Quality of Fortified Zea Mays L (Maize) and Triticum Durum (Wheat) Flours

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ABSTRACT

Maize flour is obtained through the milling process and contributes about 20% energy and 15% protein. wheat flour is rich in starch (70 to75%), water (12 to 14%), protein (8 to16%), a small portion of non-starch polysaccharides (2 to 3%), lipids (2%) and ash (1%). This study aimed to evaluate the centesimal quality of maize and wheat flour. 8 samples of flour were evaluated, being 2 ((First Choice and Mpupu) and 6 of wheat flour (Faspão, Babita, Xiluva, Eagle, Pasta and Ntombi)). Moisture by loss on dissection at 105°C, ash by incineration, fat by goldfish method, protein by biuret method, fulling number by reading on mininfra grain analyzer Scan-T, gluten, wet and dry by glutomatic system, gluten index by centrifugation and fiber by enzymatic-gravimetric method were determined as quality parameters. The results showed fat content 0.61 to 1.59%, moisture 13.3 and 13.4%, fiber 0.22 to 0.38% and protein around 5.99 to 7.09% for the corn flours. Moisture ranging from 13.6 to 13.8%, protein from 10.30 to 11.22%, ash from 0.50 to 0.70%, water absorption from 58.23 to 59.73%, falling number 276 to 354s, gluten around 24 to 29.1%, gluten index from 0 to 95%, wet gluten from 28.46 to 29.80 and dry gluten ranging from 9.36 to 10.50%. No significant differences were observed among the wheat flour samples for moisture, protein, ash, water absorption and wet gluten. Significant differences were found for falling number (FN), gluten and dry gluten. There was sufficient evidence of compliance with the flour quality criteria.

INTRODUCTION

Maize (*Zea Mays L.*) is a cereal of great importance worldwide, in countries of Africa, Latin America and part of Asia maize contributes about 20% of energy and 15% of protein, in some cases maize constitutes the only source of protein for some populations (Castro, 2008).

The maize flour is obtained through the milling process, in which the grain is broken in order to remove the endosperm separating it from the bran and germ and reduce its size (Giacomelli *et al.*, 2012).

In order to be transformed into flour for human consumption, maize undergoes some transformations. Obtaining corn flour can be done in two ways, wet and dry. The process commonly used by Agroindustries in the transformation of this cereal is dry milling, this due to the small need for machinery and the simplicity in the execution of the process (Marcolin, 2018). In the wet milling process, the production of several by-products is favored, with starch being the most important. (Marques, 2016).

The word wheat is derived from the term Triticum, which means broken, crushed in allusion to the process carried out for the separation of the grain from its coating. The designation "wheat" is applied to the plant as well as its seed (Monho, 2013). White wheat flour is obtained by grinding the endosperm of the cereal, preceded by the separation of the germ and bran, thus obtaining more palatable products (Scheuer *et al.*, 2011).

The quality of wheat grain and flour depends on the purpose of the product, thus assuming different meanings, these characteristics can be divided into physical, chemical enzymatic and rheological. Among the physical-chemical tests can be found the hectoliter weight, protein, ash or fixed mineral residue and, the rheological tests, falling number, gluten content (dry and wet) and farinography (Módenes *et al.*, 2009).

According to Vedovati (2017), most of the composition of wheat flour is starch (70-75%), water (12-14%), protein (8-16%), a small portion of non-starch polysaccharides (2-3%), lipids (2%) and ash (1%). These values are variable according to the wheat cultivar.

The proteins present in wheat are directly related to the extensibility and elasticity of the dough, a flour considered ideal for baking must present qualitative and quantitative fractions of glutenins and gliadins, which directly influence the rheological properties of gluten. The structural and functional properties of starch, in turn, influence the texture, consistency, moisture, appearance and shelf life of foods (Costa, 2013).

