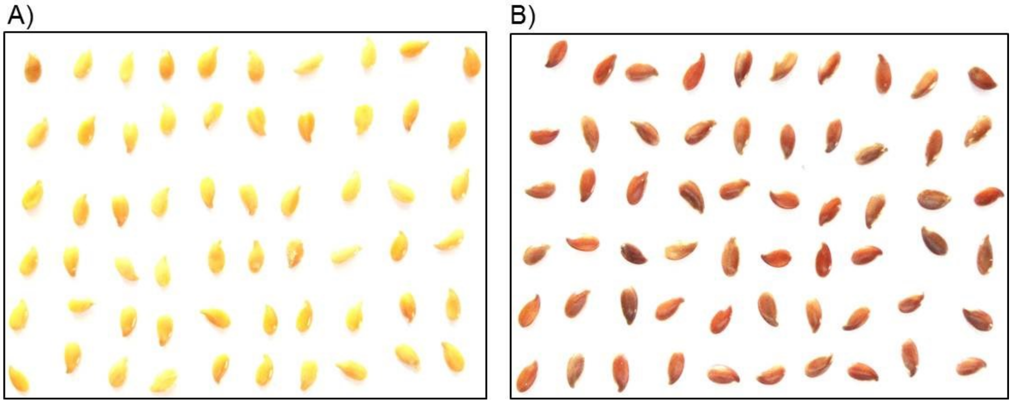

Figure 2. Golden-yellow flaxseed from Epagri-SC and reddish-brown flaxseed from UFSC – campus Curitibanos, SC.

To determine the content of phenolic compounds, a hydrophilic extract obtained after the flour extraction with methanol (3:1 mass:volume) was used, following homogenization and filtration in non-woven fabric, according to BARROSO *et al.* (2014). The total phenolic compounds content was determined using the Folin-Ciocalteu colorimetric method. For this, 1.0 ml of the extract was transferred to a test tube. Then, 0.5 ml of the Folin-Ciocalteu reagent and 1.0 ml of 20% sodium carbonate solution were added, and the volume was brought up to 10 ml by adding distilled water. This solution was then maintained in temperature about 25°C for one hour, and the absorbance was measured at 760 nm using a 7305 UV/Visible Spectrophotometer (Jenway®, Jena, Germany). Gallic acid was used for the calibration curve (Y = 0.0909X + 0.0195, R^2 = 0.9966), and all values were expressed as mg gallic acid equivalents (GAE)/100 g dry base. All analyses were performed in triplicate.

For the fatty acid profile, the reddish-brown and golden-yellowgolden-yellow-yellow flaxseeds were milled separately in a home food processor, and the flour was stored at −20 °C until analyzed. The oils were extracted from the seeds using a cold mechanical press. The content of fatty acids, in the form of methyl esters, was determined as g 100 g^{-1} of the lipid extract. Fatty acid methyl esters were analyzed by gas chromatography using a Focus GC (Thermo Fischer Scientific, Waltham, MA, USA) chromatograph with a fused-silica capillary column (Restek RT 2560; 100.0 mm length, 0.25 mm internal diameter, and 0.20 µm) and a flame ionization detector. Flow rates were as follows: nitrogen carrier, 30 ml min^{-1}; hydrogen, 30 ml min^{-1}; and synthetic air, 300 ml min^{-1}. The temperature was set at 130ºC at the start and was maintained as such for one minute, and then raised to 170ºC at a rate of 5ºC/min, and then to 215ºC at 2ºC/min, where it was maintained for 15 min, and then finally to 230ºC at 30ºC/min (Gondim-Tomaz et a., 2016). The injector and detector temperatures were 280ºC. The injection volume was 1 µl with a 1:10 split. Fatty acids were identified by comparing the retention time of the methyl ester patterns (Sigma-Aldrich, St. Louis, Missouri, USA) with the samples, and were quantified by the external standard method using the peak area, following MATTHÄUS & ÖZCAN (2011). These analyses were conducted in the Laboratory of Instrumental Analysis of the State University of Mato Grosso do Sul (UEMS), Dourados, MS.

