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Properties of dehydrated cassava puree and wheat flour blends and its relationship with the texture of doughs

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ABSTRACT

A growing interest in promoting the use of local sources of flour for the partial replacement of wheat flour is observed. Dehydrated cassava puree (DCP) is obtained by cooking, mashing, and drying the cassava roots. The objective was to evaluate the physicochemical and functional properties of DCP and its influence on the texture of unfermented doughs. Four blends with different proportions of wheat flour and DCP were used. The physical and functional properties of the blends were correlated ($p < 0.05$) with the results of TPA, forward extrusion, compression, and extensibility tests carried out with the TA. XT-plus texture analyzer. The DCP doughs presented higher consistency, cohesiveness, elasticity, resilience, hardness, and gumminess than wheat flour dough. Those textural parameters were correlated (>0.90) with properties such as average particle size and water absorption. The use of DCP for dough production is viable, and its texture characteristics are suitable for industrial processes.

1. Introduction

A growing interest in promoting the use of local sources of flour for the partial replacement of wheat flour is observed. This is significant in countries where wheat is an imported product, which affects the economy and food security (Aristizábal & Sánchez, 2007; Chisenga, Workneh, Bultosa, & Alimi, 2019). It would be useful for the industry to evaluate the use of cassava as a substitute for flours to the development of new products with high added value (Salcedo Mendoza, J.; Figueroa Flórez, J.; Hernández Ramos, 2017). However, the substitution of wheat flour affects the properties and quality of doughs and final products, especially when the replacement is made with gluten-free flours (Eduardo, Svanberg, Oliveira, & Ahrné, 2013). It has been widely reported that the decrease in gluten content significantly affects the rheology and texture of the doughs (Naqash, Gani, Gani, & Masoodi, 2017). It affects the production process and the quality of the final products since the decrease in gluten content produces lower viscosity, cohesiveness, and elasticity. Research in the field has focused on the study of starches and flours of rice, wheat, barley, soy, and potatoes (Chisenga et al., 2019).

The addition of different products obtained from cassava in wheat-based doughs has been the subject of recent research (Chisenga et al., 2019). Techeira, Sívoli, Perdomo, Ramírez, and Sosa (2014), concluded that the different varieties of cassava and other starchy products are appropriate for the manufacture of baked goods and other edible products that require high viscosity. Osorio and Galvis (2009), found that replacing wheat flour with cassava flour increases water absorption, toughness, yield, and decreases the extensibility and specific volume of baked products due to the weakening of the gluten structure. Liu et al. (2019), found that cassava-damaged changes the texture of the doughs. Mao & Flores, (2001) described that the increase in the proportion of damaged starch produces an increase in water absorption of wheat flour, firmness, and “royability” of tortillas and decreased the stretchability. Eduardo et al. (2013) concluded that the process applied to obtain the starch affects the properties and the interaction between starch and gluten network. Research is still lacking on how the replacement with different cassava-derived products and its physicochemical and functional properties affect the properties of the dough and the final product (Chisenga et al., 2019; Eduardo, Svanberg, Oliveira, & Ahrné, 2013).

Dehydrated cassava puree (DCP) is obtained by cooking, mashing, and drying the cassava roots. It has a high content of pre-gelatinized starch. The objective of this article was to evaluate the physicochemical and functional properties of DCP and its influence on the texture of unfermented doughs.

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2. Material and methods

2.1. Materials

Wheat flour and dehydrated cassava puree (DCP) were used. They were purchased in the local market (Argentina). The packing declares 1.17 g of proteins, 88.33 g of carbohydrates, and 1.67 g of fiber per 100 g of DCP. The ingredients declared are cassava, sodium bisulfite (preservative), and glycerol monostearate (emulsifier).

The ingredients used and their proportions are in Table 1. All the doughs had an identical quantity of salt, sugar, and sunflower oil (0.2, 0.3, and 4.5% of the dough weight respectively). First, The DCP, the wheat flour, sugar, and salt were mixed by shaking a closed container by hand. After that, the oil was mixed. Then, the water was incorporated. Finally, kneading by hand was carried out for 2–3 min. Before testing, all the doughs were allowed to rest for 30 min in airtight containers.

