Making of bakery products using composite flours: Wheat and cactus pear (*Opuntia boldinghii* Britton *et* Rose) stems (cladodes)

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Abstract

Cactus pear (*Opuntia boldinghii* Britton *et* Rose) stems (cladodes) are used because of their high fiber content and beneficial health contribution. In this research, the partial substitution of wheat flour (WF) by cactus pear stem flour (SF) in the development of bakery products was evaluated. Stems were dried, ground and sifted. Breads were made using pure wheat flour (control) and four formulations of flour composed of WF and SF: I (WF 100%; control), II (SF 5%), III (SF 10%), IV (SF 15%) and V (SF 20%). In the farinaceous test, flours composed of formulations II and III showed the best baking behavior. The proximate composition of breads presented significant differences ($p<0.05$) and all formulations were microbiologically stable. Sensory evaluation showed that formulation III (SF 10%) was the most acceptable for its color, odor and flavor, while the texture of formulation II (SF 5%) was the most acceptable. In conclusion, prickly pear stem flour is a viable alternative for making bakery products.

Key words: *Opuntia boldinghii*, stems, Cactaceae, bread, compound flours.

Introduction

Bread is a product of high nutritional value and is consumed in most parts of the world (Mandala *et al.*, 2007), providing energy, iron, calcium, vitamins and proteins (Indriani *et al.,* 2007). It is a perishable product and its production involves the cooking or baking of dough obtained by mixing wheat flour, edible salt (table salt) and potable water (drinking water), fermented by species of budding yeast used in baking such as *Saccharomyces cerevisiae,* and with or without the inclusion of any special component (Mesas and Alegre, 2002).

Conventionally, flours used in bread making are made from cereals, mainly wheat (Cauvain and Young, 2002). In Venezuela, wheat bread is highly consumed as part of the diet. However, in this country all the wheat for bakery, and other uses, must be imported to satisfy the internal requirement because its amount cultivated is not sufficient; this item is affecting the economy and food security of the nation.

Pacheco–Delahaye and Testa (2005) maintain that wheat can be mixed with other cereals and plants with high starch content which could constitute a locally available and less costly nutrient source in addition to enriching the dietetic fiber sources. These mixtures are referred as 'composite flour' and they have used to develop bread (Torres and Pacheco–Delahaye, 2007).

Cactus species represents an agro–alimentary resource of potential use in bread making. Cactus developed in semiarid zones are used as forage (Aranda–Osorio *et al.,* 2008), and both fruit and cladodes are fresh–consumed, representing great potential for the food industry (Moβhammer *et al.,* 2006; Moreno–Alvarez *et al*., 2008). The genus *Opuntia* is highlighted for its use in the fabrication of numerous products which include: marmalades, flours, preserves, juices, beverages and pigment sources (Moβhammer *et al*., 2006; Moreno–Alvarez *et al.,* 2003, 2007; Sáenz *et al.,* 2006). On the other hand, it has been established that consumption of stems favors reduction in cholesterol, triglyceride and hypoglycemia (low blood sugar) (Butera *et al*., 2002). Likewise, Sáenz *et al*., (2006) indicated that cladodes just like other vegetables, contribute with high amounts of water to the diet and are highly valued for their starch content.

The *Opuntia* cladodes can be processed to obtain the following products: juices, pickles, brines, marmalades, jellies, flours, candies, sauces, and as tender nopal (Sáenz *et al*., 2006).

The aim of this investigation was the development of bakery products by partially substituting wheat flour for *Opuntia boldinghii* Britton *et* Rose cladodes flour. To this respect, physico–chemical, microbiological, sensorial, and farinographic parameters were evaluated, which allowed the establishment of the feasibility of making this type of product with nutritional values of interest and making use of resources not fully exploited in the country. *Opuntia* cladodes will also have the advantage of enriching the bread with dietary fiber.

Materials and methods

Materials

One hundred (100) kg of *Opuntia boldinghii* Britton *et* Rose cladodes (stems) were collected from specimens located in the Guama Municipality, Yaracuy State, Venezuela (Figure 1). The selection criteria were as follows: mature fruits, taken from the youngest parts of the plant, ranging from 11.11 to 17.23 cm long, and 9.58 to 10.04 cm in diameter (from the apical end until the fourth cladode). The collection was done from 12.01 to 13:00 hours with the aim of ensuring a constant titratable acid value during the study, because of the Crausulacean Acid Metabolism (CAM) that Cactaceae family presents. These samples were transported, in thermal polystyrene containers fitted with dry ice reaching a temperature of 7±1°C, to the Laboratory of Biomolecules of the 'Universidad Nacional Experimental Simón Rodríguez' at Canoabo core Venezuela, in order to perform physico–chemical analyses.