The moisture of seeds was determined following the Rules for Seed Analysis (BRASIL, 2009) and presented as a decimal dry basis.

The hundred seed mass was measured in five subsamples of each replicate. Seeds were counted manually and then weighed using a precision balance (0.01 g).

The dimensions of the flaxseeds were measured using a digital pachymeter with 0.01 mm accuracy. The measurements in the three mutually perpendicular axes, that is, length, width, and thickness. Ten seeds from each experimental unit were used. Subsequently, the geometric diameter (G_d) of the flaxseed seed was calculated according to COSKUNER & KARABABA (2007).

The specific mass per unit (ρ_u), or real specific mass, was evaluated using the volume supplementation method with a solvent (IAL, 2008). Toluene (C_7H_8) was added to a calibrated volumetric flask (50 ml) containing 20 g of seeds at 25°C, and the solvent mass used to fill the flask was determined (calculated from the density, i.e., 0.87 g ml^{-1}, and the exact volume of solvent used). The volume of flaxseeds was determined, and the relationship between mass and volume was expressed in kg m^{-3}.

The apparent specific mass (ρ_{ap}) was determined using a 25 ml graduated cylinder to which a seed sample was added. The mass was then measured for the subsequent calculation of the mass:volume ratio, expressed in kg.m^{-3} (COSKUNER & KARABABA, 2007).

The porosity (ε) of the seeds, expressed as a percentage, was calculated as the difference between ρ_u and ρ_{ap} (COSKUNER & KARABABA, 2007; BOTELHO *et al.*, 2018).

The color of whole flaxseeds was determined from seeds placed in a Petri dish using a CR-400 Chroma Meter (Konica Minolta Sensing, Inc. Osaka, Japan) colorimeter using D65 illuminant. The measurements were expressed using the color coordinates L*, C*, and H* according to the color model of the International Commission on Illumination (CIE) (BECHLIN *et al.*, 2019; TROSHCHYNSKA *et al.*, 2019).

EXPERIMENTAL DESIGN AND STATISTICAL ANALYSES

The experimental design was in randomized blocks with two treatments: reddish-brown and golden-yellow-yellow flaxseed and with three repetitions. This experimental design was used in the field (for sowing and cultivation of flaxseeds) and maintained for laboratory analysis. We obtained a data set equivalent to 10 physical and 10 chemistry variables, totaling 120 observations. The results were expressed as mean ± standard deviation. Means were compared using a Student t test ($p \leq 0.05$). Statistical analyses were performed using Statistica 7.0 (Statsoft, 2007).

RESULTS AND DISCUSSION

The Table 1 present the Grains chemical attributes and fatty acid composition of grain oils of both flaxseeds: reddish-brown and golden-yellow cultivated in a conservation management system in Midwest Region, Brazil.

The AOA did not differ significantly between the two varieties (Table 1), which showed similar values. There was a significant difference ($p \leq 0.05$) in the fiber content (NDF), phenolic compounds, and fatty acids between the varieties, with higher values observed for the reddish-brown flaxseed. However, there were no significant differences between the flaxseeds for the other parameters.

Table 1. Grains chemical attributes and fatty acid composition of grain oils of both flaxseeds: reddish-brown and golden-yellow cultivated in a conservation management system in Midwest Region, Brazil.