Table 1
Proportions of wheat flour, DCP, and water used to make 100 g of dough.

Sample	A	B	C	D
DCP (g)	0	30.5	43	54
Wheat flour (g)	63	30.5	14.5	0
Water (g)	32	34	37.5	41

2.2. Methods

2.2.1. Physicochemical properties of blends and doughs

Moisture and pH of blends were determined by AOAC methods (1984). Lipid content was determined by the Twisselmann method, using petroleum ether (BP: 35–60 °C). The particle sizes were determined through the AOAC 965.22 method with modifications. Meshes of 420, 250, 210, 177, and 119μ were used.

Bulk density was determined by measuring the volume of 20 g of the sample. To determine the compressed density, multiple blows were given to the graduated cylinder of a height of 10 cm, twenty times. The density of the dough was calculated measuring the weight and dimensions of dough disks.

To determine the moisture of the dough samples, between 2 and 3 g were placed in an air oven at 60 °C for 24 h, then the sample was carried at 130 °C until constant weight.

2.2.2. Functional properties of blends

Alkaline Water Retention Index (AWRI) was determined, as described by (Barrera, 2014). Water Solubility Index (WSI) and the Swelling power (SP) were calculated using the method proposed by Anderson (Aristizábal & Sánchez, 2007).

Oil Absorption Capacity (OAC) was obtained through the method described by Dench, Rivas, and Caygill (1981) with minor modifications. The centrifugation was set at 1500 g for 25 min.

Emulsifying activity (EA), emulsifying stability (ES), and concentration minimum gelation (CMG) were determined as described by Argel, Ranalli, and Califano (2017).

2.2.3. Textural properties of doughs

All texture tests were performed in a TA. XT plus texture analyzer (Stable Micro Systems, Surrey, UK) equipped with a 50 kg load cell. All tests were carried out at 1 mm/s head speed. The parameters used in each test were calculated using the software Exponent©.

2.2.3.1. Texture profile analysis (TPA). The probe SMS P/75 was used. The test was performed until a 75% strain with waiting time between compressions of 5 s. Doughs were molded in cylinders of 2.5 mm diameter and 20 mm high and were allowed to stand for 15 min at 24–26 °C in airtight bags. This test analyzed the parameters of Hardness (N), elasticity (dimensionless), cohesiveness (dimensionless), Gumminess (N), and Resilience (dimensionless) defined by Hleap and Velasco (2010).

2.2.3.2. Forward extrusion. The HDP/FE accessory was used, and the dough was manually compressed to avoid the presence of air bubbles. After that, it rested for 15 min. The test was performed until a 50% strain. The compression force-time curve enabled evaluating the curve plateau (consistency) and the area under the curve (total work). The outlet diameter was 40 mm.

2.2.3.3. Compression. The SMS P/75 probe was used. The test was performed until a 50% strain. Dough discs of 45 mm diameter and 2 mm height were used. The maximum force and the final diameter were recorded.

2.2.3.4. Extensibility. An acrylic device was used to fix the dough sheet, as seen in Fig. 1. The P/0.5 S probe was used. The inner edge of the circle was lubricated with petrolatum. The doughs were laminated to a thickness of 2 mm. Extensibility was measured as the distance (mm) to the rupture. Toughness was measured as the maximum force (N).

2.3. Statistical analysis

The physicochemical experiments were repeated three times. Thirteen repetitions for textural properties were performed. The data were processed using ANOVA, with a significance level of 95%. The correlations were calculated using the Pearson product-moment test ($p < 0.05$).

3. Results and discussion

3.1. Physical-chemical analysis of the blends

The physical and functional properties of raw materials, blends, and their differences can be seen in Table 2. The moisture of the samples increased as the percentage of wheat flour increased. The lipids content agrees with the values published by other researchers such as Salcedo Mendoza, J.; Figueroa Flórez, J.; Hernández Ramos (2017), and Techeira et al. (2014) for products from cassava. Moisture and lipid content are properties linked to the quality and conservation of flours. A low value in these parameters would limit microbial growth and rancidity (Aristizábal & Sánchez, 2007). The moisture value found for DCP was lower than the reference value provided by Aristizábal and Sánchez (2007) for cassava starches and higher than that reported by Inca Vasquez (2015) for similar products from potatoes. The botanical source can be responsible for part of these differences. Wheat flour had a higher lipid content than DCP. That is because both botanical sources have a different chemical composition. Cassava is a low-lipid crop (Vargas Aguilar & Hernández Villalobos, 2013).

