

Coconut flour (*Cocos nucifera* L.) partial replacement on wheat flour (*Triticum aestivum*)-based tortillas and its effect on dough rheology and tortilla quality

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Abstract

One of the popular flatbreads in northern Mexico are the wheat-flour (WF) tortillas to prepare 'burritos' widely accepted in USA and other countries, but with low nutritional quality. Therefore, to increase protein and fiber contents we replaced 10 or 20% WF with coconut (*Cocos nucifera*, variety Alto Saladita) flour (CF) and evaluated the effects in dough rheology and quality of the composite tortillas. There were differences in the optimum mixing time among the doughs. The protein, fat, and ash contents of the tortillas increased ($p < 0.05$), with the CF increasing. The carbohydrate content was not different ($p > 0.05$), but the 20% CF tortillas contained more fiber than the control tortilla. Tortilla firmness increased ($p < 0.05$) and extensibility decreased ($p < 0.05$) with the CF increasing. The 80:20 blend tortillas showed the highest firmness (7.9 N), whereas the control and the 90:10 blend tortillas did not differ ($p > 0.05$) in firmness. There were no differences ($p > 0.05$) in extensibility between the composite tortillas. The physicochemical properties of the tortillas indicated that the 20% CF-containing tortilla is a better nutritive option to only wheat flour tortilla for its higher dietary fiber and protein contents, in addition to the slightly reduction in extensibility compared to the WF tortilla.

Introduction

Coconut (*Cocos nucifera* L.) flour is a byproduct obtained after extracting coconut oil and coconut milk from coconut meat. It is rich in fiber, protein, fat, vitamins and minerals [1]. The usage of coconut flour has increased in the snacks and bakery segment to align with consumers' needs and preferences. The global coconut flour market is estimated to be valued at USD 2,100 Mn in the year 2022 and is estimated to grow at an unprecedented rate to achieve a value of USD 6,699 Mn by the year 2032 with a compound annual growth rate (CAGR) of 12.3% during the assessment period 2022–2032 [2].

After drying and milling, the coconut flour can be an excellent partial replacement of wheat flour for bread-making, or fat partial replacement in other food products. These wheat-based foodstuffs frequently are poor sources of fiber and protein, and contain high proportion of fat; therefore, they are related to overweight and obesity with its health consequences. The fiber content is especially important because it helps to the intestinal motility reducing the intestinal cancer risk; additionally, it reduces the glycemic load eviting the circulating glucose peaks which are risky for diabetes mellitus patients [3].

Wheat flour tortillas are very popular in north México, with an increased consumption in USA [4]. The dough is prepared with a mix of wheat-flour, oil or shortening, water and salt, and the dough is formed into a thin, round pieces before baking. In spite of the low fiber content of wheat flour tortillas, few attempts to improve its nutritional quality and fiber content have been done [5]. Therefore, the objective of this study was to prepare different formulations for tortilla-making using blends of wheat and coconut flours, and evaluate the effect of replacement level on dough rheology and the quality of the composite tortillas.

Materials And Methods

Coconuts of the Alto Saladita variety (ASV) from Tecpan de Galeana, Gro., Mex, were used in the study. The pulp was obtained by the Walter et al. [6] and Abioye [7] procedures. After remotion of the testa, the pulp was manually grated. Refined all-purpose wheat (*Triticum aestivum*) flour was from a local market. Solvents and chemical-grade reagents as well as α -, β -, and γ - tocopherol standards were from Sigma Chem Co.

Coconuts Hardness

The coconut flesh of ten coconuts was cut into 1x1 cm pieces (10 cubes per coconut, taken from different areas of each coconut) and hardness was measured with a TA-XT2 texturometer (Texture Analyzer Stable Micro Systems, Surrey, UK) using a cylindrical attachment with diameter of 1 mm at a test speed of 1 mm/s, penetration of 7.5 mm and a force of 100 g. The force and distance thresholds were 10 g, and 1 mm, respectively.

