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Technological Quality of Dual-purpose Wheat Stored

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Defoliation may interfere in the sink-source relationship and influence the technological quality of wheat flour. This study aimed to confirm the effects of plant cutting heights and number of cuttings on the technological wheat flour quality of BRS Umbu and BRS Tarumã cultivars after six months of storage. A completely randomized design was used and treatments consisted of a combination of cutting heights (20 and 30 cm) and number of cuttings (no cutting, 1, 2 and 3 cuttings), resulting in the following treatments: 20/1, 20/2, 20/3 30/1, 30/2, 30/3 and controls with no cuttings. Grain moisture, crude protein, hectoliter weight, gluten strength, falling number and wet gluten were determined. It was observed the behavior for both cultivars and number of cuts was similar, and it was found that the defoliation height of 30 cm resulted in greater decreases in PH and W values of 2.5 and 25.5% respectively. The results indicate that defoliation does not lead to the evolution of the stored wheat evaluated technological properties and with storage, properties such as W and WG of both cultivars showed a reduction.

Keywords: Defoliation; shelf-life; Triticum aestivum.

1. INTRODUCTION

Wheat is one of the most used food crops in the world [1] and therefore it is necessary to understand the mechanisms that determine and influence the quality of grains and components of the flour produced [2]. Because it is highly consumed and has a wide variety of derivatives such as breads, pastes and cookies, it is often important to consider grain storage for later use [3], always guaranteeing product quality.

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Considering the factors involved in production, it is known that stresses, management practices, environmental conditions and storage time can affect the wheat quality and result in changes in the characteristics of the flour [4,5,1]. Wheat conducted in the dual-purpose system provides forage for animal feed and grain production in the same crop [6]. However, changes such as defoliation carried out in the vegetative and reproductive stages of the crops can influence the source-sink balance, reflecting on the production and quality of the grains produced [7].

In research with dual-purpose wheat cultivars [8] demonstrated that defoliation did not negatively affect the technological quality of cereal flour conducted in this system. However, in the case of shelf-life, some studies address the use of wheat right after harvest or need for a rest time in storage for the evolution of technological properties [9]. In this scenario, there is a lack of information about the technological quality of wheat produced in a dual-purpose system, especially using different defoliation intensities and cultivars of different plant architectures and development cycles. Finally, it is necessary to know possible changes in quality of storage grains, since during this period biological and chemical interactions may occurs [10].

Thus, the aim at this work was to verify the effects of plant cutting heights and number of cuttings on the technological wheat flour quality of BRS Umbu and BRS Tarumã cultivars after six months of storage.

2. MATERIALS AND METHODS

To obtain the grains, the experiments were conducted in 2014 with the BRS Umbu (semi-late cycle and erect-cespitose growth habit) and BRS Tarumã (late cycle and prostrate-cespitose habit) cultivars, in Lages, Santa Catarina state, Brazil (27°49′ S, 50°20′ W and altitude of 937 m).

Plant height was the criterion used for defoliations, namely 20 and 30 cm, in accordance with [11,12,13,14]. Defoliation intensity was 50% in relation to initial plant height, based on the intensities used by [15] in black oat (*Avena strigosa* Schreb.), corresponding to a residual height of 10 and 15 cm. Similar to [13,16], up to three successive cuttings were made after plant regrow. After defoliation, according to each treatment, cuttings were suspended to allow plants to proceed with their reproduction cycle and grain production.

The mineral fertilizer N-P_2O_5-K_2O with 5-20-10 (%) formulation was applied to sowing date, at a dose of 400 kg ha^{-1}. Urea was used as nitrogen (N) sources for topdressing, at a dose of 50 kg N. ha^{-1} per application, applied in the till stage (phenological growing stage GS 21) and at the first visible node (GS 31) [17]. After each cutting, was made an N fertilization, as the replenishment. When its replenishment fertilizing coincided with stage GS 31, it was performed alone without N topdressing preprogramed.