Attributes		Brown	Golden
Acidity level	g $100g^{-1}$	1.53^{a}± 0.34	1.53^{a}± 0.62
Acidity in oleic acid	*(*AOA*)*/100g	1.66 ± 0.849	1.66 ± 1.545
Water activity	admissional	0.66^{a}±0.002	0.67^{a}±0.001
Ashes	g $100g^{-1}$	2.7^{a}±0.5	3.4^{a}±0.2
Protein	g $100g^{-1}$	18.71^{a}±0.32	19.79^{a}±0.16
Carbohydrates	g $100g^{-1}$	8.19	7.26
Fiber*	FDNg $100g^{-1}$	25.6^{a}±0.7	22.6^{b}±0.9
Lipid	g $100g^{-1}$	36.9^{a}±1.66	38.65^{a}±0.45
Myristoleic Acid C14:1	g $100g^{-1}$	0.02^{a}±0.01	0.02^{a}±0.01
Palmitoleic Acid C16:1	g $100g^{-1}$	0.02^{a}±0.01	0.02^{a}±0.01
Stearic acid C18:0	g $100g^{-1}$	2.83^{a}±0.04	1.02^{b}± 0.05
Oleic acid C18:1 (ω9)	g $100g^{-1}$	20.19^{b}± 0.17	22.56^{a}± 0.21
Linoleic acid C18:2 (ω-6)	g $100g^{-1}$	14.25^{a}± 0.07	14.22^{a}± 0.06
α-Linolenic acid C18:3 (ω-3)	g $100g^{-1}$	58.64^{a}± 0.3	58.55^{a}± 0.25
Euritic Acid C22:1	g $100g^{-1}$	0.02^{a}±0.01	0.02^{a}±0.01
Total energy value	Kcal $100g^{-1}$	438.9	456.05
Phenolic compounds*	mgEAG $100g^{-1}$	679.3^{a}±0.01	589.8^{b}± 0.05

NOTE: * $p≤0.05$. Averages followed by the same lowercase letter on the line do not differ by Student t test ($p≤0.05$). AI: flour acidity index; AOA = acidity index in oleic acid.

The acidity indices were low for both flour and oil, meeting the quality criteria of percent of acid oleic values < 3% for crude flaxseed oil recommended by AOCS (AOAC 1993; DENG *et al.*, 2017). Similarly, low values were reported by Barroso *et al.* (2014) for crude oil. However, in the present study, the raw material used was processed flour, such as that used domestically or industrially to produce processed foods. In our study, processed flour had a lower concentration of organic acids compared to crude oil, which was also observed by CARDUCCI *et al.* (2018) when analyzing the flour of three reddish-brown flaxseed varieties (UFSC-Brazil, Caburé and Aguará-Argentina) produced under a conservation management system.

Factors such as environmental conditions, locality, and the management of the soil system can influence the lipid content of flaxseeds (OOMAH *et al.*, 1996; VAISEY-GENSER & MORRIS, 2003). The lipid content attributes observed in the flaxseeds grown in the county of Dourados under a conservationist soil management system (with the exclusion of chemical inputs and the use of organic inputs) were higher than those found in other studies, including those reported by NOVELLO & POLONIO (2012) and BARROSO *et al.* (2014), who analyzed grains from the Brazilian retail trade (unknown origin). The protein content of the evaluated seeds (Table 1) was similar to that reported by OOMAH (2001) and VAISEY-GENSER & MORRIS (2003), who evaluated seeds of Canadian origin and found 20% of protein.

The differences in the fatty acid composition and grain physical quality of the two varieties from our study may be attributed to the cultivation practice, soil type, developmental stage of seeds, seed physical attributes (diameter, color, moisture, mass), and factors related to their origin, which has been shown in other studies on flaxseed (BARROSO *et al.*, 2014; SINGH *et al.*, 2012; DENG *et al.*, 2017).

Flaxseeds are natural foods with a low content of saturated fatty acids (EBRAHIMI *et al.*, 2021). A study conducted in India found that the ALA content of 11 flaxseed varieties ranged from 37.5% to 54.59% (SINGH *et al.*, 2013). Furthermore, less than 5% of the ALA content was found in the Solin variety from Canada (BARTHET *et al.*, 2014). Although a higher stearic acid content was found in the reddish-brown flaxseed than the golden-yellow flaxseed, 2.83 and 1.02 $g.100g^{-1}$ respectively (Table 1) and similar to a previous study from Barroso *et al.*, (2014). This fatty acid is considered non-atherogenic because it is rapidly converted endogenously into oleic acid, which seems to have neutral effects on cholesterol (that is, it is non-hypercholesterolemic, which contrasts with other saturated fatty acids) (SANTOS *et al.*, 2013). The flaxseeds analyzed here can be considered a source of ALA due to the high content of this fatty acid (Table1). Omega 3 is obtained from ALA, which undergoes an endogenous enzymatic reaction to form eicosapentaenoic and docosahexaenoic acids (CIABOTTI *et al.*, 2019).