Determination Of Water Activity (A_w)

The water activity of the grated pulp was measured by triplicate before and after drying using a HygroPalm equipment (Rotronic AG, Bassersdorf, Switzerland). The target of A_w for the dry pulp was set at 0.65 based on preliminary assays for extracting most of the oil.

Color

The color measurement of the fresh and dry pulp, the flours, and tortillas, was carried out with a Chroma Meter CR-400 (Konica Minolta Sensing, Inc., Osaka, Japan), recording values for L^* (brightness or whiteness), a^* (redness to greeness), and b^* (yellowness to blueness).

Coconut Drying And Oil Extraction

The grated pulp was dried at 50°C for 2 h, in an Enviro-Pak air dryer (MP500 Series) with an air velocity of 3.0 m/s. Water activity of the pulp was monitored at different time intervals until reach a value of 0.65, since this value is recommended to successfully extract most of the oil and obtain the residue to prepare the coconut flour. The oil was extracted from the dry pulp using a manual oil press, where the equipment was not subjected to any type of previous heating, this in order to maintain the quality of the dry coconut pulp.

Preparation Of Coconut Flour

The dried and partially defatted coconut pulp underwent pre-grinding in a food processor (Moulinex AR6838, Apaseo el Grande, Gto., México) in order to reduce its particle size, and then continue grinding in

a Pulvex 200 mill (Pulvex de México, S.A. de C.V., CDMX, México) with a 1 mm mesh.

Proximate Composition

Proximal analysis of the wheat flour (control), coconut flours of the ASV and a commercial sample, and tortillas was done by the Methods 44-16.01, 46-13.01, 30-20.01, and 08-01.01 [8] for moisture, protein, fat, and ash contents, respectively. The two-stage Approved Method 44-15A [8] was used for tortilla moisture analysis. The conversion factors for protein content were 5.75, 5.3 [9], and 6.25 for the control, coconut flour, and composite tortillas, respectively. The carbohydrate content was calculated by difference.

Vitamin E Content

The content of vitamin E of the defatted coconut flours of ASV and the commercial sample was determined according to [10] and [11]. Once the hexane was evaporated with nitrogen, the sample in the test tube was reconstituted with 0.2 mL of absolute ethanol, turning the tube to incorporate part of the sample that could be adhered to the wall, homogenizing in vortex for 30 s. Then, the sample was placed in an amber vial. The vitamin E content was determined using an HPLC (1260 Infinity, Agilent Technologies, Santa Clara, CA, USA) with an UV-Visible detector and a C18 Agilent Microsorb column (100-3 C18, 100 x 4.6 mm). An isocratic mobile phase of methanol:water (98:2, v/v) was used. Detection was performed at a wavelength of 290 nm. Standards were solutions of α , β and tocopherol.

Soluble, Insoluble And Total Dietary Fiber

Dietary fiber (SDF, IDF, TDF) of the dry and defatted ASV coconut flour was quantified using a Megazyme kit (K-TDFR-100A). Analysis was done by duplicate.

Preparation Of Flours Blends And Dough Rheology Properties

Wheat and coconut flour blends were prepared by replacing wheat flour with 10 or 20% ASV flour. The rheological properties of the dough were determined with the Mixograph (National Mfg. Co., Lincoln, IL, USA) according to the Method 54-40.02 [8]. The optimum mixing time (min) (OMT) and water absorption (%; 14% mb) for the dough of the blends and the wheat flour only, were obtained.

Preparation Of Wheat Flour And Composite Tortillas

The ingredients used to prepare the tortillas are shown in Table 1. The amount of flour was adjusted to 14% mb. The amount of shortening in the recipe was adjusted to keep the same fat content as that of the control tortillas. Doughs of the different formulations were obtained by mixing all ingredients in a Model 2150-A-10 mixer (National Mfg., Co., Lincoln, NE, USA) according to the OMT determined in the

mixograph, then dough was divided into balls of 30 g, covered with a plastic sheet, and rested at ambient temperature (25°C) for 20 min. Then, the balls were hot-pressed for 1 s each side and baked in a hot-plate at 293–296°C for 40 s each side.

