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Rheology of Karmatta Leaves (*Ipomoea aquatic*) Puree and its Yield Value Comparision

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Abstract : Semi liquid foods in form of purees are widely encountered in the recent decade. These purees are a dispersion of solid particles in the fluid medium. The rheological studies of purees are an important parameter for design and evaluation of process and consumer acceptability. The viscosity of fluids widely depends on temperature, composition, and its shear stress. In the initial part of investigation, rheology of various purees such as ginger, ipomoeaaquatica, coriander and mint puree were studied at room temperature. Measurements and calculations of different yield stress by Hershel Buckley model. In the present study, the karmatta (*Ipomoea aquatic*) puree was investigated at different temperatures (343K, 353K, 363K and Unblanched) by varying angular frequency from 0.1 to 100 rad/s. The wide range of shear rates was achieved for rheological characterization of the purees. The structural degradation with time by shearing signifies the characteristic of the non-Newtonian flow of purees. Storage modulus G' (Pa) and loss modulus G'' (Pa) were found to increase with an increase in frequency and decrease with strain. The viscosity was observed to decrease with shear rate due to change in fluid rheology with blanching media in terms of various flow models.
Keywords : Rheology, Purees, Food.

1. Introduction

A large portion of local spice and herbs like Ginger (*Zingiber officinale*), Coriander (*Coriandrum sativum*), Mint (*Mentha*) and green leafy vegetable likekarmatta (*Ipomoea aquatic)* produces is wasted due to lack of processing and storage facility as stated by Rudra[1]. As per Beuchat [2], these foods are not only used in the recent era but also used since ancient times, as flavoring agents, medicine, and food preservatives. In the twenty-first century, there is increase in demand of natural origin, safe and eco-friendly food. Therefore, there is, need to process purees as an option to provide a new and improved product. Beuchat [3] has been reported in there literature that some spices and herbs imparting flavors and enhance the storage life of foods by its antioxidant or bactericidal or bacteriostatic activity. Processing of these vegetables into paste and puree by the thermal technique is one of the best alternatives preservation technology that minimally affects sensory and nutritional quality as compared to the old once like as sun-drying, salting, and fermentation. The thermal technique of food preservation is most widely used one as per Ahmed [4].Within this limitation, it is important to investigate the relative changes of nutrients and quality part as a component of time and temperature as determined by Erge [5]. However, for using this strategy the duty of food process is not exclusively to produce an economically sterile product but also having a vital health outcome.

Based on the literature, to overcome the problem during flow there is need of knowledge on rheological properties of these purees for development, design, and evaluation of process equipment. As rheological estimations of food has been considered as an analytical tool to give key knowledge of the basic structural organization of food. For the most part, purees of foods are suspensions of solid in liquid media as stated by Rao [6], which demonstrated a pseudo plastic (shear thinning) behavior according to Ahmed [7]. In addition to this, it exhibit non-Newtonian property and consequently the heat penetration by means of natural convection current is very eccentric as shown by Choppe [8]. Rheological studies give data on how best to control flow properties of the product so that the desired product can be prepared. In the food industries, a precise understanding of yield stress of food material is required, minimum shear stress, which initiates the flow as stated by Dzuy [9]. In the food industries, yield stress is a very important engineering property, which affects the processing requirements, and the quality of the product.So the precise evaluation and calculation of the value of yield stress by different methods has been a challenging issue during the design of flow and velocity profiles through pipelines.

In this research, noted the rheological property (yield stress) of various purees to overcome the flow issue and perform strain sweep tests at a steady frequency of 2 Hz. The limit was determined in the linear viscoelastic regime of the sample (LVR). The present work researched the potential for planning and quality control of the thermal handling unit and to create shelf-stable purees, which could be used for the food industry.

2. Materials and Methods

Vegetable leaves were purchased from the local market and washed with water, de-stemmed and transferred for experimentation within 2 h. Sample if not used were stored at 4 ^{o}C until use. The yield of leaves after de-steaming is 60-70%. A known quantity of leaves was submerged in excess of water and subjected to blanching in the respective blanching media for 5 min. Effectiveness and time of blanchingwere determined by peroxidase inactivity test. After blanching, the leaves were immediately cooled to room temperature (301K) by soaked in ice-cold water. The leaves were mechanically disrupted into a puree using mixer grinder at 298K for 15 min. The puree was passed through a 14-mesh screen to get consistency. To obtain samples with a different range of solids content, the puree samples had been centrifuged (MRC, London) at 1000 rpm for 30 min, the volume and weight of the total sample were noted and then the centrifuge tube containing serum was carefully poured out from the pelleted material. After the separation, purees of 35ml samples were prepared by mixing with 20gm pelleted material and serum for analysis.