The average particle size of DCP was higher than that found in wheat flour. The particle size influences the mixing, heating, and cooling operations affecting the rheological properties of the dough (Moreira, Chenlo, Torres, & Prieto, 2010). The average particle size was correlated with WSI, AWRI, PS, and density (≥0.90). The DCP density is the result of the larger particle size (Amador-Rodríguez et al., 2019). There was no significant difference between loose and packed density for DCP. Both DCP densities were higher than wheat flour and other powder products obtained from cassava by Techeira et al. (2014) and Salcedo Mendoza, Figueroa Flórez, and Hernández Ramos (2017). The differences of the DCP regarding other products obtained from cassava in the physicochemical properties produce variations in the functional properties.

3.2. Functional analysis of the blends

AWRI evaluates the proportion of alkaline water that flour (with 14% moisture) can retain after the hydration and the centrifugation.

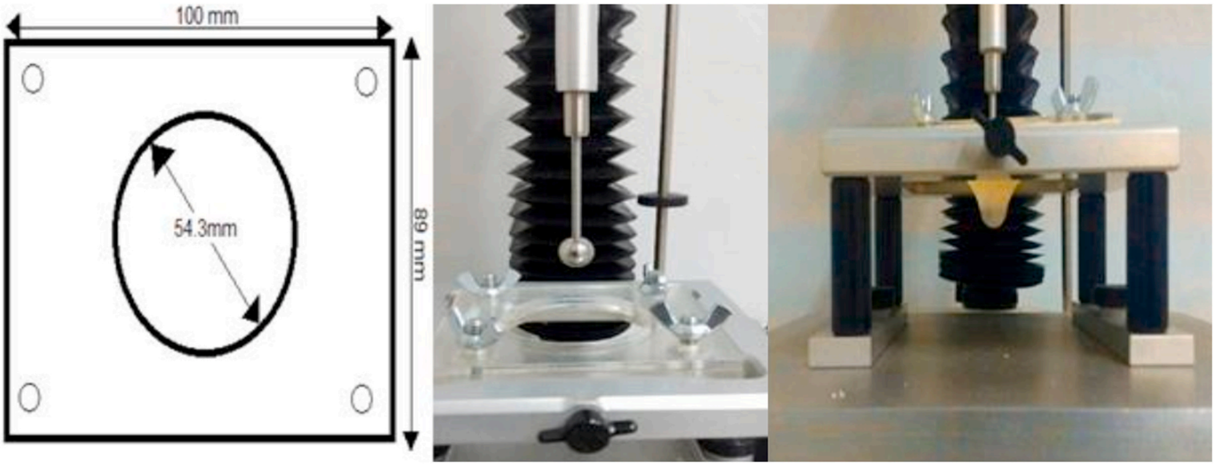

Fig. 1. Design and implementation of dough support for extensibility testing.

Table 2
Physicochemical and functional properties of flour with different levels of replacement by DCP.