Table 1
Ingredients to prepare the wheat flour (control) and the composite tortillas.

Tortilla sample	Flour (g)	Water (%)	Shortening (%)	Salt (%)
Control (100:0)	99.2	63.0	10.0	1.5
Blend-1 (90:10)	98.5	63.8	7.4	1.5
Blend-2 (80:20)	97.9	64.8	6.2	1.5

Physicochemical Analysis Of Tortillas

Tortillas’ diameter (cm) and thicknesss (mm) were measured. The proximate composition and color measurements were determined as previously described. The tortilla texture was measured objectively with a TA-XT2 texturometer (Stable Micro Systems Ltd, Godalming, Surrey, UK) using a cylindrical rounded end probe (TA-23) and the TA-108N rig (Fig. 1). The settings were test speed 2.0 mm/s, distance and force of 35 mm and 0.98 N, respectively. The force (N) required to rupture the tortilla and the distance (mm) before rupturing were recorded as firmness and extensibility, respectively.

Statistical Analysis

Data of composition of the flours and tortillas, dough rheological and tortilla textural properties, was analyzed using the SAS software (SAS Institute Inc., Cary, NC, USA). A one-way ANOVA for the variables of the flours and the obtained tortillas was performed, and Tukey-Kramer test for means comparison were done. Significance was $p < 0.05$.

Results And Discussion

Coconuts Hardness

The average hardness of the coconuts ASV was 36.6 ± 8.3 N. This value is 9.4 times higher that obtained by Siriwongwilaichat *et al.* [12] for coconuts harvested at 6 months, but our coconuts ASV were 12–14 months. In an immature coconut, the endosperm is thin and contains a lot of water, so with increasing maturation the endosperm thickens and as a result increases in hardness [13].

Chemical Analysis Of Coconut Flours And Tortillas

The contents of protein, ash, moisture, fat, and carbohydrates for the dried pulp were 10.8 ± 0.1 , 1.2 ± 0.0 , 6.4 ± 0.2 , 48.2 ± 0.4 , and 33.4% , respectively. The protein content is in the range 6–12% obtained by other authors [14, 15] as well as the ash content [16], with values between 0.85–1.26%. Regarding the fat content, an intermediate value between the reported range (34–63%) was observed, this may be due to differences in the maturity stage of the coconuts [15]. The carbohydrate content of our sample exceeds the range reported (24.6–26.3%), this increase can be favorable, in favor of a higher fiber content. Our partially defatted coconut flour (ASV) contains more protein and less fat, ash and carbohydrates than the commercial sample (Table 2) and the values for coconut flour of the USDA database report [17]. The soluble and insoluble dietary fiber contents of the ASV flour were $1.1\% \pm 0.1$ and $46.3\% \pm 0.5$, respectively, which make a total dietary fiber of 47.4%. The ASV coconut flour presented 0.16 mg vitamin E/100 g of sample, whereas the commercial sample did not show any tocopherol content. For fresh coconut pulp, the content of vitamin E reported by EFSA [18] was 0.73 mg/100g, since it is a fat-soluble vitamin, it is likely that the highest proportion of vitamin E is found in the coconut oil obtained from the dried pulp. In spite of the commercial coconut flour contained a greater amount of fat than that our ASV flour, its tocopherol content was null. It could be attributed to the method of oil extraction and grinding for obtaining the commercial flour or its handling during storage or distribution.

Table 2
Chemical composition (wb) of the partially defatted ASV flour, the commercial coconut flour and that from the USDA database [17].