According to Lamke & Amorim (2013), the processing of food (wheat and corn) for the elaboration of industrialized foods covers several stages, from the production and selection of raw materials, to the storage and final distribution of the products. Foods are processed into food products to make them more practical and attractive, in addition, the technologies employed by the industry allow the increase of the shelf life of the food and the enrichment of the products with vitamins and minerals. The quality control of these same products ensures the elaboration of products in accordance with the quality

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standards required and measured by the regulatory bodies (Paula & Nantes, 2017). The present research aimed to characterize the centesimal composition of fortified maize and wheat flours.

MATERIALS AND METHODS
Sample Collection
2 maize flour samples ((First Choice and Mpupu) and 6 wheat flour samples (Faspão, Babita, Xiluva, Eagle, Pasta and Ntombi)), packed in polypropylene bags, were randomly purchased from commercial markets in Beira city. The samples were coded according to the point of collection and were taken to the Laboratory of Food Hygiene for analysis.

Determination of Centesimal Composition and Rheology
The moisture content, ash, fat, protein, fiber and water absorption (W.a) were evaluated for the centesimal composition and the rheological parameters were evaluated for gluten content, falling number, wet gluten, dry gluten and gluten index following the methods described by IAL (2008) & Lins (2021).

Moisture Content
Moisture was determined by the gravimetric method. For this purpose, 5g of flour was previously ground in a mortar, added in a Petri dish previously weighed on an analytical balance ADAM brand of 0.0001g precision, dissected in an oven of the brand (ECOTHERM) with circulating air at 105ºC for 2 hours, then cooled to room temperature (±25º). Equation 1 was used for moisture determination.

$$\% \text{ moisture} = ((Pi\text{-}Pf))/Pi*100 \tag{1}$$

Where:
Pi- Initial weight of the sample;
Pf- Final weight of the sample.

Determination of Fat
The fat content was determined by the Goldfish method. 5g of the sample was subjected to direct fat extraction with petroleum ether, extracting (55°C) for 4 hours in a Goldfish apparatus. Expression 2 was used to determine the fat percentage.

$$\% \text{ fat content} = ((\text{Capsule Weight+Fat})\text{- Capsule Weight}))/(\text{Capsule Weight})*100 \tag{2}$$

Ashes
In an analytical balance of ADAM brand with 0.0001g of precision, 5g of the sample was weighed in porcelain crucibles and placed in a muffle furnace brand (OPTIL IVYMEN) at a temperature of 550°C until verification of incineration. The crucibles were then transferred to an oven at 105o C for 30 minutes with emphasis on lowering the temperature, followed by weighing them with the incinerated sample in inorganic matter. The percentage of ash was determined based on equation 3.

$$\% \text{ ashes content} = ((m^2\text{-}m))/((m^1\text{-}m))*100 \tag{3}$$

Where:
m - crucible weight;
m1- weight of crucible with wet sample;
m2 - weight of crucible with ash.

Proteins
Protein contents were determined by the biuret method, where 300 µL of each extract (prepared in the proportion: 10 g of flour and 90 mL of water) were mixed with 2000 µL of biuret reagent and left in a dark place for 30 minutes to give a purple color complex, and then the absorbance was read at 540 nm, in a spectrophotometer of the Brand (YOKE) previously zeroed with distilled water. The protein content of the samples was determined by extrapolation using a calibration curve consisting of casein in proportions from 0 to 10 mg/ml.

Fibers
Fiber was determined by the enzymatic-gravimetric method, where in triplicate 1g of treated sample previously passed through 32 mesh sieve was weighed. The samples were mixed with 40 mL of MES-TRIS buffer solution with pH 8.2 and 50 µg of heat-resistant α-amylase. The samples were then covered with aluminum foil and placed in a water bath at 95-100°C for 35 minutes with continuous stirring. Removed the beakers and cooled to (60±1) ºC, 100 µL of protease solution was added and again placed in a water bath. Subsequently, 5 mL of 0.561 hydrochloric acid was added to the samples under stirring. At constant temperature the pH was adjusted (4.0-4.7) by adding 1M sodium hydroxide solution. 300 µL of amyloglucosidase solution was added, covered with aluminum foil and again placed in a water bath. Subsequently, the content obtained from the enzymatic treatment was measured. The mixture was mixed with 95% alcohol at 60°C in a 4:1 ratio, covered with aluminum foil and left to stand for one hour at room temperature. At the end of the process, the previously weighed crucible was positioned in a kitassato coupled to a vacuum tube. 15mL of 78% alcohol was added and the alcoholic solution containing the alcoholic solution containing hydrolysis residue. The residue was washed with two portions of 15 mL of 95% alcohol and acetone, and the crucibles were dried in an oven at 100°C. The fiber was determined based on equation 4.