Physico–chemical and microbiological characterization of the cladodes

A sample of 250 g of fresh cladodes was taken for evaluating moisture, pH, titratable acidity, soluble solids (SST) and vitamin C according to the AOAC (1990) proposed methodology and total carotenoids following the procedure established by Moreno–Álvarez *et al*. (1999). The determination of pH was evaluated in a Hanna Instruments® potentiometer Sep–1 model with ±0.01 precision; soluble solids were determined using a Bausch & Lomb® refractometer model Abbe–3L with a precision of ±0.1 and expressed as ºBrix. Vitamin C was measured using the volumetric method of 2,6 dichlorophenol–indophenol. Mesophyll aerobes (COVENIN, 1978b), molds and yeasts (COVENIN, 1978a) from fresh cladode samples were also evaluated.

Figure 1. Plant and fruits of *Opuntia boldinghii* Britton *et* Rose.

Obtaining of cladodes flour
The samples were longitudinally cut and dried in a Felisa® stove Model FE–294AD at a temperature of 44±1 ºC until obtaining 10% moisture content. Grinding was done using a Torotrac millstone and the samples were then sifted through a W.S. TYLER sieve model RX–812 until a particle size of 210µ was obtained.

Bread formulation
Five (5) formulations were established for bread–making (Table1). These proportions were established according to Sáenz *et al*. (2002).

Proximate characterization of formulated flours
Moisture, protein (N x 6.25), fat, ash and total dietary fiber were determined by means of AOAC (1990) methodologies.

Evaluation of dough farinographic profile
A Brabender farinograph model PT–100 with automatic control was used. The parameters evaluated were: used volume (mL), % water absorption, arrival time (min), development time (min), departure time, stability (min) and mixing tolerance index (µf).

Table 1. Proportions of cladodes flour (CF) and wheat flour (WF) used for making breads.

Formulation	CF (%)	WF (%)
I	0	100
II	5	95
III	10	90
IV	15	85
V	20	80

Breadmaking

Breads were made according to Cauvain and Young (2002) establishing the following base formulation: flour 61.73%; water 32.10%; commercial *Saccharomyces cerevisiae*® yeast 1.23%; sugar 3.09% and butter 1.85%. The ingredients were mixed in a spiral kneader at 60 rpm for 20 min at 28 ºC with the aim of obtaining dough with plastic characteristics and adequate oxygenation. The dough was fermented during 120 min in an air–conditioned chamber of 30 ºC and 85% relative humidity. Then, a wooden rolling–pin was used for molding sheets of dough which were later rolled to obtain the desired form (long with conical ends and an average size of approximately 40 cm long and 10 cm wide, average weight of every units was 400 g), making shallow cuts and fermented by 50 min. Baking was done in a Werner & Pleiderer electric continuous oven at temperature 238ºC during 30 min. Two (2) kg of finished product was obtained for each formulation.

Proximate and microbiological bread characterization

The proximate analysis was done according to AOAC (1990) for protein, fat, ash and crude fiber. Microbial analysis (mesophyll aerobes, molds and yeast) was done following the COVENIN (1978 a,b) methodologies.

Sensory evaluation

The breads made with different formulations were evaluated using a 5–point hedonic scale going from '*I really like*' to' (Value 1) to '*I really dislike*' (Value 5), according to the methodology proposed by Larmond (1982). For this, a group of 40 consumers ranging from 17 to 23 years old of both sexes, all of which were students from the 'Universidad Nacional Experimental Simón Rodríguez', Campus Canoabo, Carabobo State, Venezuela were called upon to evaluate color, taste, smell and texture.

Statistical analysis

A random experimental design of five treatments (proportion of cladodes flour in every bread formulation) by triplicate was applied. Physicochemical results were the means (n=3) ±SD (standard deviation). All data were subjected to analysis of variance (ANOVA) and Tukey's means comparison by using the Statistical Analysis System (SAS, 1992) software. Friedman's non–parametric analysis was applied for the sensory evaluation. The significance level was stated at 95%.