Sample	A	B	C	D	Correlation with "% replacement" factor. ($p < 0.05$)
Moisture (d. b.)	13.9 ± 0.1^{a}	11.2 ± 0.5^{b}	10.2 ± 0.3^{b}	9.1 ± 0.2^{c}	−0.965
Lipids (%)	1.02 ± 0.05^{a}	0.85 ± 0.04^{b}	0.63 ± 0.02^{c}	0.50 ± 0.03^{d}	−0.998
Bulk Density (g/mL)	0.43 ± 0.01^{a}	0.67 ± 0.02^{b}	0.72 ± $0.04^{c.}$	0.80 ± 0.03^{c}	0.944
Bulk Density. Packed (g/mL)	0.53 ± 0.01^{a}	0.82 ± 0.02^{b}	0.81 ± 0.03^{b}	0.80 ± 0.03^{b}	0.836
Average particle size (μ)	169.94 ± 3.39^{a}	244.37 ± 7.98^{b}	282.17 ± 11.47^{c}	322.06 ± 8.79^{d}	0.991
AWRI (%)	63.75 ± 4.99^{a}	246.0 ± 13.7^{b}	242.7 ± 23.3^{b}	359.5 ± 19.4^{c}	0.931
WSI (g soluble/g sample)	10.2 ± 0.4^{a}	28.6 ± 0.4^{b}	34.2 ± 0.7^{c}	35.7 ± 0.9^{c}	0.965
SP	3.64 ± 0.08^{a}	4.2 ± 0.1^{b}	5.2 ± 0.3^{c}	6.3 ± 0.4^{d}	0.929
AE (mL/mL)	0.71 ± 0.03^{a}	0.49 ± 0.01^{b}	0.50 ± 0.01^{b}	0.51 ± 0.04^{b}	($p > 0.05$)
ES (mL/mL)	0.45 ± 0.03^{a}	0.49 ± 0.01^{b}	0.49 ± 0.01^{b}	0.51 ± 0.02^{b}	0.770
OAC (g oil/g sample)	0.28 ± 0.02^{a}	0.38 ± 0.06^{b}	0.37 ± 0.01^{b}	0.45 ± 0.04^{c}	0.850
CMG (%)	26	20	18	14	−0.9954

Values are averages of three samples ± standard deviation. There are no statistically significant differences between those levels that share the same superscript in the same row. nd: no data.

Alkaline pH is used to prevent gluten formation and the influence of gluten on water retention (Barrera, 2014). The AWRI values for DCP are more than five times higher compared to wheat flour *(Table 2)*. Also, the value of WSI for DCP was lower than the values obtained by Techeira et al. (2014), for white cassava flour. But significantly higher than wheat flour and higher than the values usually reported for starches and cassava flours.

The high AWRI and WSI of DCP could be a consequence of the high degree of gelatinization of the starch molecules and a low degree of intragranular ordering regarding products such as cassava starch and flour. That facilitates the dispersion of polar molecular components (amylose and amylopectin) and other binding sites for water (Shi et al., 2016). Blends B and C showed a significant increase in the AWRI and WSI compared to wheat flour. Correlations greater than 0.90 between AWRI and WSI parameters, and the average particle size was found.

The SP values found for DCP were inside the range established by FAO for cassava starches (Aristizábal & Sánchez, 2007). The association of a high WSI and SP, as observed in the DCP, could reflect the low strength of association in the granules produced by the physical modification of starch (Li et al., 2020; Singh, Singh, Kaur, Sodhi, & Gill, 2003).

Other authors obtained similar behaviors when AWRI, WSI, and PS analyzed flour samples with replacements with resistant starch. They concluded that variation in the content of damaged starch is the main factor that causes increases in the hydration capacity of flour or flour mixtures (Barrera, 2014; Mao & Flores, 2001; Shi et al., 2016).

The CMG value of DCP is significantly lower than that obtained for wheat flour and was negatively correlated (−0.95) with average particle size, IRAA, ISA, and PS values. The gelatinization produces dispersion of granular fragments and molecules that together with the swelling of the starch granules constitute critical factors in the formation of viscous suspensions, which would exhibit gel characteristics at suitable flour concentrations (Barrera, 2014). DCP has a high content of gelatinized starch (Brousse, Linares, & Nieto, 2019). That may be the reason why strong gels could be formed at concentrations of 14% of DCP, similar to traditional protein sources such as whey or soy, generally used to improve food texture (Argel et al., 2017).

The DCP samples exhibited a higher OAC than wheat flour. In dough production, a higher oil absorption capacity can generate an increment in the apparent and real density of doughs and final products. The oil affects the texture of doughs acting as a lubricant. This property becomes relevant to the formulation of many products since it is related to the capacity of retention of flavors and the smoothness that the product acquires (Argel et al., 2017; Manley, 1998). Retention by physical factors may be the principal determinant of fat absorption in DCP since the protein matrix and amino acid arrangement do not seem to provide a sufficient explanation in a system with low levels of proteins (~0,1%) (Argel et al., 2017; Aristizábal & Sánchez, 2007; Dench et al., 1981).

