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Viscoelastic behaviour of alginate texturized muskmelon (Cantaloupe) pulp

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ABSTRACT : A restructured muskmelon gel was formulated based on muskmelon pulp by alginate texturization for subsequent stabilization. Since the viscoelastic properties of the gel is important for processing, investigation was undertaken to study the influence of alginate on the gel like behaviour of muskmelon pulp. Experimental data from dynamic rheometric experiments showed that both storage modulus (G') and loss modulus (G'') at 25°C of restructured pulp were higher than the nonrestructured pulp; statistical evaluation ($P<0.05$) indicated G' values were significantly higher than G'' at all the frequencies tested. This implied that solid like properties were predominant. In addition low positive values of the slope of both modulii exhibited weak gel like properties for both the samples. The addition of sodium alginate and calcium to the pulp formed a complex increasing the firmness of muskmelon pulp. Effect of temperatures tested in the range of 25 to 85^{0}C showed that the values of G' or G'' were increasing for both the sample. Maximum storage modulus for both the samples was obtained at 85^{0}C at any particular frequency. It may be concluded that addition of calcium/alginate complex increased the firmness of muskmelon pulp and changed its viscoelastic properties.

KEY WORDS : Viscoelastic, Muskmelon, Restructured, Frequency sweep, Storage modulus, Loss modulus, Temperature effect

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Muskmelon is an important desert fruit grown in many countries of the world. It is a highly popular fruit for direct consumption liked for its smooth nonfibrous texture in addition to characteristic aromatic flavour, colour and sweetness. Considering its popularity a number of studies were reported (Siddappa and Bhatia, 1958; Urmil Bindra *et al.*, 1973; Kalra *et al.*, 1987; Bai *et al.*, 2001; Sapers *et al.*, 2001 and Scalzo *et al.,* 2001) on the development of value added product from muskmelon for its commercialization. Development of structured fruit products based on alginate texturization was the subject of a number of patents, papers and commercial applications.

Sodium alginate is selected as gelling agents because of the thermostability of the product developed. One of the most important and unusual properties of the alginates has been the ability of the soluble alginate salt to enter into controlled chemical reactions with calcium to produce attractive edible gels (Glicksman, 1969). This ability of the alginates has led to the texturization of apple pulp, grape fruit juice, raspberry and mango pulp (Nussinovitch and Peleg, 1990; Mouquet *et al.*, 1992).

Restructuring of muskmelon pulp with sodium alginate, calcium salt and glucono-δ-lactone is an effective method to develop a value added product which can be stabilized by thermal processing. Since perception of texture is a major sensory attribute in consumer psycho-physical appreciation, rheological measurements is of special significance in case of structured/texturized food product where texture is imparted to pulpy material through the formation of thermostable gels by alginate. Rheological behaviour of alginate gels was studied by both static and dynamic tests (Mancini *et al.,* 1990; Mitchell and Blanshard, 1976; Segeren *et al.,* 1974). Stress relaxation experiment showed a solid like behaviour whereas the results of creep experiments exhibited a liquid like viscoelastic behaviour (Moresi *et al.,* 2001).

Dynamic viscoelastic measurements are generally used for the evaluation of gel like characteristics of food material for the purpose of process engineering (Wu *et al.,* 1985 and Chen *et al.,* 1996).

In dynamic measurements the mechanical spectra of alginate gels were found to be characterized by dependency of shear storage modulus (G') and loss modulus (G") on frequency ranging from about 10^{-2} to $10^{2}S^{-1}$. Mechanical/viscoelastic properties of pure gels with or without blending of other carbohydrates are well informed (Luh *et al.,* 1976; Morris, 1983; Clark, 1982; Moresi *et al.,* 2001 and Moresi *et al.,* 2004). However addition of large quantities of fruit pulp were found to cause decrease in mechanical strength of the gel and consequently the texture of the product suffered. Most of the information on rheological characteristics of alginate texturized fruit products are based on static mechanical tests (Kaletunc *et al.,* 1990; Nussinovitch *et al.,* 1991 and Mouquet *et al.,* 1992). Dynamic rheometric experiments of alginate texturized gel containing fruit pulp have hardly been reported. Considering the importance of viscoelastic behaviour in food processing applications, the objective of the present investigation was to evaluate the viscoelastic characteristics of muskmelon pulp with and without alginate texturization.