Coconut flour sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbo-hydrates* (%)	TDF (%)
Alto Saladita V.	7.3 ± 0.1 b	20.4 ± 0.1 b	13.7 ± 0.2 a	3.2 ± 0.1 a	53.4	47.8 ± 0.5
Commercial	3.9 ± 0.2^a	18.1 ± 0.2^a	17.4 ± 0.3 b	4.9 ± 0.1 b	55.7	n.d.**
USDA Database	n.d.**	14.3	14.2	n.d.**	57.1	35.7

Values are mean $\pm$ standard deviation. Values in the same column with different superscripts mean significant differences ($p < 0.05$). *

Calculated by difference. ** No determined

Dough Rheological Properties Of The Flours Blends

The OMT of the control flour and the 90:10 mix was not different ($p > 0.05$), however, the

80:20 mixture showed an increase of 0.5 min, that is an OMT of 6.0 min. This could be because this mix contains a higher ratio of coconut flour compared to the 90:10 mix, and provides a higher amount of protein, therefore will absorb more water and takes longer to mix optimally. The water absorption

increased as the level of substitution increased (1–2%). This is attributed to the fact that protein and fiber compete for water, and the coconut flour is rich in protein (20.4%) and fiber (47.5%) [19].

Physicochemical Analysis Of Tortillas

The diameter and thickness of the control tortillas were 13.4 ± 0.5 cm and 1.7 ± 0.2 mm, respectively, similar to those obtained by Salazar-García et al. [20], but it was thinner than that reported by Montemayor-Mora et al. [21]. The tortilla made with the mix 80:20 showed a diameter of 12.7 ± 0.4 cm and thickness of 2.0 ± 0.1 mm. The protein, fat, and ash contents of the tortillas increased as the ASV flour substitution level increased (Table 3). The carbohydrate contents (total carbohydrates minus total dietary fiber) of the control and the tortillas containing 10 or 20% ASV were 49.2%, 45.9%, and 42.5%, respectively. The TDF content of the composite tortillas were 5.1% and 8.5%, whereas that of the control tortilla was 1.9%. The TDF content of the 20% ASV flour containing tortilla compared to the control tortilla is 4.5 times higher.

Table 3
Chemical composition (wb) of the control and the composite tortillas containing 10 or 20% ASV flour.

Tortilla blend	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	TDF*	Carbo-hydrates**
Control	30.4±0.0 ^c	9.1±0.2 ^a	8.0±0.2 ^a	1.4±0.0 ^a	1.9	49.2
90:10	28.9±0.0 ^b	10.4±0.2 ^b	8.1±0.2 ^a	1.6±0.0 ^b	5.1	45.9
80:20	27.1±0.1 ^a	11.0±0.1 ^b	9.0±0.3 ^b	1.9±0.0 ^c	8.5	42.5

Values are mean of triplicate ± standard deviation. Values in the same column with different superscripts mean significant differences ($p < 0.05$). *Total dietary fiber estimated using the contents of the constituent flours. ** Calculated by difference minus TDF.

Other baking products have been modified by partial replacement of wheat with coconut flour. Abioye [7], substituted chapatti with 20% coconut flour and TDF content increased 2–3%, similarly for composite cakes by Hossain *et al.* [1], where the increase was proportional to the level of coconut flour substitution. Composite noodles including up to 30% coconut flour by Gunathilake and Abeyrathne [22], who noted a gradual increase in the substituted samples. After partial replacement of wheat flour to prepare chapatties, cakes, and noodles, the previously cited authors noted that the sensory and quality parameters were significantly affected as the substitution was greater. However, it was compensated by the nutritional properties of the final product. A maize milling by-product highly rich in dietary fiber has been used for fortification of biscuits and improve their nutritional characteristics [23].

According to the European Union Food Safety Authority [18], foods with a contribution greater than 6% of TDF are considered as “rich in fiber”, and our tortilla with the 80:20 mixture contained 8.5% TDF; therefore,

it is a rich in fiber product. The energy values estimated from data in Table 3, for the control and the 20% ASV flour-containing tortillas, were 305.2 and 303.9 kcal/100 g, respectively, after correction by water content in the products. These values were 11 and 28% lower than those reported by Abioye [7], for control and 20% substituted chapatties, mainly due to the higher fat content of chapatties. We took account of the fat content in the added ASV flour to our tortillas.

