J. Agric. Sci. Mansoura Univ., 29 (12): 7107 - 7115, 2004

PRODUCTION OF TORTILLA CHIPS FROM CORN AND/OR SORGHUM:
I. PHYSICOCHEMICAL CHANGES OCCURRED IN STARCH GRANULES

Hegazy, Nefisa A.*; A. R. Shalaby*; F. A. Salem; Somaya M. Abd El-Moneim** and A. M. Hussein***

*** Food Sci. and Tech. Dept., National Research Centre, Dokki, Cairo and**

****Food Sci. Dept., Fac. Agric., Zagazig Univ., Zagazig, Egypt.**

ABSTRACT

This study was performed mainly to produce tortilla chips from maize and sorghum grains. Two varieties of white corn (Single cross 10 and triple cross 321) and two varieties of yellow corn (Single cross 152 and single cross 156) beside Dorado sorghum were used. Physicochemical changes occurred in starch granules of raw materials during tortilla chips processing were as follows: dry matter losses (DML) were 7.00, 6.27, 8.58, 9.84 and 5.98% for WC10; WC321; YC152; YC156 and DS, respectively. The moisture content of WC10, WC321, YC152, YC156 and DS increased during lime-cooking and steeping from 11.42, 9.92, 11.39, 12.77 and 11.09 to 70.5, 69.3, 67.7, 73.79 and 64.43%, respectively. The corresponding water retention was 233.8, 225.7, 208.6, 281.4 and 181.2% . The obtained masas had the best machinability properties. The amyloviscosity profiles of grain starches gelatinized in water revealed that corn starch is more available for gelatinization than sorghum . Corn starches had a constant viscosity during cooking which increased during cooling. Sorghum had a highest peak viscosity at 95C followed by decrement due to granules break down. Gelatinization in lime decreased the temperature of initial viscosity of all grains and increased the corn flour viscosity, whereas sorghum viscosity was decreased. The temperature of the max. viscosity (peak) decreased from 94.5 to 72C for corn varieties and from 94.5 to 77C for sorghum. The viscosity at 50C was higher in corn flour gelatinized in water than corn and sorghum starches gelatinized in lime solution.

INTRODUCTION

Corn is considered as one of the principal crops in Egypt and its production is increasing annually. The produced corn is mainly directed for animal and poultry feeding, although there is a suffering from a shortage of cereal-based foodstuffs. Sorghum is the fifth most important cereal in total world production. The grain of sorghum is similar in composition and properties to maize. So, sorghum is a substitute for corn in some Latin American countries because it is cheaper, produces higher grain yields, and has nutritional value similar to corn. Therefor, it would be beneficial to manufacture both corn and sorghum as food staffs and to try introducing a new corn and sorghum products to Egyptian food market. Snaks and covenience foods seemed to be regularly consumed in developing countries as well as have been long consumed in the Egyptian diets as popular food. Therefore, corn and sorghum could be used in such products, i.e. tortilla chips.

Tortilla chips are made from corn and sorghum by the nixtamalization process. Nixtamalization causes some changes in the physical appearance of the protein bodies and starch of the kernel. The structural and chemical changes of the grain during tortilla chips processing affect the functional properties, i. e., texture, color, crispiness, flavor and shelf life, of the final products. The physicochemical properties of alkaline-cooked products prepared from different grains have been reported, as well as the structural changes occurring during preparation of nixtamalized, baked and fried products have also been documented (Choto *et al.*, 1985 and Gomez *et al.*, 1989).

Most of the studies on grain alkaline-cooking dealing with starch have focused on the changes in structural and rheological properties. Alkaline-cooking process weakened the cell walls which facilitate the pericarp removal, solubilized cell walls in the peripheral endosperm, caused swelling and partial destruction of starch granules, and modified the physical appearance of the protein bodies (Gomez *et al.*, 1989). The over lime-cooking of maize increased starch gelatinization leading to a sticky masa with reduced particle size (Lee, 1992 and Ramirez-Wong *et al.* (1994). Alam (1996) reported that during lime cooking, calcium diffuses to the Centre of the starch granules and plays an important role in gelatinization and viscosity of the starch as well as improves the physical properties of the end product. Bryant and Hamaker (1997) stated that starch gelatinization indicators, such as: enzyme digestion, water retention capacity, starch solubility and gelatinization temperature are increased by addition of lime at levels between 0 and 0.5%, peaking at 0.2% .