■ METHODOLOGY

Texturization of musk melon pulp :

Muskmelon of Havamadnu variety and proper maturity was purchased from the local market, thoroughly washed in running water, hand peeled with stainless steel knives, cut into pieces and subjected to pulping in a pulper (Raylons metal works,Mumbai, India) fitted with 30 mesh screen. Texturization of musk melon pulp was carried out using the method desribed by Kaletunc *et al.* (1990) with modification. In the present study musk melon pulp (80 %) was neutralized with 2 N NaOH, adjusted to 25°B with sugar, blended with the all the ingredients together – sodium alginate (1 %), glucono-δ-lactone (1 %) and calcium hydrogen orthophosphate. The mixture was placed in a glass Petri dish and kept at 5°C for 16 hours for gel formation. The thickness of the gel slab was 2.5 mm.

Dynamic visco elasticity :

Dynamic rheometric measurements were carried out using a controlled stress rheometer, MCR-100 (Paar Physica, Physica Messtechnik GmbH, Stuttgart, Germany) equipped with a software US 200 version 2.30 for data acquisition and controlling the equipment. Oscillatory shear experiments on musk melon pulp with and without restructuring were conducted using a plate-plate measuring system (50 mm dia). During the experiments 50 mm photocopy paper discs were attached on both the plates to avoid sliding of the sample and the zero adjustment was automatically evaluated. After placing the sample on the lower plate, the upper plate was lowered down on the surface and finally pressed to 2 % of the initial height of the gel disc (Moresi *et al.,* 2001).

Dynamic strain sweep measurements were conducted at 25°C at constant frequency of 0.1 Hz as well as 10 Hz whereas dynamic frequency sweep was performed at constant strain of 0.5 %. In case of nonrestructured pulp the measurement gap was kept at 0.5 mm. The testing of the sample was performed at temperatures ranging from 25° to 85°C maintained by a peltier device and temperature bath. During the experiment storage modulus (G') and loss modulus (G") were recorded as a function of frequency.

■ RESULTS AND DISCUSSION

Linear viscoelastic behaviour of restructured and nonrestructured muskmelon pulp at frequencies of 0.1 Hz and 10 Hz operating the rheometer under controlled strain mode are represented in Fig. 1. It was reported earlier that by performing a series of strain sweep tests at low frequency it is possible to confirm that alginate gels behave like solid material. Linear strain range at both the frequencies was constant upto 0.0095. At the