The range of L* values of the tortillas was 61.0 to 70.7. Tortilla lightness increased ($p < 0.05$) as the amount of ASV flour increased. This indicates that the ASV flour contributes to the tortilla having a more pleasant whitish color for the consumers. The a* values of tortillas were close to zero, and the b* values of the composite tortillas (20.4 and 19.4) were not different, whereas the control tortilla was the least yellow (18.2).

The textural properties of tortillas are shown in Table 4. Tortillas firmness increased with the increase of ASV flour. Control and the 90:10 blend tortillas were not different ($p > 0.05$) in firmness (10.5 N vs 9.9 N), whereas the 80:20 blend tortillas showed the highest firmness (7.9 N) and differed ($p < 0.05$) from the rest. A soft tortilla requires more force for rupturing and it extends more before rupturing. The area (Nmm) under the curve of the force vs distance plot, that is the work needed to rupture the tortilla, follows the same trend as firmness. A firmer tortilla withstands less force and requires less work or energy for rupturing. There were no differences ($p > 0.05$) in extensibility between the composite tortillas, but extensibility was reduced 12% and 19% for the 90:10 and the 80:20 blends compared to the control.

Table 4
Textural properties of the wheat flour (control) and the composite tortillas.

Tortilla	Firmness (N)	Area (Nmm)	Extensibility (mm)
Control 100:0	10.5±1.6 ^b	52.5±13.9 ^c	24.9±2.5 ^b
Blend 90:10	9.9±2.0 ^b	42.4±13.7 ^b	21.9±3.4 ^a
Blend 80:20	7.9±1.2 ^a	33.1±6.7 ^a	20.1±2.5 ^a

Different superscript letters in the same column indicate significant differences ($P < 0.05$). Values are means of 15 measurements ± standard deviation.

Conclusions

Partial substitution of wheat flour with ASV coconut flour in tortilla making improved total dietary fiber and protein content without significantly affecting the textural properties and color of tortillas. The 20% ASV flour containing tortilla provides 8.5% TDF and 11% protein, representing 4.5 times the TDF and 1.2 times the protein of the 100% wheat tortillas. The optimum mixing time of the wheat flour and the 90:10 blend was comparable ($p > 0.05$); however, the 80:20 blend presented a longer ($p < 0.05$) time of 6 min. Water absorption increased as the substitution level increased. The 80:20 blend tortillas showed the

highest firmness (7.9 N), whereas the 100% wheat and the 90:10 blend tortillas did not differ ($p > 0.05$) in firmness. Extensibility was similar ($p > 0.05$) between the composite tortillas. Therefore, due to high nutritional quality and similar properties of the wheat-based tortilla, the one prepared with the 80:20 blend is a good option.

Abbreviations

ASV: Alto Saladita Variety

CAGR: Compound annual growth rate

CF: Coconut flour

EFSA: European Food Safety Authority

HPLC: High performance liquid chromatography

IDF: Insoluble dietary fiber

mb: moisture basis

OMT: Optimum mixing time

SDF: Soluble dietary fiber

TDF: Total dietary fiber

USA: United States of America

USDA: United States Department of Agriculture

Declarations

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Author Contribution. ARI-R: Conceptualization, draft preparation, editing and funding acquisition; FL-E, FV-L, LCM-B, GRC-M, AMC, NGH-S: technical development and supervision.