The nixtamal was grounded in a stone grinder into masa with medium or coarse particles. Gomez *et al.* (1992) stated that starch solubilization was unchanged after alkaline-cooking and increased after steeping. Physical destruction of the kernel by grinding increase the starch solubilization in masa. Steeping and alkaline-cooking caused swelling and agglomeration of starch granules through out endosperm. Grinding the nixtamal caused compelete physical disruption of kernels, resulting in dispersion of swollen starch granules. Pflugfelder *et al.* (1988b) stated that particle size distribution of masa was most influenced by grinding conditions, while the proportion of free starch granules, dispersed lipids and dissolved solid components in masa critically affected the properties of tortilla masa and fried masa products.

This work was carried out to evaluate corn and sorghum grains for their suitability for tortilla chips production. In this experiment chemical comparition of grains was recorded along with the physicochemical changes occurred in starch granules during tortilla chips processing including dry matter losses and water retention, pasting properties as evaluated by Brabender amylograph.

MATERIALS AND METHODS

Materials:

Two varieties of white corn *(Zea mays),* i.e. single cross 10 and triple cross 321; two varieties of yellow corn, i.e. single cross 152 and 156; and local variety (Dorado) sorghum (*Sorghum bicolor L.*) were purchased from corn Breeding section, Field Crops Department, Agric. Res. Centre, Giza, Egypt.

Methods:

Dry matter loss:

A sample of each corn variety and sorghum (100gm) was treated with $Ca(OH)_2$ solution then with water. The extract was transferred into a volumetric flask (200ml.) and the volume was made up to the mark with water. An aliquid of the extract (200ml) was placed in a weighed porcelain desh and evaporated till dryness on a water bath, then heated in an oven at 60C until constant weight.

Water retention capacity:

Water retention capacity was determined according to the method of Almeida-Dominguez *et al.* (1991).

Initial and peak pasting viscosities:

Viscosity was measured using a Brabender Amylograph (Brabender Duisburg Nr. 940053, Type 680022). A sample of each corn and sorghum flour (60 gm) was suspended in 460 ml water. The suspension was placed in an amylograph, then temperature was raised at the rate of 1.5°C /min. with constant stirring. The sample was then held at 95°C for 20 min . and then cooled to 50°C. (Tonella *et al.* , 1983) .

RESULTS AND DISCUSSION

To obtain a good quality tortilla chips, it is very important to follow-up the changes occurred during processing and to control them.Otherwise, great variations in quality parameters of the product will occur according to grain variety and processing conditions. One of the most critical aspects of the tortilla chips process is masa texture. Masa texture depends on many factors including grain variety, dry matter losses, water uptake, degree of starch gelatinization and the differences of starch crystalline form in size and shape. Therefore, dry matter losses, water retention, starch gelatinization and starch crystallinity were measured for all grains during tortilla chips preparation .

Dry matter losses and water retention:

The loss of dry matter and water retention by grains during tortilla chips process are economically important to commercial tortilla chips producers. Achieving minimum dry matter losses and retain the appropriate amount of water are important to maintain low production costs and maximum nutrient content in the product, rather than their positive effect on the quality of the end product. Therefore, dry matter losses and water retention by different corn varieties and Dorado sorghum were measured during tortilla chips production.

Dry matter losses (DML):

From Table (1) it is observed that dry matter losses (DML) were 7.00, 6.27, 8.58, 9.84 and 5.98% for WC 10; WC 321; YC 152; YC 156 and DS, respectively. The obtained results revealed that sorghum had lost less dry matter during cooking, steeping and washing than white corn or yellow corn. Similar observation was previously given by Serna-Saldivar *et al.* (1988), Katz and Hediger (1974), Sproule *et al.*, (1988) and Alam (1996). However, the obtained data are considered low when compared with losses occurred when nixtamal is commercially processed (Khan *et al.*, 1982). Such difference could be attributed to that commercial nixtamal is subjected to agitation , pumping and conveying during processing.

Table (1): Water retention and dry matter loss of different corn varieties and sorghum during tortilla chips preparation.

Variety	Grains			Masa				DML	
	W. W.	M. C.	D. W.	W. W.	M. C.	D. W.	W. R.	(gm)	(%)
WC 10	200	11.42	177.16	550	70.50	164.75	233.8	12.41	7.00
WC 321	200	9.92	180.16	550	69.30	168.86	225.7	11.30	6.27
YC 152	200	11.39	177.22	500	67.70	162.0	208.6	15.22	8.58
YC 156	200	12.77	174.46	600	73.79	157.28	281.4	17.16	9.84
DS	200	11.09	177.82	470	64.43	167.17	181.2	10.65	5.98

W.W.: Wet weight (gm).
M. C.: Moisture content (gm).
D. W.: Dry weight (gm).
W. R.: Water retention (%).
DML : Dry matter losses.