All the rheological test were conducted by using a modular compact Rheometer MCR 102 (Anton Paar, GmbH, Germany) and was mounted with a four-bladed vane geometry ST22-4V-40.The geometry was precisely brought down vertically into the specimen container by 10 mm from the surface level as proposed by Steffe [10]. After insemination, 35 ml of sample was poured into the Rheometer cup having test volume of 40ml. The temperature of the cup having sample was maintained at 303K. Strain sweep test and frequency sweep test were performed at already specified a blanched temperature (343K, 353K, 363K and unblanched temperature of leaves. Strain sweep tests were performed with increasing strain from 0.01–100% at a steady frequency of 1 Hz to obtain the linear viscoelastic range (LVE). While the dynamic parameters (G' and G") does not depend upon the size of applied strain and for the frequency sweep test a constant strain of 3% was chosen. Frequency sweep test is an outstanding strategy for analyzing the viscoelastic conduct of food, which can be useful for exploring its physical and chemical structure as stated by Cruz [11]. Frequency sweep test was completed at frequency 0.1–30 Hz (at a steady strain of 3%) to assess the dynamic rheological properties including loss modulus and storagemodulus.New samples was taken with applicable care for every experimentation to avoid the consequences of aging and to stay from high shear rate throughout sample loading, . The rheological estimations were investigated utilizing the Rheoplus software package of Anton Paar GmbH. All the rheological estimations were tired triplicate according to given methodology by Lad and Murthy [12]

3. Results and Discussion

The yield stress is time dependent property as shown by Cheng [13]. Major issues experienced during the measurement of the yield stress lie on various yield values got from various procedures and the reproducibility of the test data shown by Steffe [10]. Hence, an appropriate time scale of the experiment must be chosen generally, which cause a more organized structure due to their textural and subjective spread ability with an increment in shear rate. The difference in yield stress is because of its communication between the particles. The rheological study at constant ramped in shear rate from 1/s to 100/s showed an initial decrease of viscosity and afterward it showed a constant value. The initial decrease of viscosity was attributed to an irreversible deflocculating, which are described by Gallegos [14].The viscosity-shear rate curves of different purees were similar and the behavior was shear thinning. Viscosity decreased little when the shear rate increased and the flow became Newtonian. This is the characteristic of pseudoplastic fluids, which has been observed in Fig (6) of our viscosity-shear rate diagrams.

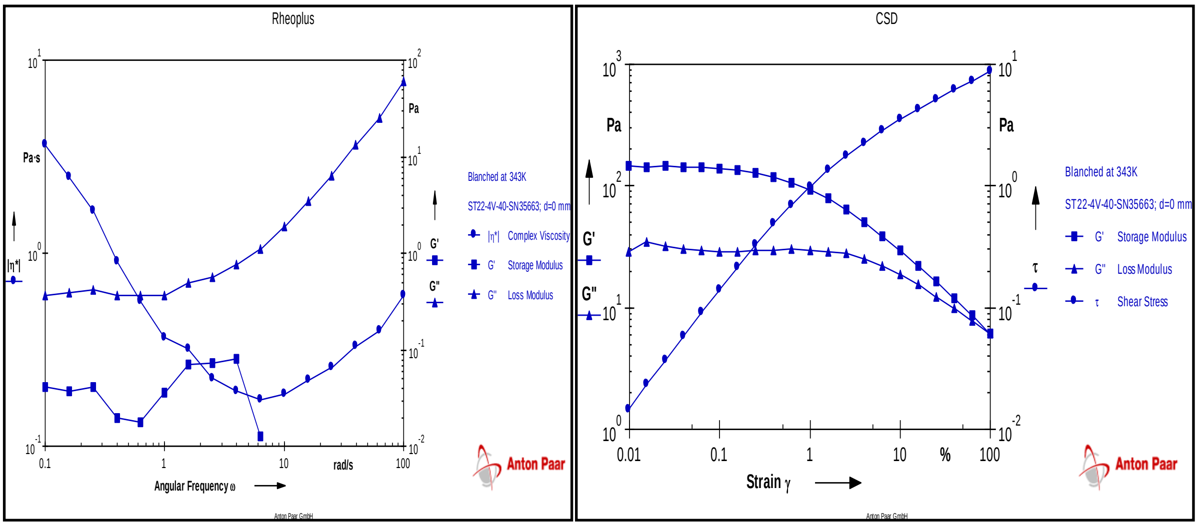

Fig. 2: Frequency and amplitude sweep tests for blanched ipomoea aquatic puree at 353K