$$\% \text{ of fibers} = (RT\text{-}P\text{-}C\text{-}BT)/m*100 \tag{4}$$

Where:
RT - total residue of sample;
BT- total residue of blank;
C - ash of the sample;
M - mass of the sample outlet;
P - protein content.

Falling Number Determination
Through the humidity obtained in the reading in the Mininfra Grain Analyser Scan-T, it was determined the required amount of sample for the analysis in the falling number table, with the weight found, it was weighed the amount found in the table according to the humidity of the flour in an analytical balance, subsequent addition

of 4.5mL of distilled water in a test tube. Then, with the aid of funnel was introduced with subsequent homogenization for 30 seconds, then the sample already prepared was placed in the equipment ("Falling Number" FN 1000 -Perten Instruments. Stirring for 60 seconds at the end of the test, the result of the alpha amylase activity present in the flour was obtained.

Water Absorption (Wa)
Water absorption was determined according to the method described by Wang et al. (2006). 5g of sample was weighed into a 50 mL centrifuge tube and 30 mL of distilled water was added. The sample was shaken for 30 s with a glass rod. The contents were left to stand for 10 min and then the sample was centrifuged at 2300 rpm for 25 min. The supernatant was decanted and drained. The tube was placed tilted downwards (angle of 15° to 20°) in an oven at 50°C with air circulation for 25 min. The tube was cooled in a desiccator and weighed. The water absorption was calculated in relation to 100g of sample.

Determination of Gluten
The gluten content analysis was performed in the Gluten Determinator System (Glutomatic, Centrifuge and Glutork). For this, 10g of wheat flour was weighed in duplicate in mixed chambers and 4.7mL of 2% NaCl solution was added to the sample, where they were coupled to the Glutomatic and washing started. After washing, the samples were transferred to metal sieves and taken to the centrifuge, where a centrifugation was performed for 1 minute. After the centrifugation, the gluten that had passed through the sieve was scraped and weighed, followed by all the wet gluten resulting from the washing (retained and passing), which resulted in the wet gluten value. After weighing, the wet gluten was compressed and dried in the Glutork for 4 minutes. At the end of drying, the sample was weighed, giving the dry gluten value. Expression 5 used to determine the gluten content.

% of gluten= PGSx100/P   (5)

Where:
PGS - Weight of dry gluten;
P - Weight of the sample.

Determination of the Gluten Index
The gluten index was determined using the wet gluten, in the centrifugation process the harvester allowed a small amount to pass to the rear through the holes (which is weighed separately from the mass remaining on the front side of the harvester. This was followed by the residue

from the inner (A1) and outer (A2) parts. Equation 6 used for the determination of the gluten index.

GI=A1/(A1+A2) x100%   (6)

Where:
A1 - The mass present in the inner part of the harvester;
A2 - The mass present on the outside of the harvester.

Wet and Dry Gluten
For the determination of wet gluten (percentage) is done by weighing the sample (10 g) of flour with 5ml of water, then a sieve is placed where the 10g of flour and 5ml of water are mixed, shakes by making a slightly circular motion the sieve to spread the flour and shakes to spread the water throughout the sample. Separation of insoluble proteins and starch from gluten-forming flour (gliadins and gluteins), using the Glutomatic device, the gluten samples are taken to a centrifuge with a rotational frequency capacity of 6000 in 5 minutes in order to reduce the moisture in the gluten and then the samples are weighed and to obtain the result, expression 7 was used.