It seems that, the magnitude and composition of DML were dependent on both kernels characteristics and processing conditions (Almeida-Dominguez *et al.*, 1991). In this respect, Pflugfelder *et al.* (1988a) stated that soft kernels have more DML than hard kernels when the process was performed under the same conditions. On the other hand, DML increased with increasing cooking time, but steeping accounted for much of the losses (Khan *et al.*, 1982 and Pfluglelder *et al.*,1988b). In this study, sorghum was exposed to one-third of the cooking time and one-half of the steeping period of corn, therefore it had less DML (5.98%) than corn (7.0%). It is worthy to mention that excess DML results in lower product yield and loss of nutrients into the sewage water (Almieda-Dominguez *et al.*, 1998). However, in any case appropriate assessment of the kernel grains quality and monitoring of processing conditions are fundamental to achieve minimum dry matter losses into the sewage water and maximum retention of nutrients in the end product which means the minimizing of both pollution and production costs, rather than produce a consistently high quality product.

Water retention:

The moisture content of WC10, WC321, YC152, YC156 and DS increased during lime-cooking and steeping from 11.42, 9.92, 11.39, 12.77 and 11.09 to70.5, 69.3, 67.7, 73.79 and 64.43%, respectively, as seen from Table (1). The corresponding water retention was 233.8, 225.7, 208.6, 281.4 and 181.2%. It has been reported that the moisture content of maize and sorghum increased during lime cooking and steeping from 11.7 and 14.2 to 50.8 and 53% respectively (Serna-Saldivare *et al.,* 1988).

It is worthy to mention that although the increased water uptake during tortilla chips processing is economically important to the producers, it leads to a development of undesirable masa. Nevertheless, the optimum moisture content of masa for tortilla and tortilla a chips processing is very difficult to determine, since it varies according to many factors including grain types, grain varieties, lime concentration, cooking temperature and cooking time (Vargas-Lopez *et al.,*1990). So, while moisture content of 51% has been found to be optimal (Gomez *et al.,*1987). Serna-Saldivar *et al.* (1988) stated that at 55% moisture, the masas had the best machinability. Moreover, masa with 58% moisture content was optimum for sheeting and forming (Ramirez-Wong *et al.,*1994), as well as those containing 63% moisture was considered to be suitable for tortilla manufacturing (Alam, 1996). In this study the obtained masas with the moisture content listed in Table (1) had the best machinability properties.

Pasting properties of different grains used for tortilla chips production:

It is well known that as gelatinization proceeds, the starch granule's network is obliterated and individual linear macromolecules (amylose) diffuse into the aqueous medium increasing its viscosity (Aguilera and Stanley, 1999). So, the degree of starch getatinization of different grains used in this work was performed using Brabender amylograph. The amyloviscosity profiles of grain starches gelatinized in water are given in Fig (1). It could be observed that all flour types of corn had a similar curve shape with different values . The obtained viscosity curves indicated that starch in WC10 is more available for gelatinization, whilst swelling and gelatinization of starch in the other types were restricted due to granules tightly locked within endosperm cells as indicated by Gomez *et al.* (1989). Moreover, corn starch seemed to be very resistant to breakdown, keeping a constant viscosity during cooking (95°C hold period). However, all corn samples increased in viscosity during cooling. The increase in viscosity upon cooling has been reported to be due to the starch retrogradation i.e., the recrystallization or reassociation of gelatinized starch (Appelquvist and Debet, 1997 and Kamel, 2001).

Sorghum had a different curve shape with highest peak viscosity at 95°C as a result granules swelling to the maximum, because its starch granules are more available in raw flour for gelatinization (Suhendro *et al.,* 1998), followed by granules breakdown which led to a decrease of viscosity during the 95°C hold period. The major factor in starch gelatinization is granule swelling which depends on the strength and character of the micellar network within the granule, which in turn is dependent on the degree and kind of association (Bhattachary and Hanna, 1987) which greatly differs between starch types rather than in individual granules of each starch species. Therefore, it could be noticed that the gelatinization levels varied according to the type of starch.