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References

1. Hossain S, Shishir MZI, Saifullah MD, Shahidullah-Kayshat MD, Wasit-Tonmoy S, Rahman A, Shams-Ud-Din MD (2016) Incorporation of coconut flour in plain cake and investigation of the effect of sugar and baking powder on its baking quality. *International J Nutr Food Sci* 5(1): 31-38. <https://doi.org/10.11648/j.ijnfs.20160501.15>
2. Coconut Flour Market Outlook (2022-2032) Report (2022). <https://www.futuremarketinsights.com>
3. Carlson JL, Erickson JM, Lloyd BB, Slavin JL (2018) Health effects and sources of prebiotic dietary fiber. *Curr Dev Nutr* 2:nzy005. <https://doi.org/10.1093/cdn/nzy005>
4. Rodríguez-Noriega S, Buenrostro-Figueroa, JJ, Reboloso-Padilla ON, Corona-Flores J, Camposeco-Montejo N, Flores-Naveda A, Ruelas-Chacón X (2021) Developing a descriptive sensory characterization of flour tortilla applying flash profile. *Foods* 10:1473. <https://doi.org/10.3390/foods10071473>
5. Subiria-Cueto R, Larqué-Saavedra A, Reyes-Vega ML, de La Rosa LA, Santana-Contreras LE, Gaytán-Martínez M, Vázquez-Flores AA, Rodrigo-García J, Corral-Avitia AY, Núñez-Gastelum JA, Martínez-Ruiz NR (2019) *Brosimum alicastrum* Sw. (Ramón): An alternative to improve the nutritional properties and functional potential of the wheat flour tortilla. *Foods* 8:613. <https://doi.org/10.3390/foods8120613>
6. Walter EHM, Nasamiento MS, Kaye AY (2009) Efficacy of sodium hypochlorite and peracetic acid in sanitizing green coconuts. *Lett Appl Microbiol* 49:366-371. <https://doi.org/10.1111/j.1472-765X.2009.02670.x>
7. Abioye OS (2018) Valorization Strategies of Coconut Flour. Dissertation, Ghent University, Belgium.
8. AACC International (2000) Approved Methods, 10th edn, American Association of Cereal Chemists, St. Paul MN
9. Shinaga SM, Margata L, Silalahi J (2015) Analysis of total protein and non-protein nitrogen in coconut water and meat (*Cocos nucifera* L.) by using Kjeldahl method. *Int J Pharmtech Res* 8(4):551-557
10. Hess D, Keller HE, Oberlin B, Bonfant R, Scheup W (1991) Simultaneous determination of retinol, tocopherols, carotenes and lycopenes in plasma by mean of high performance liquid chromatography on reversed phase. *Int J Vitam Nutr Res* 61:232-238
11. Onibi GE, Scaife JR, Murray I, Fowler VR (1998) Use of α -tocopherol acetate to improve fresh pig meat quality of full-fat rapeseed-fed pigs. *J Am Oil Chem Soc* 75:189-198. <https://doi.org/10.1007/s11746-998-0031-x>