Results and discussion

Table 2 shows the results of the physico–chemical characterizations of the cladodes (stems). Titratable acidity, pH and vitamin C content differ from the findings of Moreno–Álvarez *et al*. (2006) for cladodes of the same species, differences that may be associated with the collecting season and the geographic regions. The values of moisture, total carotenoids and soluble solids were similar to findings of the stated authors. The results confirming that *Opuntia* cladodes are an excellent source of carotenoids: This characteristic is an advantage taking into consideration the antioxidant capacity and biological activity of these pigments (Moreno–Alvarez *et al*., 1999; Moreno–Alvarez *et al*., 2003).

The microbiological evaluation of the raw material is shown in Table 3. The values for mesophyll aerobes, molds and yeasts are found within the limits indicated by Moreno–Álvarez *et al*. (2007) for *Opuntia eliator* Miller fruits and by Frazier and Westhoff (2003) for fruits and vegetables during harvest season, which indicate values between $1x10^3$ and $6.7x10^5$ CFU/g considering them useful as raw materials.

Table 2. Physical and chemical parameters of *Opuntia boldinghii* cladodes.

Parameter	Value*
pH	4.30 ± 0.01
Titratable Acidity (g of citric acid /100g of pulp)	0.18 ± 0.01
Soluble Solids (SST) (º Brix)	7.0 ± 0.1
Vitamin C (mg of ascorbic acid /100 g of pulp)	12.11 ± 0.08
Moisture content (%)	88.66 ± 0.48
Total Carotenoids (mg/100 g of pulp)	34.840 ± 0.001

*Mean value (n=3) ± standard deviation.

Table 3. Microbiological evaluation of *Opuntia boldinghii* cladodes.

Parameter	Value
Mesophyll aerobes (CFU /g)	$2.90x10^4$
Molds(CFU/g)	$1.80x10^4$
Yeast (CFU/g)	$4.50x10^3$

The results for the stem (cladode) flour proximal analysis are presented in Table 4. Moisture is similar to the findings of Moreno–Álvarez *et al*. (2006) for cladodes of the same species. The protein content reported in this investigation (7.43%) is within the values reported for different species of the genus *Opuntia* (Sáenz *et al*., 2006). Ether extract of 3.41% is greater than in the findings of Moreno–Álvarez *et al*. (2006) for cladodes of the same species, a difference which may be attributed to the different climatic conditions where harvesting was done. The ash and dietary fiber content of 28.94 and 41.5%, respectively, are similar to the findings of Sáenz *et al*. (2006) and Moreno–Alvarez *et al*. (2006) for *Opuntia* cladodes (stems) less than one year old.

Table 4. Proximate composition of cladode flour.

Parameter (%)	Value*
Moisture (%)	10.05±0.08
Protein (%)	7.43±0.38
Ether extract (%)	3.41±0.17
Ash	28.94±0.07
Dietary Fiber	41.50±1.28

*Mean value (n=3) ± standard deviation.

The proximate composition of the flours composed of wheat and stem flour are presented in Table 5. According to COVENIN (2001), the wheat flour for bread–making must have a protein content of 15%, a value which is surpassed in formulations II (16.10%) and III (15.25%), while in formulations IV and V the values were 14.90 and 13.75, respectively. Compared with the ash content marked by the same standards (0.9%), the compound flours showed higher values which is due to the elevated percentage of ash present in the stems (Moreno–Álvarez *et al*., 2006). Formulation II (5% SF) did not show significant differences with respect to the 100% WF, while the other flours had significant differences. As to fat, ash and fiber content, the compound flours showed differences with respect to formulation I, which marks an effect for the substitution of wheat flour for stem four.