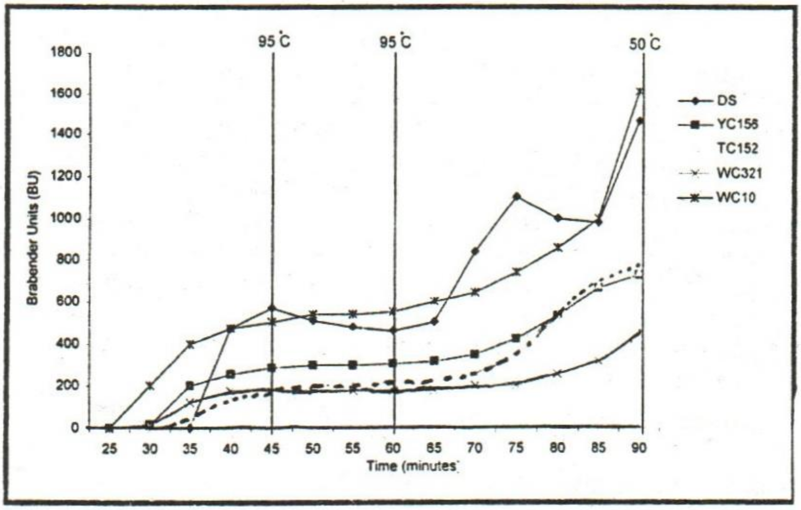

Fig (1): Amylographic characteristics of different flours gelatinized in water.

The viscosity curves of different starch types cooked in 1% lime solution were illustrated in fig (2). No relationship could be established between viscosity curves of starch gelatinized in the water (fig.1) and those gelatinized in the presence of lime (fig. 2). It seems that the presence of lime affected both viscosity peak profile and viscosity value . It could be observed that both YC152 and DS starches were very resistant to breakdown since their viscosity were constant during the 95°C hold period whilst the viscosity of WC321, WC10 and YC156 starches decreased as a result of swollen granules breakdown. It was reported that the elimination of any apparent peak indicates a lack of breakdown of swollen granules and slows granule swelling (Bryant and Hamaker, 1997) as in the case of YC152 and DS starches . *The low viscosity development observed for YC152 and DS during* the heating period with lime may be due to slow water diffusion and limited swelling of starch granules within endosperm cells (Gomez *et al.,* 1989). During alkaline cooking, sorghum starches are modified to a greater extent than corn starches (Serna-Saldivar *et al.,* 1988).

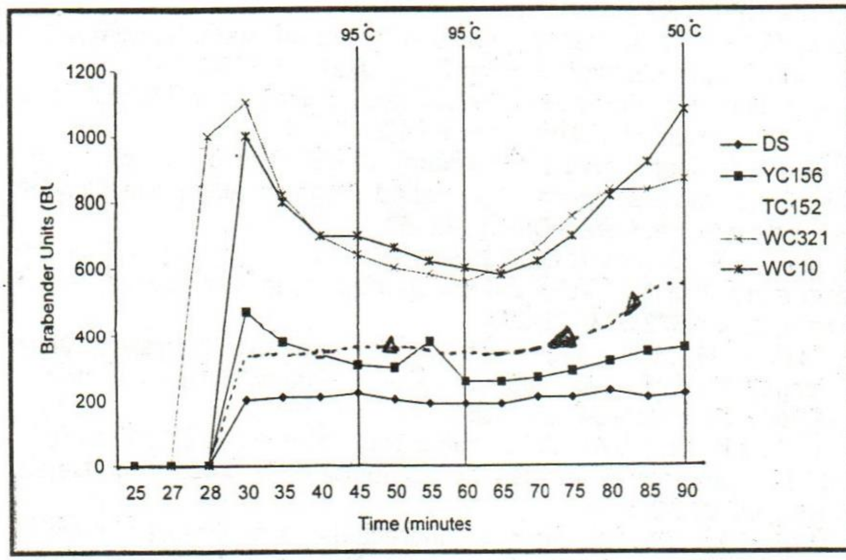

Fig (2): Amylographic characteristics of different flours gelatinized in 1% lime solution

It has been reported that amylographic viscosity peak could serve as an index of the flour suitability for making tortilla products (Mensah-Agyapong and William, 1992). They added that samples showed a depression between viscosity peak and the end of holding period at 95°C did not form a satisfactory tortilla dough. Moreover, McDonough *et al.* (1987) stated that flour with a low peak seemed to indicate that it will produce a sticky dough. However, during the experiment it has been observed that the doughs obtained from all grains in this work had a good adhesiveness and no problems of stickness.