None of the samples analyzed showed high values of EA or ES compared to other non-traditional flours such as Rice, Quinoa, and Lentil flours (Álvarez Restrepo, Lopera Cardona, & Gallardo Cabrera, 2014). Salcedo Mendoza et al. (2017) reported higher values of EA in cassava starch than those presented in this work. There was no significant difference among the samples B, C, and D. That values were significantly lower than wheat flour. This is probably due to because the substitution with DCP decreases the amount of total protein in the emulsion. In the same way, B, C, and D blends showed statistically similar values of ES, but these were greater than those obtained for wheat flour. A high-grade correlation (−0.97) was obtained between CMG and ES.

3.3. Textural properties

The physical properties of soughs and the statistical data obtained from the texture tests can be seen in Table 3.

3.3.1. TPA analysis

Fig. 2 shows the typical graphs obtained from the TPA test in doughs. The hardness value for the D dough was significantly higher than that obtained for dough A. The hardness of the doughs B, C, and D was also higher than that found by Rodríguez-Sandoval, Fernandez-quintero, Sandoval-Aldana, and Cuvelier (2008) in samples of reconstituted cassava mass. However, the difference may be related to the moisture of the reconstituted cassava mass (65% wet base) was higher than the doughs with DCP.

Table 3
Physicochemical and textural properties of doughs and their correlation with the percentage of DCP.

Sample	A	B	C	D	*Correlation with "% replacement" factor" ($p<0.05$)*
Physicochemical Prop.					
Moisture (db)	58.4 ± 0.9^{a}	60.5 ± 1.0^{b}	61.9 ± 0.3^{c}	76.7 ± 1.3^{d}	0,8018
Density (g/mm3)	1.25 ± 0.03^{a}	1.2 ± 0.1^{a}	1.29 ± 0.06^{a}	1.3 ± 0.2^{a}	($p > 0.05$)
-TPA-					
Max. force -Hardness (N) /kgf	9.8 ± 0.3^{a} /1.00 ± 0.03	28.3 ± 0.8^{b} /2.89 ± 0.08	30.4 ± 1.2^{c} /3.09 ± 0.12	40.2 ± 3.0^{d} /4.09 ± 0.31	0.9742
Elasticity	0.23 ± 0.02^{a}	0.34 ± 0.01^{b}	0.41 ± 0.01^{c}	0.680 ± 0.003^{d}	0.9068
Cohesiveness	0.32 ± 0.02^{a}	0.430 ± 0.001^{b}	0.48 ± 0.02^{c}	0.69 ± 0.01^{d}	0.9286
Gumminess (N) /kgf	3.09 ± 0.5^{a} /0.31 ± 0.05	12.43 ± 0.4^{b} /1.27 ± 0.04	14.7 ± 0.6^{c} /1.49 ± 0.06	27.05 ± 0.02^{d} /2.76 ± 0.02	0.9532
Resilience	0.05 ± 0.01^{a}	0.121 ± 0.001^{b}	0.15 ± 0.01^{c}	0.30 ± 0.01^{d}	0.9114
-Forward extrusion-					
Consistency (N-Plateau) /kgf	19.99 ± 1.39^{a} /2.04 ± 0.14	64.6 ± 6.8^{b} /6.58 ± 0.69	61.5 ± 4.6^{b} /6.27 ± 0.47	86.4 ± 7.2^{a} /8.81 ± 0.73	0.9410
Area under the curve	710.9 ± 62.9^{a}	2345.4 ± 257.2^{b}	2017.8 ± 35.8^{b}	2677.2 ± 183.6^{c}	0.9030
-compression-					
Max. Force (N). /kgf	30.7 ± 2.8^{a} /3.13 ± 0.28	71.2 ± 8.3^{b} /7.26 ± 0.85	75.5 ± 2.3^{b} /7.69 ± 0.23	34.17 ± 4.02^{a} /3.48 ± 0.41	($p > 0.05$)
spread (mm)	5.5 ± 0.5^{a}	2.1 ± 0.2^{b}	1.3 ± 0.6^{b}	0.5 ± 0.2^{c}	−0.8111
-Extensibility-					
Extensibility (mm)	46.8 ± 4.4^{a}	21.9 ± 1.4^{b}	22.8 ± 1.7^{b}	27.8 ± 1.3^{c}	−0.7457
Toughness (N) /kgf	0.60 ± 0.06^{a} /0.061 ± 0.006	0.58 ± 0.08^{b} /0.059 ± 0.008	0.39 ± 0.05^{c} /0.040 ± 0.005	1.1 ± 0.1^{d} /0.11 ± 0.01	($p > 0.05$)

Values are the average of three samples for moisture and density and of thirteen for textural properties ± the standard deviation. There are no statistically significant differences between those levels that share the same superscript in the same row.