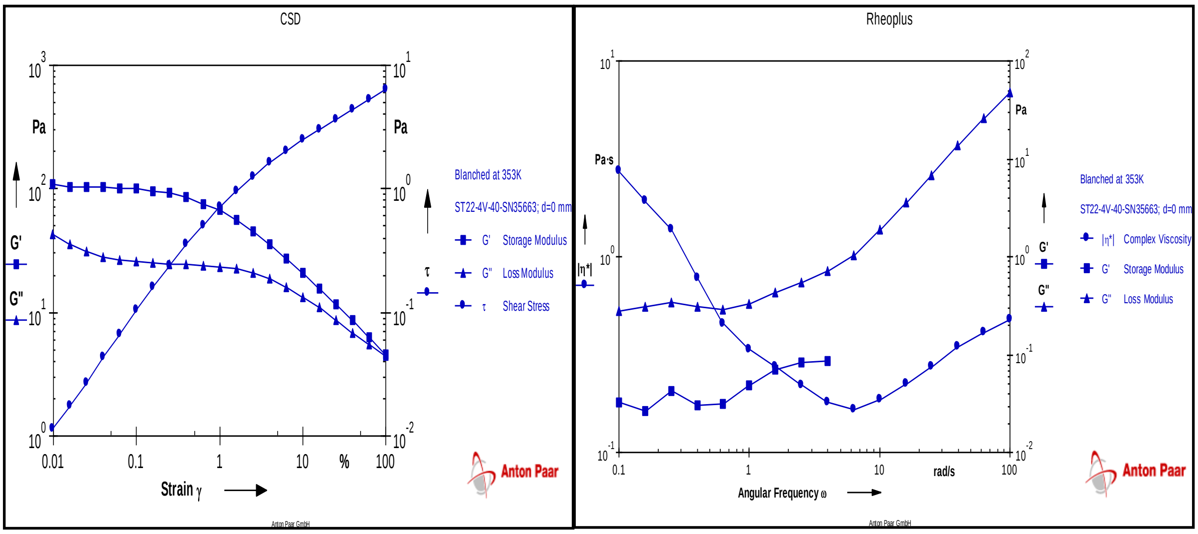

Fig. 3: Frequency and amplitude sweep tests for blanched ipomoea aquatic puree at 353K.

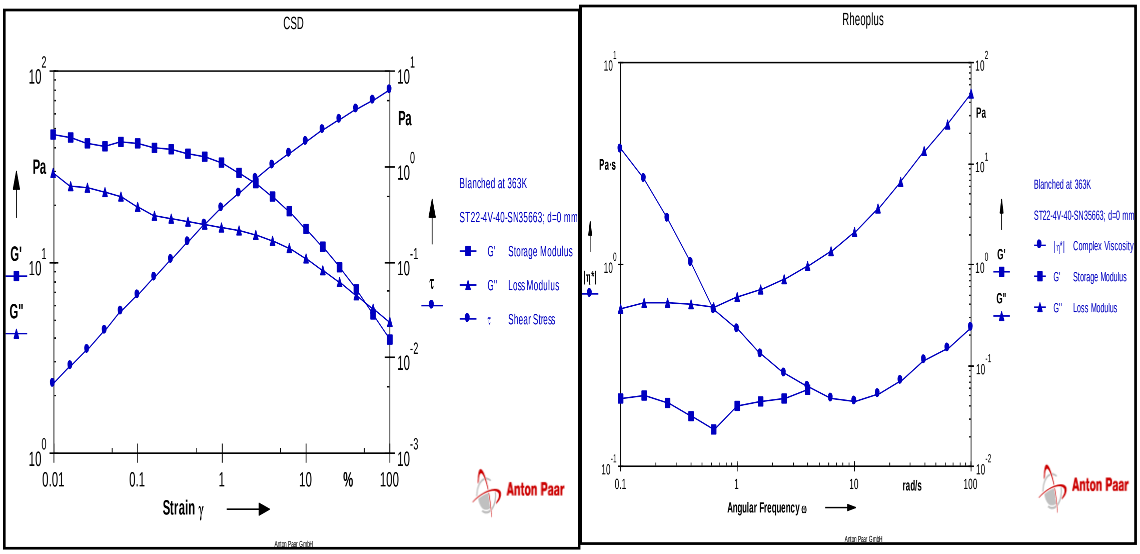

Fig. 4: Frequency and amplitude sweep tests for blanched ipomoea aquatic puree at 363K