REFERENCES

Aguilera, J.M. and D.W. Stanley (1999). Microstrctural principles of Food processing and Engineering, Second Edition. Chap. 5. p.185-241, in Food Structuring. Published in Aspen publishers, Inc. Gaithersburg, Maryland

Alam, S.O.A. (1996). Utilization of Nigerian and Egyptian maize grains to produce substituted bread tortilla for decreasing wheat consumption. M.Sc. Thesis, African Studies, Cairo Univ., Egypt.

Almeida- Dominguez, H.D.; S.O. Serna-Saldivar and L.W. Rooney (1991). Properties of new and commercial sorghum hybrids for use in alkaline cooked foods . Cereal Chem., 68 (1) : 25-31 .

Almeida- Dominguez, H.D.; G.G. Ordonez-Duran and N.G, Almeida (1998). Influence of kernel damage on corn nutrient composition, dry matter losses, and process ability during alkaline cooking . Cereal Chem., 75 (1) : 124-128 .

Appelquvist, I.M. and M.M. Debet (1997). Starch biopolymer interaction – Akeview .Food Rev.Int., 13 (2) : 163-224 .

Bhattachary,M. and M.A. Hanna (1987). Kinetics of starch gelatinization during extrusion cooking . J. Food Sci ., 52(2) : 764-766.

Bryant, C.M. and B.R. Hamaker (1997). Effect of lime on gelatinization of corn flour and starch. Cereal Chem.,74(2): 171-175.

Choto, C.E.; M.M. Morad and L.W. Rooney (1985). The quality of tortillas containing whole sorghum and pearled sorghum alone and blended with yellow maize. Cereal Chem., 62: 51.

Gomez, M.H.; L.w. Rooney R.D. Waniske and R.L. Pflugfelder (1987). Dry corn masa flour for tortilla and snack food production . Cereal Foods World, 32 (5): 372,373,375-377.

Gomez, M.H.; C.M. McDonough L.W. Rooney and R.D. Waniske (1989). Changes in corn and sorghum during nixtamalization and tortilla baking. J. Food Sci., 54: 330-336 .

Gomez, M.H.; J.K. Lee; C.M. McDonough; R.D. Waniska and L.W. Rooney (1992). Corn starch changes during tortilla chip processing. Cereal Chem., 69: 275-279.

Kamel, M.M.(2001). Physico-chemical characteristics of Egyptian Jasmine rice as affected by under- pressure and Microwave parboiling methods. J.Agric. Sci. Mansoura Univ., 26: 7853-7868.

Katz, S.H. and L.A. Hediger (1974). Traditional maize processing. Techniques Sci., 184: 765. C.F. : J. Food Sci., 45: 720 (1980).

Khan, M.N.; M.C. Des-Rosiers; L.W. Rooney ;R.G. Morgan and V.E. Sweat (1982). Corn tortilla : Evaluation of corn cooking procedures. Cereal Chem., 59(4) : 279.

Lee, J.K. (1992). The effect of processing conditions and maize varieties on physicochemical characteristics of tortilla chips. Dissertation Abstracts International B; 52: 453- order no. DA 9206526. P 130 .

McDonough, C.M.; A.Tellez-Giron; M. Gomez and L.W. Rooney (1987). Effect of cooking lime and alkali content on the structure of corn and sorghum nixtamal. Cereal Food World, 32:660-666.

Mensah-Agyapong, J. and H.F.A. William (1992). Nixtamalization of maize (Zea mays L) using a single screw cook-extrusion process on lime treated Grits . J.Sci. Food Agric., 60:509-514.

Pflugfelder, R.L.; L.W. Rooney and R.D. Waniska (1988a). Dry matter losses in commercial corn masa production . Cereal Chem., 65(2): 127-132.

Pflugfelder, R.L., L.W. Rooney and R.D. Waniska (1988b). Fractionation and composition of commercial corn masa . Cereal Chem., 65(3) : 262 .

Ramirez-Wong, B.; V.E. Sweat R.T. Torres and L.W. Rooney (1994). Cooking time, grinding and moisture content effect on fresh corn masa texture. Cereal Chem., 71 (4) : 337 .

Serna – Saldivar, S.O; A. Tellez – Giron and L.W. Rooney (1988). Production of tortilla chips from sorghum and maize . J. Cereal Sci., 8 (2) : 275 – 284 .

Serna-Saldivar, S.O.; L.W. Rooney and R. D. Waniska (1988a). Wheat Flour tortilla production. Cereal Foods World, 33 (10):855-864.