12. Siriwongwilaichat P, Thongart K, Thaisakornphan P (2014) The effect of blanching on texture and color of frozen young coconut meat. *Food Appl Biosci J* 2: 143-151.
<https://doi.org/10.14456/fabj.2014.16>
13. Anonyme (2006) Fruit: Encyclopédie en ligne. Website:
http://encyclopedia.jrank.org/fo/FRA_GAE/FRUIT_par_le_français_du_fructus.html
14. Assa RR, Konan KJL, Prades A, Nemlin J, Koffi E (2010) Physicochemical characteristics of kernel during fruit maturation of four coconut cultivars (*Cocos nucifera* L.). *Afr J Biotechnol* 9: 2136-2144.
15. Prakruthi A, Sunil L, Prasanth KPK, Gopala KAG (2014) Composition of coconut testa, coconut kernel and its oil. *J Am Oil Chem Soc* 91:917-924. <https://doi.org/10.1007/s11746-014-2447-9>
16. Solangi AH, Iqbal MZ (2011) Chemical composition of meat (kernel) and nut water of major coconut (*Cocos nucifera* L.) cultivars at coastal area of Pakistan. *Pak J Bot* 43(1):357–363
17. US Department of Agriculture, Agricultural Research Service. (2018) Nutrient Data Laboratory, USDA Branded Food Products Database. <http://www.ars.usda.gov/nutrientdata>
18. EFSA (2010) *EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA): Scientific Opinion on Dietary Reference Values for water. EFSA J* 8:1459 [48 pp.]. <https://doi.org/10.2903/j.efsa.2010.1459>. Available in internet: www.efsa.europa.eu
19. Friend CP, Serna-Saldivar SO, Waniska RD, Rooney LW (1992) Increasing the fiber content of wheat tortillas. *Cereal Food World* 37:325–328
20. Salazar-García MG, Buitimea-Cantúa NE, Silveira-Gramont MI, Cota-Gastélum AG (2008) Evaluación de textura en tortillas de harina de trigo por métodos de corte y extensibilidad. *Biotecnia X*(1):19-28
21. Montemayor-Mora G, Hernández-Reyes KE, Heredia-Olea E, Pérez-Carrillo E, Chew-Guevara AA, Serna-Saldivar SO (2018) Rheology, acceptability and texture of wheat flour tortillas supplemented with soybean residue. *J Food Sci Technol* 55(12):4964-4972. <https://doi.org/10.1007/s13197-018-3432-3>
22. Gunathilake KDPP, Abeyrathne YMRK (2007). Incorporation of coconut flour into wheat flour noodles and evaluation of its rheological, nutritional and sensory characteristics. *J Food Process Preserv* 32:133–142. <https://doi.org/10.1046/j.1439-0361.2003.02062.x>
23. Paraskevopoulou A, Rizou T, Kiosseoglou V (2019) Biscuits enriched with dietary fiber powder obtained from the water-extraction residue of maize milling by-product. *Plant Foods Hum Nutr* 74:391-398. <https://doi.org/10.1007/s11130-019-00752-8>

Figures

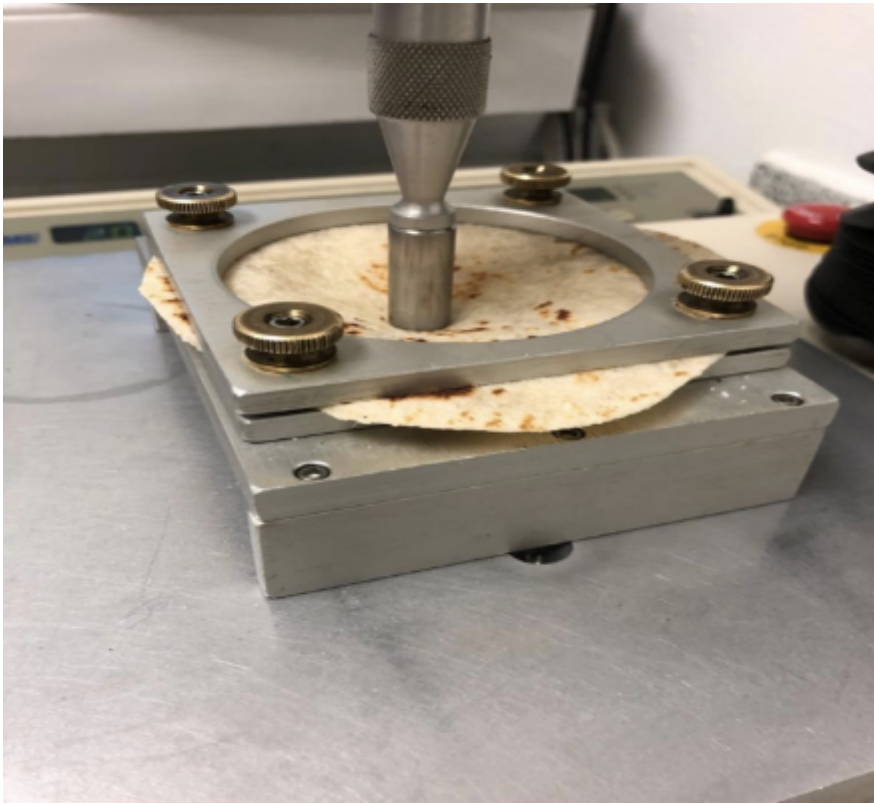


Figure 1

Tortilla firmness and extensibility measurement