Regarding the phenolic compounds, there was a significant difference between the two flaxseeds ($p \leq 0.05$), with higher values for the reddish-brown flaxseed of 679.3 mgGAE g^{-1} compared to 589.8 mgGAE g^{-1} for the golden-yellow flaxseed. The stearic acid content (C18:0) was higher in the reddish-brown flaxseed, whereas the oleic acid content (C18:1) was significantly higher in the golden-yellow flaxseed ($p \leq 0.05$).

The main bioactive compounds reported in flaxseeds are hydroxylated derivatives of benzoic and cinnamic acids, coumarins, and flavonoids (OOMAH *et al.*, 1996). The phenolic acids present in flaxseed support its antioxidant properties and are beneficial to health, even in small quantities (BARROSO *et al.*, 2014; SINGH *et al.*, 2012).

Although flaxseeds are known to exert antioxidative effects, some studies have detected differences in the quality of flaxseed varieties worldwide, suggesting geographical and varietal specificity (DENG *et al.*, 2017). The phenolic compounds contents reported in the present study (Table 1) were similar to those observed by OOMAH *et al.* (1995), who obtained values ranging from 790–1030 mg/100 g for Canadian flaxseeds and these values were higher than soybean, for example (CIABOTTI *et al.*, 2019).

The grains physical attributes of two flaxseeds: reddish-brown and golden-yellow cultivated in a conservation management system in Midwest Region of Brazil were presents in Table 2. The flaxseed moisture ranged from 8.9 to 11.5 % (dry basis). There was a significant difference between the hundred seed mass. For the seed color attributes these significant differences was already expected. The highest values of the hundred seed mass (> 0.50 g; Table 2) were observed for the reddish-brown flaxseed, while the chromaticity ($C^*>4$), color angle ($H^*>60°$), and luminosity ($L^*>9$) were higher for the golden-yellow flaxseed.

The moisture can directly influence the size of seeds and determine their deterioration time; that is, the lower the moisture of seeds, the better the physical conditions for their storage and subsequent viability (RÊGO *et al.*, 2015). In this study, reddish-brown flaxseeds exhibited a mean moisture of 0.115 g^{-1} (10.27%), which was within the commercial standard limit (up to 13%) (BRASIL, 1999). This finding was consistent with the results of BECHLIN *et al.* (2019) (Table 2). The higher moisture may have influenced the higher values of hundred seed mass as well as the length and width of reddish-brown flaxseeds, as observed by SINGH *et al.* (2012) when assessing the dimensions of flaxseed cv. *Neelam* with different moisture. These authors attributed such an increase in seed size to the expansion of intracellular spaces due to water absorption. However, in our study, the greater size of reddish-brown flaxseeds resulted in a reduced ε of the samples, and consequently, lower aeration between the seeds (Figure 3). Furthermore, it increased the ρ_{ap} values more than 680 kg m^{-3}, which was also reported in previous studies (SINGH *et al.*, 2012; COSKUNER & KARABABA, 2007; RÊGO *et al.*, 2015; PRADHAN *et al.*, 2010).

Table 2. Grains physical attributes of both flaxseeds: reddish-brown and golden-yellow cultivated in a conservation management system in Midwest Region, Brazil: water content (decimal, dry base: b.s.), mass of 100 grains (g), porosity ε (%), chromaticity (C*), angle color H * (°) and brightness (L).

Genotypes	Water content (b.s.) $g\ g^{-1}$	Mass 100 grain* g	ε %	C**	H*** Degree	L*
Golden	0.089±0.007	$0,47^{b}$±0,037	22.45±8.96	24.05^{a}±2,425	69.20^{a}±1.820	54.96^{a}±1.952
Brown	0.115±0.012	$0,55^{a}$±0,048	21.68±13.54	$13,08^{b}$±0,882	47.80^{b}±0.799	44.06^{b}±0.518

NOTE: **p*≤0,05, ***p*≤0.01, *** *p*≤0.001, Ns: not significant. Same lowercase letters in the column do not differ by Student t test (*p*≤0.05).