Treatments involved a combination of cutting heights (20 and 30 cm) and number of cuttings (no cuttings, 1, 2 and 3), resulting in the following: 20/1, 20/2, 20/3, 30/1, 30/2, 30/3 and controls without cuttings. A completely randomized design was used. Each cultivar was considered an independent experiment and analyzed separately. Grains were harvested with a plot combine (Wintersteiger). The grains were homogenized to form samples of each treatment and for use in laboratory analyses.

Part of the samples remained stored for six months, based on the period used by [18,3], under controlled conditions of temperature (10 ± 3ºC) and relative humidity (40 ± 5%), thus ensuring that possible changes in technological quality was attributed to the treatments, without interference from the conditions of storage. Another part of the samples, immediately after harvest, was sent for the analysis in the cereal laboratory of Passo Fundo University, Rio Grande do Sul state, Brazil, according to the methodologies described below.

Grain moisture (%), crude protein (%) and hectoliter weight (%) (HW) content was determined using an Infratec 1241 near-infrared reflectance spectrophotometer (NIRS) for wavelengths between 700 and 1100 nm, the near-infrared region. Gluten strength (10E-4J) (W) was determined in a Chopin alveograph (Villeneuve-la-Garenne Cedex, France), using method 54-30 of the American Association of Cereal Chemists [19]. Falling Number (FN) was evaluated in wheat flour using a Perten Instruments 1500 falling number device, according to [19], method 56-81B, with results expressed in seconds. Wet Gluten (%) (WG) was determined using a Glutomatic gluten tester, according to [19], method 38-12.

The cultivars were not considered factors of statistical analysis because desired to obtain results from grains of different characteristics, such as growth habit. The data were submitted to analysis of variance (ANOVA) and the means compared using Tukey's test of 5% probability, applying the SAS® (Statistical Analysis System) software, version 9.0.

3. RESULTS AND DISCUSSION

Grain moisture is an important factor that affects the flour quality [1]. Table 1 shows the moisture values of the grains before and after six months of storage. The grains showed moisture content of approximately 13%, with a reduction in levels after the storage period, to values below the above mentioned, being in accordance with [20] recommendations. This reduction may be associated with the environment humidity conditions, where the grains may have lost water to it, in order to achieve hygroscopic balance. This result was observed for both cultivars and regardless of the treatment employed.

When analyzing wheat grains after a storage period [21,18] observed reductions in protein values. In other way [3] found no significant changes in the grains protein content due to the storage time. This last result corroborates with those found in the present study, where the grains protein levels were maintained during storage for both cultivars (Table 2). Since nitrogen fertilization is a factor that interferes with the quality of the grains produced [22], the protein levels stability even in the treatment that provided more plants stress (30/3), may be related to nitrogen replacement fertilization after defoliation.

Table 1. Grain moisture (%) of dual-purpose wheat of BRS Tarumã and BRS Umbu cultivars, submitted to plant cutting heights and number of cuttings, before and after six months of storage

	Plant cutting heights (cm)			
	20 initial	**20 after storage**	**30 initial**	**30 after storage**
Number of cuttings	BRS Tarumã			
0	13.00 a	12.40 b	13.80 a	12.35 b
1	13.05 a	12.20 b	13.05 a	12.25 b
2	13.90 a	12.30 b	13.10 a	12.30 b
3	13.70 a	12.40 b	13.75 a	12.30 b
CV (%)	**0.14**		**0.27**	
	BRS Umbu			
0	13.10 a	12.20 b	13.77 a	12.37 b
1	13.17 a	12.00 b	13.27 a	12.27 b
2	13.07 a	12. 17 b	13.00 a	12.30 b
3	12.97 a	12.37 b	13.70 a	12.30 b
CV (%)	**0.36**		**0.32**	

Same lowercase letters in the lines do not differ by Tukey's test

Table 2. Grain protein (%) of dual-purpose wheat of BRS Tarumã and BRS Umbu cultivars, submitted to plant cutting heights and number of cuttings, before and after six months of storage