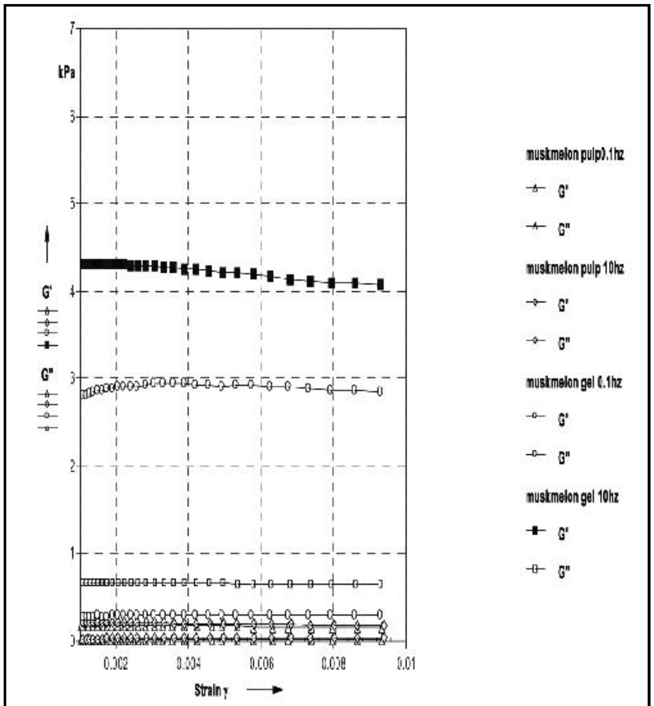

Fig. 1 : Strain sweep profile of non-structured and restructured muskmelon pulp at frequencies of 0.1 and 10 Hz at a temperature of 25⁰

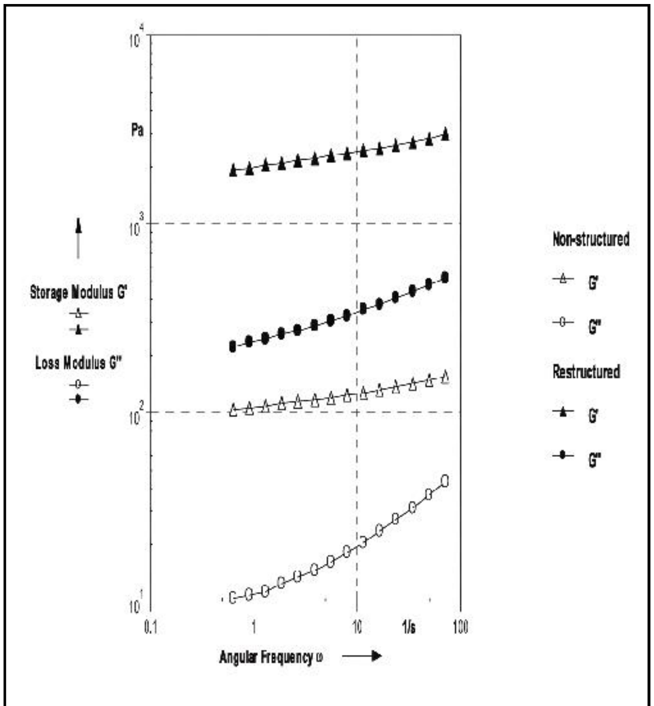

Fig. 2 : Storage modulus (G') and loss modulus (G") of non-structured and restructured muskmelon pulp measurement temperature=25⁰C

frequency of 10 Hz both storage and loss modulus of restructured pulp were found to be higher than that of 0.1 Hz. Whereas in case of non restructured pulp both the moduli G' and G'' were almost similar at 0.1 Hz and at 10 Hz, G' being more than G'' values. Amplitude sweep measurements was used for the frequency sweep experiment keeping the strain at 0.005 to include linear viscoelastic range in studying the dynamic rheological characteristics of restructured muskmelon pulp as compared to nonrestructured one.

Storage (G') and loss modulus (G'') of both restructured and nonrestructured pulp as a function of frequency at 25°C as log-log plot (Fig. 2) showed that both G' and G'' values of restructured pulp are higher than the nonrestructured pulp. Predominance of storage modulus (G') over loss modulus (G'') indicated a solid like characteristics of restructured product. It was also observed that slope of the curve in case of G' was much lower than G'' for both the restructured and nonrestructured muskmelon. It was reported earlier (Steffe, 1996) that typical slope value for gel generally less than the concentrated solution. Since G' and G'' values of the restructured were found to be more than that of nonrestructured pulp at all frequencies the muskmelon gel may be considered as a weak gel. G' and G'' values taken at different temperature (Fig. 3 a and b) also