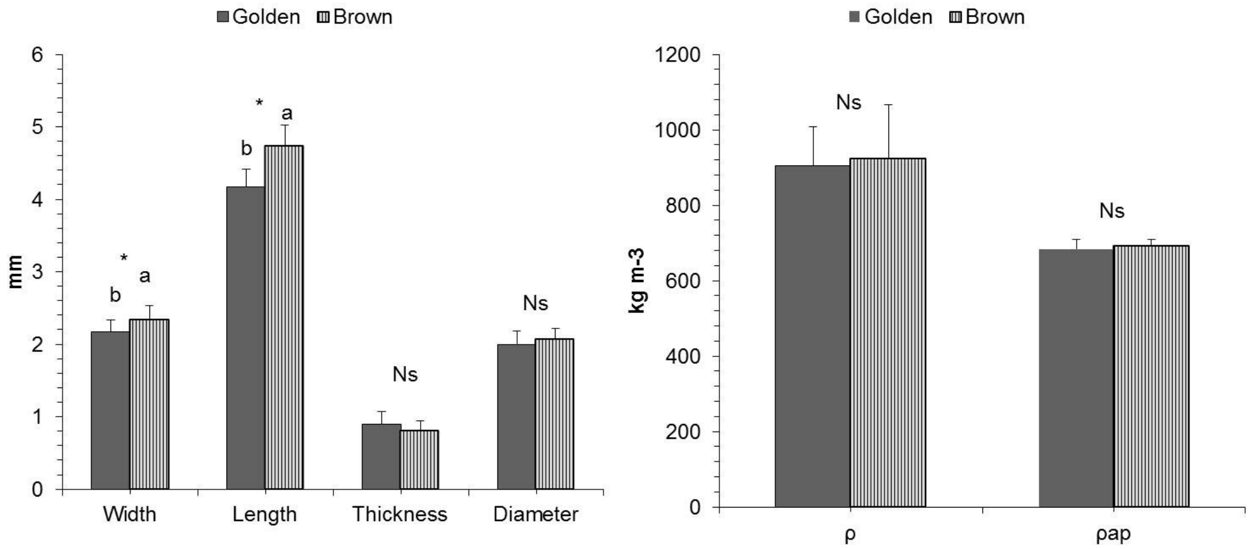

Figure 3. Width, length, thickness, geometric diameter, unitary density (ρu), and apparent specific mass (ρap) of the grains from two flaxseed varieties (reddish-brown and golden-yellow) cultivated in a conservationist management system in Midwest Brazil.

NOTE: *(*p*≤0.05), Ns: not significant. Equal lowercase letters do not significantly differ by a Student test (*p*≤0.05). Bars indicate standard deviations from the mean.

There were no significant differences in the physical variables of the specific mass per unit (ρ_u) and the apparent specific mass (ρ_{ap}) between the two varieties. However, the width and length (2.20 and 4.50 mm for reddish-brown and golden-yellow flaxseed, respectively) were different between the two varieties, with higher values observed for reddish-brown flaxseed (Figure 3), while the porosity (ε) remained above 20% for both grains color (Table 2).

The values of length, width, and thickness of the reddish-brown flaxseeds observed in this study were similar to those reported by PRADHAN *et al.* (2010)

in Canada. However, the results for these parameters were lower than those documented by SINGH *et al.* (2012) in India for the cv. *Neelam* despite the climatic conditions in Mato Grosso do Sul State be more similar to this. It must be noted that in addition to the variety, the cultivation system, soil and climate conditions can effectively influence the physical properties of seeds (CARDUCCI *et al.*, 2018; SINGH *et al.*, 2012; SINGH *et al.*, 2013).