Table 5. Proximate composition of mixtures of cladodes flour (CF) and wheat flour (WF) used for making breads.*

Parameter (%)**	I	II	III	IV	V
Moisture	12.89±0.03 [a]	12.73±0.05 [b]	12.47±0.02 [c]	12.20±0.05 [d]	12.04±0.03 [e]
Protein	16.44±0.02 [a]	16.10±0.18 [a]	15.25±0.13 [b]	14.90±0.09 [c]	13.75±0.16 [d]
Fat	3.95±0.14 [a]	2.40±0.06 [b]	2.30±0.04 [c]	2.20±0.02 [c]	2.08±0.02 [d]
Ash	0.45±0.05 [a]	2.05±0.04 [b]	3.34±0.04 [c]	4.01±0.02 [d]	5.99±0.02 [e]
Crude fiber	0.30±0.03 [a]	0.42±0.02 [b]	2.57±0.04 [c]	3.90±0.05 [d]	6.42±0.06 [e]

**Mixtures of flours were showed in Table 1.

**Mean value (n=3) ± standard deviation. Different letters in the same row indicate significant differences (p<0.05).

The parameters of the farinographic study of the flours used are shown in Table 6. An increase in water absorption, resulting higher in the mixtures compared to pure wheat flour was observed. This effect increased with the increase the proportion of stem flour used in the mixture. Similar variations in this property has been reported for other compound fours based on wheat and the same has been associated with the presence of dietetic fibers (Moreno–Álvarez *et al.*, 2006). With respect to the other parameters and based on the criteria indicated by Durán *et al*. (2001) and Dobraszczyk (2004), substituting up to 15% wheat flour for stem flour is considered. The behavior is the same for a strong consistency, characteristics of flour destined for bread–making.

Table 6. Farinographic profile of flours.*

Parameters	I	II	III	IV	V
Water Absorption (%)	60.0	61.0	62.0	63.0	64.0
Arrival time (min)	1.5	1.5	1.5	1.5	1.5
Development time (min)	7.5	6.0	6.0	5.0	3.0
Departure time (min)	10.5	9.0	8.0	7.5	5.0
Stability (min)	9.0	7.5	6.5	6.0	4.0
Mixing tolerance index (MTI) (μf)	80.0	80.0	60.0	60.0	40.0

*Mixtures of flours were showed in Table 1.

The increase in the proportion of cactus pear stem flour mixed with wheat flour caused a decrease in dough stability, noting that at cladode concentrations higher than 15%, the wheat–stem mixture tends towards a weak flour, which affects the bread quality of the raw material given that this type of flour is not recommendable for baking. Weak flours are useful for making products like cookies and biscuits.

Table 7 shows the results of the proximate analysis of the breads. The protein content of formulation II did not show significant differences (p<0.05) with respect to Formulation I, which indicates that the 5% substitution did not influence the protein level. The remaining formulations (III, IV, V) did show significant differences (p<0.05). In the other hand, the protein content was above 13% in all substitutions; this value of protein content (13%) is the minimum required in bread, according to the findings of Granito and Guerra (1995). According to COVENIN (1988), the protein contents of the formulations of breads from cladodes are greater than the protein contents of white bread (7.5%) and whole bread (8%). Fat content from the stem flour formulations showed significant differences (p<0.05) in comparison with the 100% wheat flour. A significant increase in ash and dietary fiber content was observed in the bread made with prickly pear stem flour in comparison to the wheat flour bread. This change is due to the elevated levels of these nutrients within the stems. The dietary fiber is important because it has showed beneficial in human health (Slavin, 2008).

The results of the microbiological analysis are shown in Table 8. The mesophyll aerobes count, expressed as CFU/g, is below the findings of Pacheco–Delahaye and Testa (2005) for breads made with wheat and banana flour. The levels of the microorganism determined, are in accordance with COVENIN (1988) requirements (10^2–10^3 CFU/g) for bread.

The results obtained from the sensory evaluation are indicated in Table 9. It was shown that the increase in the wheat flour proportion influenced consumer preferences. Color, smell, taste and texture parameters presented significant differences as demonstrated through the Friedman nonparametric test with 95% of reliability (Table 10). Significant differences with respect to the studied variables were detected in this test, which indicates that the evaluation was a judgment tool for discerning consumer preference. In studying the values obtained, it can be inferred that the formulation with 10% stem flour shows high values with respect to color, taste and aroma whereas the formulation with 5% stem flour was most accepted in terms of its texture.