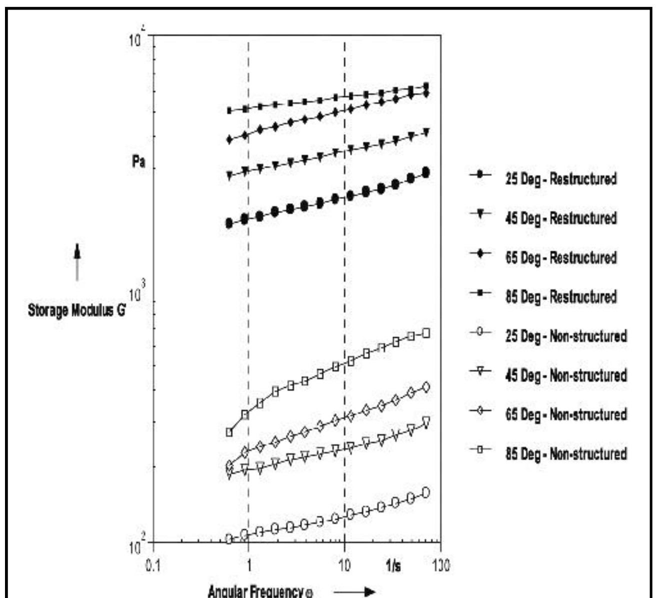

Fig. 3a : Effect of temperature of storage modulus of non-structured and restructured muskmelon pulp

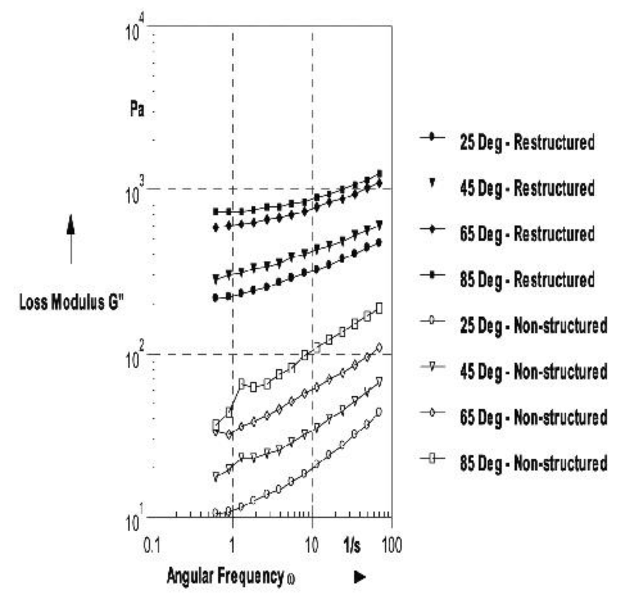

Fig. 3b : Effect of temperature on loss modulus of non-structured and restructured muskmelon pulp

showed the same trend. Chao and Lai (1999) while studying the dynamic rheological properties of a leaf gum/ starch mixed gel also observed that storage modulus was higher than the loss modulus and loss modulus showed steeper gradient typical of weak gel. Both storage and loss modulus of restructured as well as nonrestructured muskmelon pulp showed a increasing trend with the frequency at all the temperature studied. The effect of temperature on the viscoelastic properties of muskmelon pulp and gel showed a definite trend *i.e.* increase of both storage and loss modulus as the temperature increased. Hydrophobic interactions become stronger with the increase of temperature as reported by Oakenfull and Fenwick (1977). It may be inferred that hydrophobic interactions are stronger during the gelation of muskmelon pulp. However, Mao and Tang (1999) concluded from their experiment on the effect of temperature on gellan gels that hydrophobic interactions were less important. They observed that failure stress and strain of gellan gels decreased with increasing temperature indicating that the hydrogen bonding contributed significantly to the stabilization of gellan gels.

Conclusion :

It may be concluded from this experiment the muskmelon pulp as such showed gel like behaviour. Viscoelastic properties of muskmelon pulp changed with the addition of alginate and calcium salt for texturization. Higher values of storage modulus (G') for restructured gel as compared to pulp indicated increase of firmness due to texturization. Temperature showed a significant influence and definite trend on viscoelastic properties on both muskmelon pulp and restructured gel.

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