In the present study, ρ_u and ρ_{ap} (Figure 3) varied inversely with the moisture content. Corrêa *et al.* (2006) stated that the higher the moisture of seeds, the lower their density. Thus, the reduction in ρ_{ap} was due to the increase in water volume, and not the mass (SINGH *et al.*, 2013). Assessing the physical properties of flaxseeds is important for developing and operating systems and equipment for seed storage, processing, and transportation (SHARMA, SHARMA, & PRASAD, 2015).

The color parameter L* indicates the luminosity of the evaluated material (Table 2), and ranges from 0 (absolute black) to 100 (white). In this study, the L* values were observed to be low, indicating that the analyzed seeds had darker colors. Chromaticity (C*) is a color variable expressed as the hypotenuse of the point formed in the color space by the coordinates a* (green–red) and b* (blue–yellow). The C* values observed in the present study were low, which can be attributed to the low composition of green-red and blue-yellow in the reddish-brown-colored flaxseed. Conversely, the golden-yellow flaxseeds exhibited higher values for the yellow coordinate (+b) in the color composition, resulting in higher C* values. The colorimetric differences between the seeds are also related to their nutritional quality, since lighter or darker skin results from different concentrations of plant secondary metabolites, such as carotenoids and bioactive compounds (TROSHCHYNSKA *et al.*, 2019; BECHLIN *et al.*, 2019). In this study, the highest concentration of phenolic compounds was observed in the reddish-brown flaxseed, which had lower values for the color parameters evaluated (Tables 1 and 2).

CONCLUSION

The reddish-brown and golden-yellow flaxseed from Midwest Brazil, cultivated under a conservation management system (i.e., with low agricultural inputs), exhibited similar physical and chemical patterns as founded to other author with grains grown in a conventional system. However, the reddish-brown flaxseed showed high hundred seed mass, width, length, color parameters (L*, C*, and H*), NDF contents, phenolic compounds contents, and stearic and oleic acid contents compared to the golden-yellow flaxseed. The flaxseeds produced in the conservationist management system showed the same grain physical and chemical quality as the international and Brazilian grains produced in the conventional management system, described in the literature, especially reddish-brown flax. As grain quality were not negative impacted by the conservationist management system, these results corroborate with incentives for increasingly sustainable flaxseed production with greater eco-efficiency and food security. Thus, this soil management system is an economical alternative that should be made available to all farmers.

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Linhaças produzidas no centro-oeste do Brasil: qualidade química e física

RESUMO

As propriedades químicas e físicas linhaça podem ser alteradas pelas condições edafoclimáticas e de manejo do solo. Nosso objetivo foi avaliar a qualidade físico-química dos grãos de linhaça marrom e dourada produzidas em um sistema de manejo conservacionista (ou seja, com baixos insumos agrícolas) em Dourados, MS região Centro-Oeste do país. O delineamento experimental foi em blocos ao acaso, com três repetições. Os dados foram submetidos ao teste T de Student a 5%. Os grãos de linhaça marrom e dourada cultivadas no Centro-Oeste, em sistema de manejo conservacionista, exibiram perfis físicos e químicos semelhantes. No entanto, a linhaça marrom apresentou maior massa de 100 grãos, largura, comprimento, parâmetros de cor (luminosidade, cromaticidade e ângulo de coloração), conteúdo de fibra em detergente neutro, compostos bioativos, ácido esteárico e oleico do que a linhaça dourada. As linhaças produzidas via sistema de manejo conservacionista apresentaram a mesma qualidade física e química de grãos internacionais e brasileiros produzidos em sistema de manejo convencional, descritos nas literaturas. Os resultados corroboram aos incentivos futuros para uma produção cada vez mais sustentável na busca por maior eco-eficiência e segurança alimentar. Assim, a produção de linhaça em manejo conservacionista tem potencial para ser uma alternativa econômica para todos os agricultores.

PALAVRAS-CHAVE: *Linum usitatissimum L.*.; manejo conservacionista do solo; atributos físicos-químicos.

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Correspondência:
Fernanda Rosan Fortunato Seixas
Universidade Federal da Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brasil.