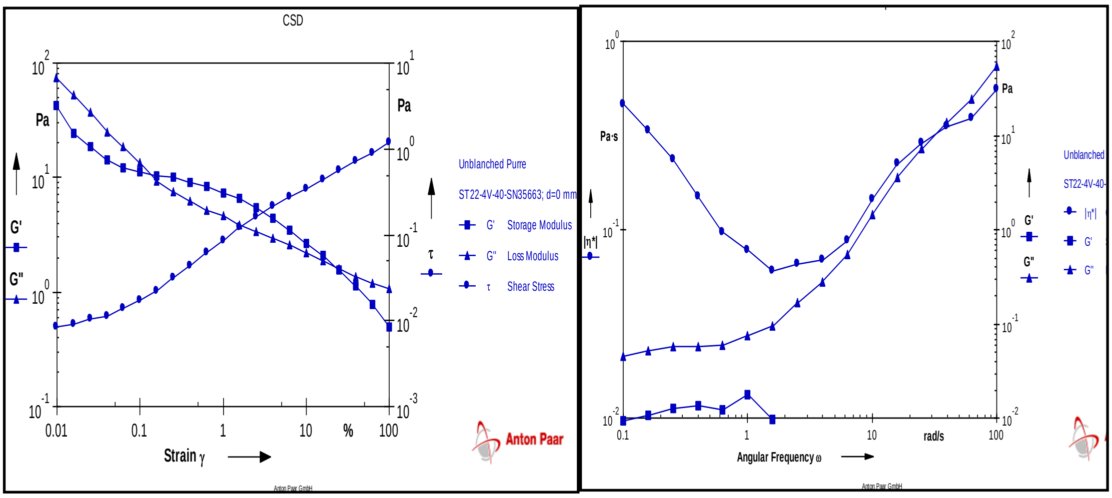

Fig. 5: Frequency and amplitude sweep tests for unblanched ipomoea aquatic puree.

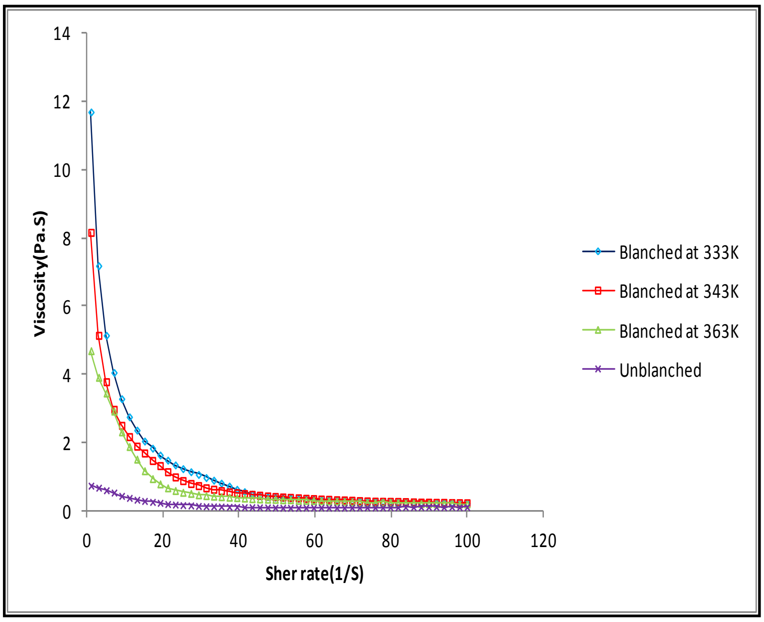

Fig. 6: Effect of the viscosity of Ipomoea aquatic leave puree with the shear rate at various conditions.