	Plant cutting heights (cm)			
	20 initial	**20 after storage**	**30 initial**	**30 after storage**
Number of cuttings	BRS Tarumã			
0	17.55 a	17.50 a	17.50 a	17.20 a
1	17.75 a	17.77 a	17.75 a	17.60 a
2	18.25 a	18.30 a	18.20 a	18.10 a
3	18.80 a	18.80 a	19.10 a	19.10 a
CV (%)	**0.18**		**0.24**	
	BRS Umbu			
0	15.25 a	15.25 a	15.10 a	15.05 a
1	16.20 a	16.15 a	16.20 a	16.20 a
2	16.75 a	16.95 a	16.35 a	16.45 a
3	17.00 a	16.95 a	17.23 a	17.10 a
CV (%)	**0.34**		**0.69**	

Same lowercase letters in the lines do not differ by Tukey's test

Hectoliter weight (HW) is an important indicator of the wheat physical quality and the potential for flour production [23] and that is why it is desirable that the values remain as high as possible. Regardless of cultivar and treatment, it was observed that grains HW values decreased from storage (Table 3). Similarly, [24, 18] found a reduction in HW after wheat storage. According to [25] this reduction occurs due to the grains organic components consumption, with decrease of its density. Stands out although the HW reduction was statistically significant, this decreases on average for the two cultivars of 1.2 and 2.5%, respectively, for plants managed at 20 cm and 30 cm. These values are lower than those found by [18] working with Bezostaya and Lancer wheat cultivars, with HW reduction values of 7 and 10%, respectively, after six months of storage. The fact that the reduction in HW values found in this work is lower than the mentioned above, may be related to protein levels maintenance, as it is a grain filling component.

Gluten strength (W) means the greater or lesser flour capacity to go through a mechanical treatment when it is mixed with water [24]. With storage, [26, 24] observed an increase in W, fact that for the last authors occurred until the eighth month of storage with subsequent reduction. Unlike the results found by authors cited above, in this work a reduction in W of 12.8 and 25.5% in average, was observed for plants subjected to 20 and 30 cm treatment, respectively, after six months of storage for both cultivars (Table 4). Since protein is the most important indicator of wheat grain quality [27] and is directly related to W, it can be seen that although its values have been maintained during storage, W showed superior reductions in the treatment with greater defoliation and changes in the source-sink relationship (30/3), for both cultivars (Table 4).

Another characteristic related to grains protein content that decreased with the storage period for both cultivars and regardless of treatment used was wet gluten WG (Table 5). This result corroborates those found by [28,18,29] in wheat after storage period. A reduction of 18.7% in WG contents after six months of storage were reported by [18] for the wheat Bezostaya cultivar. This value was higher than found in present study, which was 9.3% on average for cultivars and treatments.

Falling number determines the alpha-amylase enzyme activity, and higher FN value, lower enzyme activity, which complicates the industrial process, requiring greater amylolytic enzymes addition for flour use in bakery products. However, a high FN value is not a difficult problem to solve, since normally the reinforcers or improvers formulation used in baking presents alpha-amylase enzyme in order to correct this wheat flour deficiency [30,24]. According to [31], wheat grains can be classified with respect to FN values as high enzyme activity (<200 s), ideal enzyme activity (201-350 s) and low enzyme activity (>350 s). Similarly, [21] consider FN value ideal between 250-300 s.

Table 3. Hectoliter weight (kg.100 L^{-1}) of dual-purpose wheat of BRS Tarumã and BRS Umbu cultivars, submitted to plant cutting heights and number of cuttings, before and after six months of storage

	Plant cutting heights (cm)			
	20 initial	**20 after storage**	**30 initial**	**30 after storage**
Number of cuttings	BRS Tarumã			
0	74.15 a	73.25 b	74.20 a	73.02 b
1	73.65 a	73.00 b	73.35 a	71.85 b
2	72.70 a	72.30 b	72.10 a	69.62 b
3	72.30 a	71.95 b	71.20 a	68.20 b
CV (%)	**0.11**		**0.23**	
	BRS Umbu			
0	74.67 a	73.17 b	75.25 a	74.55 b
1	74.80 a	73.20 b	75.17 a	73.27 b
2	73.15 a	72.45 b	73.95 a	72.45 b
3	72.60 a	71.40 b	72.95 a	71.40 b
CV (%)	**0.26**		**0.40**	