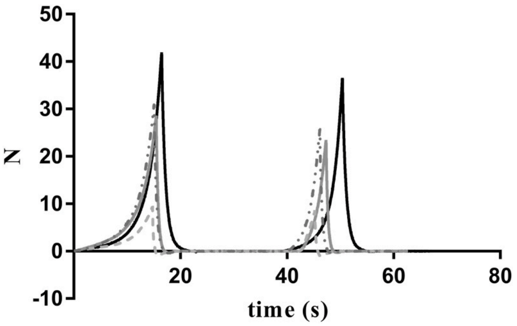

Fig. 2. Typical graphs obtained as a result of the TPA test.

Elasticity increased when the proportion of DCP increased, i. e. as the level of replacement increases, the dough retains more of its original structure after the first compression. The DCP dough triples the elasticity of the formulation A. In practice, this parameter indicates the behavior that dough will have during rolling or shaping and after it. Martínez, Díaz, and Gómez (2014) obtained similar effects in doughs with partial replacement of gluten-free flours by insoluble fibers.

Cohesiveness exhibited the same tendency to increase when the proportion of DCP increased. The cohesion value of the DCP dough was more than double that of formulation A. Rodríguez-Sandoval et al. (2008) found lower values of cohesiveness in the sample of reconstituted cassava mass than that of the DCP dough.

Gumminess and resilience also increase when the level of substitution increases. DCP dough presents gumminess values more than nine times higher than the formulation A. Also, DCP dough presented six times greater resilience values than the dough A.

The hardness obtained by TPA was positively correlated with AWRI (0,97), average particle size (0.97), and dough moisture (0.79) and negatively with CMG (−0,99). Gumminess had a correlation of −0.98 with CMG and of 0.93 with dough moisture. Resilience was correlated with dough moisture (0.97), the SP (0.94), and with the average particle size (0.91). The moisture of the doughs was correlated (0.96) with the values of elasticity and cohesion obtained through TPA. Gumminess, elasticity, and cohesion were correlated with SP (≥0.95). These texture parameters were also correlated with the mean particle size (≥0.90) and with AWRI (≥0.85).

3.3.2. Forward extrusion test

Consistency is a difficult concept to measure and define since it implies numerous properties such as hardness, viscosity, plasticity, and elasticity. Consistency can be used as a guideline to establish the characteristics required for industrial equipment to be able to process the dough during operations such as kneading, rolling, cutting, etc. (Manley, 1998).

The consistency of the dough was incremented when the level of substitution increased. According to Martínez et al. (2014), a marked increase in the consistency of doughs could be related to a larger particle size, which is in agreement with the correlation found in this study between the consistency of the doughs and the average particle size (0.94). Also, a correlation between consistency and AWRI (0.93) was found. The total work required to extrude the DCP dough is four times higher than that needed for dough A. The total work required for Doughs B and C showed statistically similar values a higher total work than dough A. The total work was correlated positively with AWRI (0.95) and average particle size (0.89). To form a dough, the DCP required 11% of its water retention capacity, whereas wheat flour required 50% of its water retention capacity. This could be hindering the movement of the particles. Also, the particle size was probably affecting the movement capacity of the particles, since, under the same force, the larger particles present greater trouble to move than smaller particles (Moreira et al., 2010). This could also be an explanation for the high values of the textural parameters “hardness” and “gumminess” in TPA.

3.3.3. *Compression test*

Unlike the previous tests, the force values for the DCP dough and the wheat flour dough do not present significant differences. Doughs B and C double the maximum strength values for the other doughs but do not have a significant difference between them. No significant correlation was found between this parameter and the other properties studied. The interaction between DCP and the gluten network could be responsible for the different behavior of partial replacements.