When this food material is subjected to a range of frequency for finding out the character of the product by measuring its storage modulus (elastic modulus) G' and loss modulus (viscous modulus) G" value. Purees having greater G” value indicate its more viscous property and lesser value recommends that not so much viscous but having better elastic property. The measurements of this property are useful in distinguishing changes happening in objects, for example, gel development, crystallization, and melting. Both Frequency and amplitude sweep test was performed for both blanched and unblanched puree at 303 K. Fig (2) demonstrates that G” and G’ value for blanched purees were shown an increment, as the frequency increase from 0.1 to 100 rad/s. However, in this case, G’ value demonstrated a rise and fall with frequency, so it gives a curve with overshoot and damping and prevails the entire range of frequency which indicate in Fig (3, 4). The loss modulus of the puree was discovered higher when contrasted with storage modulus and subsequently, it implies that the puree displays a relatively good gel behavior. Fig (2) shown decrement of G’ and G” value with increment in shear stress from 10^{-2} to 10 Pa and strain from 0.01 to 100 %. However, it gives a higher storage modulus values than loss modulus. Comparative behavior was accounted by Opazo-Navarrete [15]; Lad and Murthy [12] for aloe vera suspension and for rocket leave puree as shown by Ahmed [4].Opazo-Navarrete [15]observed that increment in pressure reduces both G' and G". Similar trends were observed at blanched (343K, 363K) and unblanched purees.which are shown in Fig (4, 5) It also found that both G' and G" improve the temperature and the frequency. The outcomes of this work demonstrated that there is just a minor increment in both moduli with frequency in the range. The blanched sample has a 2-fold decrement in the G' value contrasted with the unblanched sample. Thus, heat addition causes tissue softening because of the loss of cell wall structure and the adding up of different constituent (lipids, starch etc) coming out from the cell wall. Most of the researcher analyze different purposes behind this conduct; though, the correct method after this is still unknown as per literature Ahmed [4].A substantial increment in G' at a higher temperature for rocket leave puree, which was depicted in perspective of gelatinization of starch. Iqbal [16] review that release of starch take places from chloroplast of leaves during heating.

Table3: Parameters of Ostwald model fitted to ipomoea aquatic purees.

Temperature	**Ostwald model**		
	n	K	R^2
333K	0.3099	5.0156	1
343K	0.2317	7.7977	0.99
363K	0.1354	12.414	0.99
Unblanched	0.4598	0.6536	1

The increment in blanching temperature, viscosity decreased as well as the shear thinning behavior (n decreased). The rheological study at constant ramped in shear rate showed an initial decrement of viscosity and afterward it showed a constant value. The reason for the initial decrement of viscosity was attributed to an irreversible deflocculating, which was described by Gallegos [14]. The viscosity-shear rate curves of different blanched purees were similar and the behavior was shear thinning. Viscosity was decreased when the shear rate was increased and the flow became Newtonian. Fig (6) showed the characteristic of pseudoplastic fluids, which observed in our viscosity-shear rate diagrams. Table (3) shows that the parameters for the rheological Power-law models at blanching at 343K, 353K, 363K and unblanched one. The Ostwald-de-Waelle fit model satisfactorily at all temperatures examined, and the coefficient of determination (R^2) greater than 0.99, shown in table (3). The values of the flow behavior index (n) observed for Ostwald-de-Waelle model were below the value of one (n <1), featuring thus a pseudoplasticbehavior. Silva [17] reported the value of the behavior index (n) indicated the degree of pseudoplastic for fruit juices and pulps were further away that meet the unit, the greater the pseudo-plasticity of the product. Fig.(7) showed best pseudoplastic behaviors, where it can be noted that the slope of the curves decreases with increasing strain rates, which implies in a decrease in the viscosity when strain rate increases. It also shows that the effect of blanching on the mechanical strength of ipomoea aquatic puree at different blanched temperatures was illustrated.

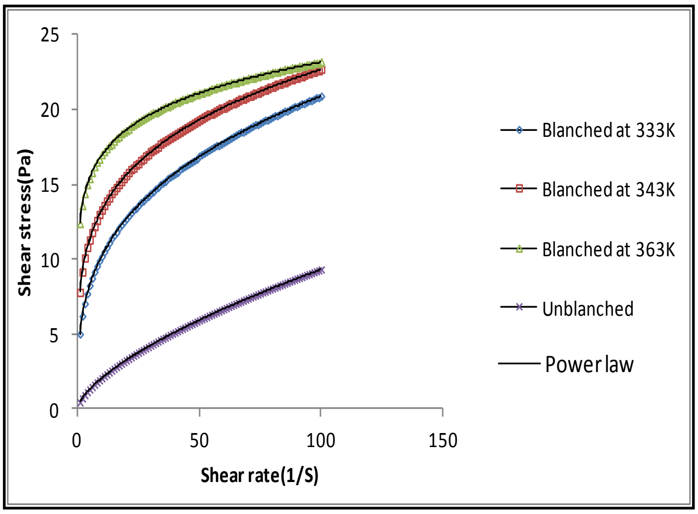

Fig. 7: Shear rate vs shear stress diagram of ipomoea aquatic purees at different conditions.