Same lowercase letters in the lines do not differ by Tukey's test

Table 4. Gluten strength ($10E^{-4}J$) of dual-purpose wheat of BRS Tarumã and BRS Umbu cultivars, submitted to plant cutting heights and number of cuttings, before and after six months of storage

	Plant cutting heights (cm)			
	20 initial	**20 after storage**	**30 initial**	**30 after storage**
Number of cuttings	BRS Tarumã			
0	132.67 a	126.33 b	126.00 a	110.33 b
1	129.00 a	118.00 b	153.67 a	137.00 b
2	141.00 a	125.00 b	191.00 a	139.00 b
3	156.00 a	123.67 b	276.00 a	205.33 b
CV (%)	**2.58**		**3.05**	
	BRS Umbu			
0	136.00 a	130.00 b	166.00 a	138.00 b
1	137.00 a	124.00 b	149.50 a	128.50 b
2	146.50 a	114.50 b	144.33 a	111.50 b
3	128.00 a	120.50 b	148.00 a	105.50 b
CV (%)	**2.33**		**3.91**	

Same lowercase letters in the lines do not differ by Tukey's test

Table 5. Wet gluten (%) of dual-purpose wheat of BRS Tarumã and BRS Umbu cultivars, submitted to plant cutting heights and number of cuttings, before and after six months of storage

	Plant cutting heights (cm)			
	20 initial	**20 after storage**	**30 initial**	**30 after storage**
Number of cuttings	BRS Tarumã			
0	38.75 a	34.77 b	38.21 a	33.64 b
1	40.32 a	34.87 b	37.90 a	34.45 b
2	38.83 a	36.22 b	39.09 a	35.49 b
3	40.72 a	37.34 b	42.82 a	41.62 b
CV (%)	**0.93**		**1.41**	
	BRS Umbu			
0	34.70 a	32.27 b	33.55 a	29.40 b
1	38.36 a	36.12 b	37.26 a	35.83 b
2	40.25 a	34.30 b	37.49 a	35.72 b
3	41.79 a	38.04 b	39.61 a	38.20 b
CV (%)	**1.45**		**2.04**	

Same lowercase letters in the lines do not differ by Tukey's test

Table 6. Fallling number (s) of dual-purpose wheat of BRS Tarumã and BRS Umbu cultivars, submitted to plant cutting heights and number of cuttings, before and after six months of storage

	Plant cutting heights (cm)			
	20 initial	**20 after storage**	**30 initial**	**30 after storage**
Number of cuttings	BRS Tarumã			
0	192.00 b	203.00 a	194.00 b	202.33 a
1	188.00 b	196.33 a	196.00 b	202.33 a
2	192.33 b	198.00 a	198.67 b	274.00 a
3	203.00 b	210.00 a	216.00 b	285.00 a
CV (%)	**0.96**		**1.25**	
	BRS Umbu			
0	219.00 b	223.50 a	204.67 b	218.40 a
1	214.00 b	227.50 a	212.00 b	217.50 a
2	213.00 b	223.00 a	216.00 b	221.00 a

	Plant cutting heights (cm)			
	20 initial	**20 after storage**	**30 initial**	**30 after storage**
3	202.00 b	207.50 a	221.00 b	226.00 a
CV (%)	**0.91**		**0.43**	

Same lowercase letters in the lines do not differ by Tukey's test

Like that results found by [26,18,29], in this work an increase in FN values was observed with the wheat grains storage period, regardless of cultivar and management used (Table 6). According to the classification mentioned above, the increase in FN can be considered favorable, obtaining values closer to ideal FN.

4. CONCLUSION

It can be inferred the wheat technological quality of BRS Tarumã and BRS Umbu cultivars conducted in a dual-purpose system had modifications after six months of storage. For both cultivars and managements employed, reductions occurred in hectoliter weight and technological properties of gluten strength and wet gluten and the falling number increase. Therefore, there was no properties evolution, and the cereal could be marketed soon after harvest.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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