GH=m1x100%   (7)

Where:
GH - Wet gluten;
m1 - Mass value of wet gluten.

Statistical Analysis
Analysis of variance (ANOVA) was performed using the general linear model (GLM), through the statistical package Rstudio 4.2.1. In case of significant effects, the difference of the experimental units was evaluated by Tukey's test at 5% level.

RESULTS AND DISCUSSIONS
Centesimal Composition of Maize Flour
The results of the physicochemical constitution of corn flour are shown in table 1.

Table 1. Centesimal composition (100g) of fortified maize flours.

The evaluated samples showed fat content ranging from 0.61 to 1.59%. Higher (1.59%) lipid content was observed in sample A and lower (0.61%) for sample B, with significant differences (p <0.05) between them. These variations in fat content are possibly correlated with the composition and/or variety of maize used and the type of processing employed, since the samples underwent different treatments, with sample A being processed together with the germ.

Higher results (0.61 and 1.59% fat) were reported by Giacomelli et al. (2012) in their study on the nutritional

Table 1: Centesimal composition (100g) of fortified maize flours

Samples	Parameters			
	Fat (%)	Moisture (%)	Fiber (%)	Protein (%)
A	1,59	13,3	0,38	7,09
B	0,61	13,4	0,22	5.99

Source: Authors

composition of cornmeal, obtained contents ranging from 3.26 and 4.84% of fat. Results close to those obtained in the present research were referenced by Teodoro (2018) in his study with aim of determining the iron and centesimal composition of wheat and corn flours, obtained fat content ranging from 1.6 to 1.8%. Araujo (2019) studying the centesimal composition, water absorption index and solubility index in flaked cornmeal marketed in Teresina, obtained fat content ranging from 1.11 to 2.33%.

Moisture of 13.3 and 13.4% was evident in the samples evaluated, without significant differences. This range of values can be considered acceptable assuming that the moisture levels established by the National Health Surveillance Agency, ANVISA (2017), range from 13 to 15%.

Results close to those found in the present research were reported by Giacomelli et al. (2012) (11.05 to 12.57% moisture), when performing the nutritional composition of precooked, stone-ground maize flour and the culinary preparation "polenta". The moisture content of maize flour should not exceed 14% (Delagustin, 2012).

Studying moisture determination in corn flours using thermogravimetry and the classical method of analysis made by Fernandes & Araújo (2007), when analyzing the moisture content, they obtained results ranging from 10.2 to 12.2%. According to ANVISA through RDC N°711, of July 1, 2022, the flours must have a maximum of 14%. The results evidenced fiber content ranging from 0.22 to 0.38%. Higher (0.38%) fiber was observed in sample A. High values (0.22 and 0.38% fiber) were reported by Giacomelli et al., (2012) around 2.63 to 3.88% fiber, when developing their research on nutritional composition of corn flours. The protein content ranged from 5.99 to 7.09%. This range can be considered acceptable assuming that, Mutla et al. (2018), the protein content of maize depends on the variety, growing conditions and environmental factors of cultivation. Values divergent to those obtained in the present study were reported by Somavat et al. (2016), around 10.31%, 11.16% and 8.4% of protein content respectively, for purple, blue and yellow maize.

Centesimal and Rheological Composition of Wheat Flours

Table 2 represents the proximate, rheological and faringraphic composition of wheat flour.