Flow behavior was defined by both Herschel-Buckley model and Ostwald model was utilized to depict rheological conduct of non-Newtonian liquids determined by Eq. (1) and Eq. (2) respectively by Holdsworth [18].

$$\tau = \tau_o + K(\gamma)^n \qquad (1)$$

$$\tau = K(\gamma)^n \qquad (2)$$

Where τo is yield stress, τ is shear stress, γ is the shear rate, n is flowbehavior index and K is consistency index. The estimations of K and n of puree at the temperature of 303 K was examined for various models and studies recommended that the value decreases with the ascent in temperature as shown by Kiran[19]. Table (1) shown the different yield value ofpurees because of their composition, particle size and which determine the flow. The data in Fig (1) indicate that the flow behavior index (n) <1, allude to shear thinning conduct. In the present work, n and K values of different purees was found by using both fitted models, which are shown in Table (2). Rocket leave puree was shown n value 0.04 to 0.2 as per literature Ahmed [4] and Aloe Vera brought about the value of n in the range 0.16 to 0.25 as per Opazo-Navarrete [15], Lad and Murthy [12]. This is the characteristics of common food materials, as an example, purees, and paste that have a considerable range of particles within the dispersion. The rationale for the shear thinning behavior because of entangled communication of the particles in dispersion with one another. Fig (1) showed the fits of Herschel-Buckley model which has drawn as solid lines.

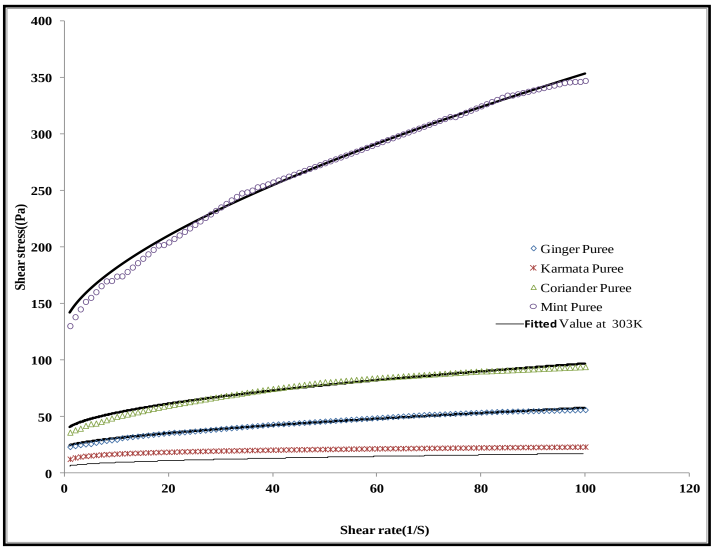

Fig. 1: Shear rate vs shear stress diagram for various Purees at 303K

Table 1: Experimental values of the yield stress of different purees at 303 K

Purees	Yield stress(τ_0)Pa
Ginger	23.02
Ipomoea Aquatica	5.03
Coriander	36
Mint	130.2

Table 2: Parameters of Heschel-Buckley and Ostwald model fitted to different purees.

Purres	**Heschel –Buckley model**			**Ostwald model**		
	n	K	R^2	n	K	R^2
Ginger	0.63652	1.85768	0.99	0.2458	17.683	0.9651
Ipomoea aquatica	0.4414	1.62136	0.99	0.2666	5.0264	0.999
Coriander	0.5421	5.02891	0.998	0.2574	28.795	0.9802
Mint	0.63803	11.822	0.999	0.2361	99.379	0.9629

4. Conclusions

The yield stress value, which shows the initial stress, required for the flow of different purees like ginger, karmatta, coriander and mint are 23.02, 5.03, 36, 130.2 Pa respectively found. The rheology of blanched and unblanched purees of karmatta leaves has considered by frequency and strain tests. Both storage modulus and loss modulus found to increase with frequency and temperature except the frequency test for unblanched puree, where a decrease trend of storage modulus has observed. However during frequency sweep test G' showed a level of damping and overshoot, which prevails the entire extent of frequency. It was also found that the unblanched sample of purees has a nearly 2 fold increment in the G' value as compared to blanched one. All the purees demonstrated an initial decrease in viscosity value but after some time it demonstrated a consistent value. The purees tried to fit with both models however; Ostwald model fittedwell-having R^2value above 0.98.

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