DCP dough shows less increase in final diameter than formulation A. Doughs B and C had no significant difference between them, and their values were also lower than those of formulation A. For all doughs studied, the maximum force and the increase in diameter after compression were less than those obtained by Laguna Cruañes (2013). The increase in the final diameter of the dough discs was correlated with the TPA-elasticity (−0.80), and with average particle size (−0.82). At least in part, this behavior could be explained due to the difficulty that large particles have in flowing.

3.3.4. *Extensibility test*

The DCP dough showed 40% lower extensibility than dough A. Doughs B and C presented statistically comparable values of extensibility to each other and 55% lower than dough A. The extensibility values obtained for B, C, and D doughs were relevant since they exceed those found for other authors to dough sheets made with alternative flours or doughs with partial substitutions, considering the replacement percentage evaluated (Osorio & Galvis, 2009; Soto-Jover, Boluda-Aguilar, & López-Gómez, 2015). The DCP dough presented a higher toughness than the dough A. The increase of toughness had a positive correlation with the moisture of the dough (0.86).

The particles of DCP may be disrupting into the gluten matrix producing its weakening and that affects the extensibility of the doughs. The decrease of extensibility and the increase of toughness has been attributed to the increase in the content of damaged starch, fiber components, or the lack of water. That would occur due to the disruption in the gluten matrix and also due to the water restriction in the formation of gluten (Barrera, 2014; Ktenioudaki, O’Shea, & Gallagher, 2013; Mao & Flores, 2001). This could explain the behavior of doughs B and C.

3.4. *Effect of DCP on the texture of doughs*

The replacement rate obtained a high-grade (>0.95) positive correlation with all the textural parameters analyzed by the TPA test and with the forward extrusion test. A strong negative (>0.90) correlation was found between the replacement rate and the spread after the compression test. A positive correlation (>0.80) was found within the replacement rate and the extensibility and with the moisture of the doughs.

Other authors showed that the gluten-free doughs even with the addition of hydrocolloids or doughs with different levels of replacement with potato-based products, cassava-based products, or resistant starch, have less hardness, gumminess, cohesiveness, elasticity, resilience, and consistency than doughs with gluten (Arp, Correa, Zuleta, & Ferrero, 2017; Eduardo et al., 2013; Leray, Oliete, Mezaize, Chevallier, & De Lamballerie, 2010; Nawaz et al., 2019; Sciarini, Ribotta, León, & Pérez, 2010). The results obtained demonstrate that the increase in the level of replacement with DCP generates a significant increase in all the TPA parameters and also in the consistency evaluated through the forward extrusion test. This could be of interest to improve the machinability of doughs or batters gluten-free, and for the development of DCP-based products. However, an excessive increase in the consistency of doughs could generate problems related to the force needed for industrial processing. It is still necessary to study the behavior on the industrial scale and into the different cooking methods, and the effect on finished products.

4. Conclusions

Our results confirm that the texture properties of doughs are correlated with the functional and physicochemical properties of wheat flour, DCP, and blends.

The DCP increases the average particle size and the water retention capacity of the blends. That affects the textural properties of the doughs increasing hardness, gumminess, resilience, elasticity, and consistency. The use of DCP for unfermented dough production is possible, and its texture characteristics are appropriate for the industrial processes that are currently carried out.

The larger particle size of DCP than that of wheat flour affects the extensibility of the doughs, probably due to the particles being able to hinder the formation of the gluten network. DCP produce the weakening of the gluten network in doughs with partial replacement. That could negatively affect fermented doughs but, this must be investigated properly. However, the extensibility of DCP was significantly higher than other gluten-free doughs or doughs with partial replacements.

CRediT authorship contribution statement

Amanda Cazzaniga: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing - review & editing, Visualization. **Sandra Hase:** Conceptualization, Methodology, Formal analysis, Writing - review & editing. **M. Marcela Brousse:** Investigation, Resources, Supervision. **Andrés R. Linares:** Conceptualization, Methodology, Investigation, Supervision.

Declaration of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.lwt.2020.110310.

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