Table 2: Centesimal (100g), faringraphic and rheological characterization of wheat flours

Parameters	Samples					
	A	B	C	D	E	F
Moisture (%)	13.7±0.15[a]	13.8±0.25[a]	13.6±0.15[a]	13.6±0.40[a]	13.6±0.10[a]	13.6±0.17[a]
Protein (%)	10.90±0.28[a]	11.22±0.51[a]	10.30±0.01[a]	10.35±0.11[a]	11.02±0.67[a]	10.36±0.11[a]
Ash (%)	0.70±0.02[a]	0.65±0.05[a]	0.50±0.03b	0.70±0.01[a]	0.65±0.02[a]	0.69±0.05[a]
W.a (%)	58.23±0.24[a]	59.73±0.55[a]	59.20±1.30[a]	58.23±0.49[a]	58.58±0.35[a]	58.16±0.28[a]
FN (%)	269±1.46b	325.67±0.62[a]	331.67±0.10[a]	324.0±0.11[a]	350.0±0.17[a]	334±0.14[a]
Gluten (%/s)	29.1±0.83[a]	27.6±2.08[abc]	28.5±0.61[ab]	25.7±0.58[bcd]	24.0±0.76[d]	25.5±0.30[cd]
GI (%)	0	0	0	0	95	0
GH (%)	29.80±0.91[a]	29.31±0.78[a]	28.78±0.20[a]	28.46±1.45[a]	29.13±0.68[a]	29.08±1.18[a]
GS (%)	10.50±0.30[a]	9.86±0.45[ab]	9.36±0.47[ab]	9.73±0.25[ab]	9.43±0.20[b]	9.75±0.13[b]

Means ± standard deviation followed by the same letter in the same row do not present significant differences at 5% Tukey level. W.a = Water Absorpt; FN = Falling Number; GH = Wet Gluten; GI = Gluten Index; GS = Dry Gluten.
Source: Authors

Moisture

The samples showed moisture ranging from 13.6 to 13.8%, where higher values were observed in formulations B (13.8) and A (13.7), without significant differences between them. These results are acceptable considering the criteria established by Normative Instruction No. 08, of June 2, 2005, of the Ministry of Agriculture, Livestock and Supply, Brazil (2005).

Similar values (13%) were reported by Resosemito et al. (2022) when studying on obtaining and physicochemical evaluation of deglutenized special wheat flour, obtained moisture around 13.0%, Lins (2021) (13.3 to 13.9% moisture), studying the influence of the semolina purification step on the physicochemical and rheological characteristics of wheat flours, by Oro (2013) in his study on the adaptation of methods for the evaluation of the technological quality of whole wheat flour, obtained 13.6 to 13.9% moisture content, and by Costa (2013) in the range of 13.8% moisture content, when studying about the evaluation of the industrial quality of wheat strains by means of physical-chemical, rheological and baking methods. Lower results were reported by Macedo (2017) when developing his research on physicochemical characterization of wheat flours used in bakeries in the municipality of Paraiso Tocantis, obtained moisture contents around 11.73 to 12.74%, and by Rosa-Campos et al. (2014) in their study entitled physicochemical analysis of sixteen brands of enriched type 1 wheat flours, marketed in the federal district, obtained moisture around 10.88 to 11.77%.

Protein

The protein content showed results ranging from 10.30 to 11.22%. Higher protein content was observed in samples B (11.22%) and E (11.02). On the other hand, samples C, D, F and A showed protein contents around 10.30, 10.35, 10.36 and 10.90%, respectively. Statistically, all samples did not show significant differences (p >0.05) among themselves.

In his study on determination of the technological value and utilization of various types of blends of soft wheat flour and durum wheat semolina for the manufacture of traditional bread Monho (2013), obtained protein contents ranging from 9 to 12%. Rosa-Campos et al. (2014) in their study entitled physicochemical analysis of sixteen brands of enriched type 1 wheat flours, marketed in the Federal District, obtained 10.49 to 11.07% protein, results in agreement with those obtained in this study. Superior results were described by Singer (2006), physicochemical, rheological, enthalpy and baking properties of flour obtained from irrigated wheat, obtained protein ranging from 10.49 to 10.60%.

Ashes

The results obtained in the determination of the fixed mineral residue content ranged from 0.50 to 0.70%. These results can be considered acceptable assuming that, Cezar (2012), the maximum ash content should be 0.8%. Higher values were verified in samples A and D (0.70%), F (0.69%) and B and E (0.65) without significant differences (p >0.05) between them, unlike sample C.