Sproule, A.M.; S.O. Saldivar; A.J. Bocxholt; L.W. Rooney and D.A. Knabe (1988). Nutritional evaluation of tortilla and tortilla chips from quality protein maize. Cereal Food World, 33(2):233–236.

Suhendro, E.L.; C.M. McDonough; L.W. Rooney; R.D. Waniska and S. Yetneberk (1998). Effects of processing conditions and sorghum cultivar on alkaline – processed snacks . Cereal Chem., 75 (2) : 187 – 193 .

Tonella, M.L., M. Sanchez ; and M.G. Salazar (1983). Physical, chemical, nutritional and sensory properties of corn based fortified food products. J. Food Sci., 48 : 1637 – 1640 .

Vargas-Lopez, J.M.; O . Pareds – Lopez and E. Espitia (1990). Evaluation of lime heat treatment on some physicochemical properties of amaranth flour by response surface methodology . Cereal Chem . , 67 (5) : 417 – 421 .

إنتاج شيبس الطرطية من الذرة /السورجم .١. التغيرات الفيزوكيماوية التى تحدث فى حبيبات النشا

نفيسة حجازى*ــ على شلبى*ــ سمية عبد المنعم ــ فوزى سالم** و أحمد حسين***

*** قسم الصناعات الغذائية ــ المركز القومى للبحوث**

**** قسم علوم الأغذية ــ كلية الزراعة ــ جامعة الزقازيق ــ الزقازيق ــ مصر**

أجريت هذة الدراسة لأمكانية أنتاج شيبس الطرطية من حبوب الذرة الشامية والذرة الرفيعة حيث تم استخدام صنفين من الذرة الأبيض هما هجين فردى ١٠ وهجين ثلاثى ٣٢١ وصنفين من الذرة الأصفر هما هجين فردى أصفر ١٥٢ و١٥٦ بجانب الصنف (دورادو) من الذرة الرفيعة ، والتغيرات الفيزوكيماوية التى ظهرت فى حبيبات نشا المواد الخام أثناء تصنيع شيبس الطرطية هى كمية المادة الصلبة المفقودة (D M L) وكانت ٧، ٦,٢٧ ، ٨,٥٨ ، ٩,٨٤، ٥,٩% بالنسبة الى هجين فردى ١٠ ، هجين ثلاثى ٣٢١ وهجين أصفر ١٥٢ وهجين أصفر ١٥٦ والدورادو على التوالى ، وكذلك محتوى الرطوبة بالنسبة لهذة الأصناف زاد اثناء المعاملة بالقلوى والنقع من ١١,٤٢ ، ٩,٩٢ ، ١١,٣٩ ، ١٢,٧٧ ، ١١,٠٩ % الى ٧٠,٥ ، ٦٩,٣ ، ٦٧,٧، ٧٣,٧٩ ، ٦٤,٤٣% على التوالى بالنسبة لهجين فردى ١٠، هجين ثلاثى ٣٢١ وهجين فردى أصفر ١٥٢و١٥٦ وكذلك صنف الذرة الرفيعة ، وكذلك نسبة الماء المحتجز كانت ٢٣٣,٨ ، ٢٢٥,٧ ، ٢٠٨,٦ ، ٢٨١,٤، ١٨١,٢% والعجينة المتحصل عليها كانت ذات صفات تكنولوجية ممتازة ، وكذلك لزوجة حبيبات النشا المجلتنة فى الماء كانت أفضل فى الجلتنة بالنسبة لأصناف الذرة البيضاء والصفراء من السورجم وكذلك لزوجة نشا الذرة كانت ثابتة أثناء المعاملة بالحرارة (الطبخ) فى حين ذادت أثناء التبريد بينما نشا السورجم كانت لزوجة عالية على ٩٥°م ثم أنخفضت نتيجة لتكسير الحبيبات بينما الجلتنة فى القلوى قللت درجة حرارة التحول لكل الحبوب وزودت لزوجة دقيق الذرة فى حين السورجم لزوجتة قلت وكذلك درجة حرارة اللزوجة القصوى قلت من ٩٤,٥ الى ٧٢°م بالنسبة لأصناف الذرة فى حين السورجم قلت من ٩٤,٥ الى ٧٧°م وكذلك اللزوجة عند ٥٠°م أرتفعت من دقيق أصناف الذرة المجلتنة فى الماء مقارنة بالذرة والسورجم المجلتنة فى القلوى.