Table 7. Proximate composition of breads making from cladodes and wheat flours.*

Parameter**	I	II	III	IV	V
Protein	16.34±0.06^a	15.90±0.07^a	15.10±0.23^b	14.70±0.20^b	13.41±0.25^c
Fat	2.60±0.02^a	2.55±0.04^b	2.48±0.02^b	2.43±0.08^c	2.30±0.09^c
Ash	0.44±0.08^a	1.50±0.11^b	3.140.12^c	4.78±0.07^d	6.42±0.14^e
Fiber	0.40±0.04^a	2.52±0.03^b	2.60±0.12^b	3.96±0.10^c	6.50±0.17^d

*Mixtures of flours were showed in Table 1.

**Mean values (n=3) ± standard deviation. Different letters in the same row indicate significant differences (p<0.05)

Table 8. Microbiological evaluation of breads making from cladode and wheat flours mixtures.*

Formulation	Mesophyll aerobes (CFU/g)	Yeast (CFU/g)	Molds (CFU/g)
I	$2.80x10^3$	$2.10x10^1$	$3.10x10^2$
II	$2.70x10^3$	$2.20x10^2$	$4.10x10^2$
III	$2.60x10^3$	$2.40x10^2$	$3.30x10^2$
IV	$2.90x10^3$	$2.30x10^2$	$3.20x10^2$
V	$3.10x10^3$	$2.60x10^2$	$3.80x10^2$

*Mixtures of flours were showed in Table 1.

Table 9. Ranking values of sensory evaluation breads making from cladodes and wheat flours mixtures.*

Formulation	Flavor	Odor	Color	Texture
I	3.01	3.17	3.00	3.41
II	3.63	3.56	3.50	3.60
III	3.70	3.59	3.93	3.44
IV	2.54	2.51	2.35	2.49
V	2.12	2.17	2.22	2.06

*Mixtures of flours were showed in Table 1.

Table 10. Friedman test values in the sensory evaluation.

Flavor		Odor		Color		Texture	
F	p	F	p	F	p	F	p
36.843	0.00001	33.998	0.00001	45.022	0.00001	39.145	0.00001

F: Friedman statistic.
P: Probability value using the approximation of Chi–squared.

Conclusions

It can be proven that the technological feasibility of bread– making using a natural resource such as the cladodes (stems) of *Opuntia boldinghii* exists. The farinographic profile indicates that flours composed of 5 and 10% stem flour are the most suitable for making bread. The chemical characterization of the breads showed significant differences among those made with composite flours and pure wheat flour. The sensory evaluation showed that the presentation of 5 and 10% stem flour were best accepted. The agro–industrial exploitation of these products would permit the use of a marginal species in the country with adequate nutritional value, in addition to reducing the cost of making pastry and bread products.

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References

Association of Official Analytical Chemists (AOAC). 1990. Official Methods of Analysis of the AOAC. 15th edition. Washington, D.C. 1298 p.

Aranda–Osorio, G., Flores–Valdés, C.A. and Cruz–Miranda, F.M. 2008. Inclusion of cactus pear cladodes in diets for finishing lambs in Mexico. Journal of the Professional Association for Cactus Development 10: 49–55

Butera, D., Tesoeire, L., Di Gaudio, F., Bongiorno, A., Allegra, M., Pitaudi, A., Kohen, R., and Livera, M. 2002. Antioxidant activities of sicilian pear (*Opuntia ficus–indica*) fruit extracts and reducing properties of betalainas: Betanin and indicaxanthin. Journal of Agricultural and Food Chemistry 50: 6895–6901.

Cauvain, S.P. y Young, S.L. 2002. Fabricación de Pan. Editorial Acribia, S.A. Zaragoza, España. 419 p.

COVENIN. 1978a. Método para el Recuento de Hongos y Levaduras. Norma Nº 1337. Comisión Venezolana de Normas Industriales. Caracas, Venezuela. 6 p.

COVENIN. 1978b. Método para el Recuento de Microorganismos Aerobios en Placa de Petri. Norma Nº 902. Comisión Venezolana de Normas Industriales. Caracas, Venezuela. 5 p.

COVENIN. 1988. Pan. Norma Nº 226. Comisión Venezolana de Normas Industriales. Caracas, Venezuela. 15 p.

COVENIN. 2001. Harina de Trigo. Norma Nº 217. Comisión Venezolana de Normas Industriales. Caracas, Venezuela. 9 p.

Dobraszczyk, B.J. 2004. Trigo y Harina. pp. 127–171. In: Dendy, D.A. y Dobraszczyk, B.J. (Eds.) Cereales y Productos Derivados. Editorial Acribia, S.A. Zaragoza, España.