In the evaluation carried out by Lins (2021) studying the influence of the semolina purification step on the physicochemical and rheological characteristics of wheat flours, they obtained ash content ranging from 0.48 to 0.77%, by Macedo (2017) around 0.60%, and by Rosa-Campos et al. (2014) with 0.49 to 0.55% of fixed mineral residue, and also by Lanzarini (2015) obtained ash content around 0.48 to 0.78%, when performing quality control applied to bread wheat flour produced in mills in the state of Paraná , results close to those obtained in the present research.

Allied results were described by Silva et al. (2015) analyzing different brands of wheat flour, obtained ash content around 0.50%, and by Paixão (2022) when studying the quality control applied in wheat flours produced in the State of Maranhão: emphasis on physicochemical and rheological analyzes, obtained 0.70% of fixed mineral residue.

Zimmermann (2009) when analyzing wheat flours found ash values between 1.4 and 2.5% for two of the flours analyzed, being considered whole flour, different from what occurred in this work in which all flours remained in the type 1 range, Oro (2013) in his study on adaptation of methods for evaluating the technological quality of whole wheat flour, having obtained ash content around 1. 61%, Guarienti & Caiera (2022), studying special flour and obtained from clean and germinated cereal, found ash content between 0.66% and 1.61%.61%, Guarienti & Caierao (2022), studying on the special flour and obtained from the cleaned and degerminated cereal, found ash content between 0.66% and 1.35%, results above those obtained in the present research. These low ash contents may be associated with the composition of the raw material used, on the other hand, Silva et al. (2015) point out that low ash values indicate better quality, since the higher the ash content, the greater the presence of bran in it, interfering with the quality of bakery products.

Water Absorption (W.A)

Water absorption values ranged from 58.23 to 59.73%. Statistically, there were no significant differences (p>0.05) between the formulations.

Results allied to those obtained in the present research were revealed by Oro (2013) in his study on adaptation of methods for evaluation of technological quality of whole wheat flour, obtained 58.5% of water absorption, Martins et al. (2012) when developing their study on water absorption in a mixture of wheat sticks of different commercial brands, obtained values for water absorption ranging between 54.07 and 67.66%, and by Silva (2017) in his research on rheological and physicochemical analyzes of wheat flour from six different cultivars recommended for the state of Paraná, obtained 58% of water absorption. Costa et al. (2008) seeking to differentiate the technological parameters of flour from national and imported wheat grains, obtained water absorption values in the range of 54.43 and 59.3% for imported flours and 53.3 and 57.6% for national flours, Paixão (2022) controlling the quality applied in wheat flours produced in the State of Maranhão: emphasis on physicochemical and rheological analyzes, obtained 57 to 58.7% of water absorption, going in accordance with the results obtained in this study. Junqueira et al. (2007), flours with high technological quality for bread production are those that present water absorption between 60 and 64%, by Costa (2013) in the study of Evaluation of the industrial quality of wheat strains through physical-chemical, rheological and baking methods having obtained values ranging from 59.4 to 77.0% of water absorption, results higher than those obtained in the present research. This significance can be justified given that, Fernandes et al. (2008), for wholemeal flours high values of water absorption are expected due to their high fiber content in relation to refined flour. Similarly, Noort et al. (2010) explained that the presence of wholemeal flours does not cause a significant increase in water absorption in farinography.

Falling Number (FN)

The results obtained on the drop number ranged from 276 to 354 seconds. Samples B, C, D, E F showed higher percentage of drop number. Lower (269s) was observed in sample A, being different from the others. These differentiations regarding the FN are possibly correlated with the quality of wheat and treatment in processing. Results consistent with those obtained in this study were described by Lins (2021) in his research on the influence

of the semolina purification step on the physicochemical and rheological characteristics of wheat flours, obtained values of falling number around 350 seconds, Cezar (2012) obtained a falling number around 200 to 350 seconds, when developing his study on quality control in wheat flour, Lazarini *et al.* (2020) analyzed ten samples of type 1 wheat flour finding results for FN in the range 351.33 to 390 seconds, and by Silva (2017) in his study on rheological and physicochemical analysis of wheat flour from different cultivars in the Paraná state, obtained a drop number of 350 seconds. Higher results than those obtained in the present research were reported by Singer (2006) when evaluating the physicochemical, rheological, enthalpy and baking properties of flour obtained from irrigated wheat, obtained falling number around 409 to 477 seconds.

Gluten Content

The gluten content showed results ranging from 24 to 29.1%. Higher gluten content was observed in samples A (29.1%), C (28.5%) and B (27.6%), with significant differences (p <0.05) between them. These results possibly, given Silva *et al.* (2015), are directly related to water absorption, especially for bakery doughs that have a high elasticity.

Results consistent with those obtained in this study were described by Lins (2021) in his research on the influence of the semolina purification step on the physicochemical and rheological characteristics of wheat flours, obtained gluten content from 24 to 29%.

Results lower than those obtained in the present research were reported by Silva *et al.* (2015) around 16.01 and 23.51% gluten, when studying different brands of wheat flours, Dias *et al.* (2015) (8.0% gluten) when performing physicochemical analysis of traditional wheat flour, Zimermann *et al.* (2009) studying physicochemical and rheological evaluation of the main wheat flours marketed in bakeries in the municipality of Cascavel, obtained gluten content ranging from 9.25 and 10,55%.

Gluten Index

Gluten index results ranged from 0 to 95%. In the evaluation made by Costa (2013), he found the gluten index in the range of 98.22%, close to the results obtained in this research. Allied results (95% gluten index) were referenced by Paixão (2018), ranging from 95.60 to 97.29%. Cauvain & Young (2009) reinforce that when the gluten formed is considered very strong and not very extensible, the resulting bread will be dense and without volume; however, if the gluten network is considered weak, it breaks at the time of fermentation, generating breads with holes.

Wet Gluten (GH)

No significant differences (p >0.05) were found between the samples. In the evaluation made by Oro (2013) in his study on the adaptation of methods for the evaluation of the technological quality of whole wheat flour, he obtained wet gluten content around 16.98 to 25.75%, and

by Dias *et al.* (2015) when studying about physicochemical analysis of traditional wheat flour, obtained 24% of wet gluten content, results lower than those obtained in the present research.

Similar results were found by Costa (2018), in which it was observed a variation of 24.83 to 28.72% for wet gluten, when evaluating the content of wet gluten and dry gluten of wheat flours of wheat flours marketed in conquista Vitoria - BA, Silva (2017) in his study on rheological and physicochemical analysis of wheat flour from different cultivars in the Paraná state, in the range of 28.02% of wet gluten, by Costa (2013) in the study of on evaluation of the industrial quality of wheat strains by means of physical-chemical, rheological and baking methods, having obtained a variation of 28.9%.

Dry Gluten (GS)

The averages ranged from 9.36 to 10.50%. Sample A (10.50%) had the highest mean, followed by formulation B with a mean of around 9.86. Significant differences (p <0.05) were found between samples B, C, D, E and F compared to sample A.

In the evaluation made by Oro (2013) in his study on adaptation of methods for evaluation of technological quality of whole wheat flour, revealed dry gluten content around 9.9%. Paixão (2018) reported dry gluten around 9.76 to 9.86%, Dias *et al.* (2015) when studying about physicochemical analysis of traditional wheat flour, reported a range of 9.65% of dry gluten contents, Costa (2013), approached dry gluten contents around 9.6%.6%. According to Ribeiro (2009), the ideal range for dry gluten content is between 7.5 and 14%, Silva (2017), obtained results ranging from 7 to 10% depending on their applications, results similar to those obtained in the present study.

CONCLUSION

No significant differences were observed between the wheat flour samples for moisture, protein, ash, water absorption, and wet gluten. Significant differences were found for falling number (FN), gluten and dry gluten. There was sufficient evidence of compliance with the flour quality criteria.

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