Durán, L., Fizman, S.M., y Benedito, C. 2001. Propiedades Mecánicas. pp. 147–187. In: Alvarado, J. y Aguilera, J.M. (Eds.). Métodos para Medir Propiedades Físicas en Industrias de Alimentos. Editorial Acribia, S.A. Zaragoza, España.

Frazier, W.C. y Weshoff, D.C. 2003. Microbiología de los Alimentos. Editorial Acribia, S.A. Zaragoza, España. 426 p.

Granito, M. y Guerra, M. 1995. Uso del germen desgrasado de maíz en harinas compuestas para panificación. Archivos Latinoamericanos de Nutrición 45(4): 322–328.

Indriani, D., Prabhasankar, P., Rajiv, J., and Venkateswara, R.G. 2007. Influence of whey protein concentrate on the rheological characteristics of dough, microstructure and quality of unleavened flan bread (parotta). Food Research International 40: 1254–1260.

Larmond, E. 1982. Laboratory methods for sensory evaluation of food. Pub N◦ 1637. Food Research. Departament of Agriculture. Canada. pp. 81–119.

Mandala, I., Karabela, D., and Kostaropoulos, A. 2007. Physical properties of breads containing hydrocolloids stored at low temperature. I. Effect of chilling. Food Hydrocolloids 21: 1397–1406.

Moβhammer, M.A., Stintzing, F., and Carle, R. 2006. Cactus pear fruits (*Opuntia* spp.): A review of processing technologies and current uses. Journal of the Professional Association for Cactus Development 8: 1–25

Mesas, M. y Alegre, M.T. 2002. El pan y su proceso de elaboración. Ciencia *y* Tecnología Alimentaria 3(5): 307–313.

Moreno–Álvarez, M.J., Gómez, C., Mendoza, J. y Belén, D. 1999. Carotenoides totales en cáscara de naranja (*Citrus sinensis* L. variedad 'Valencia'). Revista Unellez de Ciencia y Tecnología 17**:** 92–99.

Moreno–Álvarez, M.J., Medina, C., Antón, L., García, D. y Belén, D. 2003. Uso de pulpa de tuna (*Opuntia boldinghii*) en la elaboración de bebidas cítricas pigmentadas. Interciencia 28(9): 539–543.

Moreno–Álvarez, M.J., García–Pantaleón, D., Belén–Camacho, D.R., Medina–Martínez; Muñoz–Ojeda, N., Herrera, I. y Espinoza, C. 2006. Evaluación Bromatológica de frutos y cladodios de la tuna (*Opuntia boldinghii* Britton y Rose). Boletín Nakari 17(1**):** 9–12.

Moreno–Álvarez, M.J., Betancourt, M., Pitre, A., García, D., Belén D. y Medina, C. 2007. Evaluación de la estabilidad de bebidas cítricas acondicionadas con dos fuentes naturales de betalainas: Tuna y remolacha. Bioagro 19(3): 149–159.

Moreno–Álvarez, M.J., García–Pantaleón, D., Belén–Camacho, D., Medina–Martínez C., y Muñoz–Ojeda, N. 2008. Análisis bromatológico de la tuna *Opuntia eliator* (Cactaceae). Revista Facultad de Agronomía de la Universidad del Zulia 25(1): 68–80.

Pacheco–Delahaye, E. y Testa, G. 2005. Evaluación nutricional, física y sensorial de panes de trigo y plátano verde. Interciencia 30(5): 300–304.

Sáenz, C., Berger, H., García, J.C., Galletti, L.J., García de Cortázar, V., Higuera, L., Mondragón, C.; Rodríguez–Félix, A., Sepúlveda, E. y Varnero, M. 2006. Utilización Agroindustrial del Nopal. Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO). Roma, Italia. 165 p.

Statistical Analysis System (SAS). 1992. Users Guide. SAS Versión 6.0. Statistical Analysis System Institute. USA.

Slavin, J.L. 2008. Position of the American Dietetic Association: Health implications of dietary fiber. Journal of the American Dietetic Association 108: 1716–1731.

Torres, E. y Pacheco–Delahaye, E. 2007. Evaluación nutricional, física y sensorial de panes de trigo, yuca y queso llanero. Revista Chilena de Nutrición 34(2): 133–141.