Effect of different Hydrocolloids on Rheology of Tamarind (Tamarindus indica L.) Juice

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Abstract- The flow properties of tamarind pulp were evaluated upon addition of food hydrocolloids and thickeners such as Alginate, Agar, CMC, Pectin, Guar gum at concentration of 1% for all and 0.5% for only agar.Tamarind (*Tamarindus indica* L.) is most important fruit for food industry. Rheological charecterization is important for product development. Hydrocolloids are used for enhancing viscosity and creating gel structure of fruit juice. The experiments were carried out at temperatures ranging from 5-35^{0}C. The power law model was successfully applied to fit the experimental results of shear stress versus shear rate and flow behavior index(n) was less than 1(0.331-0.812) in all cases. From this experiment we observed that tamarind juice with hydrocolloids showed non–newtonian behaviour.

Keywords: Rheology, Viscosity, Hydrocolloids, Tamarind

I. INTRODUCTION

Tamarind (*Tamarindus indica* L.) is one of the most economically important versatile fruit[1] which can be used for different purposes either nutritional or medicinal [2,3] .Tamarind pulp/juice is an excellent source of vitamins, minerals, electrolytes and antioxidants[4]. In South East Asian and South American countries tamarind fruit pulp extract is used in soft drinks as a replacement of chemical acidulants such as citric acid[5]. Tamarind chutneys, pickles are consumed along with rice, breakfast items and various snack foods. Other industrially important products include tamarind juice, concentrate and powder[6]. The juice is very popular due to its sweet, sour flavor. However phase separation is the most common problem in pulps and non-clarified juices. It affects the product quality and consumer acceptability as well. Hydrocolloids play an important role to improve consistency and ultimately the quality of the product[7].

Hydrocolloids are water soluble, high molecular weight polysaccharides and are applied in food systems for enhancing viscosity, creating gel structure, improving consistency, rheological and textural characteristics and lengthening the physical stability[8,9,10,11]. Knowledge of viscosity is considered as an important parameter in assessing the significance and feasibility of any hydrocolloids in food[12] and is important in understanding and designing texture[13]. The rheological properties of food products are strongly influenced by temperature[14-18]. Therefore it is significant to study the rheological characteristics of food products as function of temperature. There are reports available on flow properties of tamarind juice and effects of temperature and concentration on it[19-21]. However the effect of temperature on rheology of tamarind juice made with addition of hydrocolloids has received little attention.

Therefore the aim of this work were(i) to study the impact of different hydrocolloids (guar gum, CMC, pectin, alginate and agar) on flow behavior and viscosity of tamarind juice (ii) modeling of the experimental data using flow equation (iii) to determine the effect of temperature on tamarind juice containing hydrocolloids.

II. MATERIALS AND METHODS

Matured tamarind (*Tamarindus indica* L.) flesh procured from local market was used throughout the experiment. Tamarind pulp was extracted with boiling water. Total soluble solid content of pulp was maintained 11.5 Brix. The total soluble solid (TSS) was determined with the help of a hand refractometer (Erma, Tokyo). Each hydrocolloid at 1% w/w level was then added into the hot pulp and stirred for 10 minutes. These samples were then analyzed for viscosity measurement[22]. Rheological characteristics of the samples were evaluated using Brookfield viscometer (LVDV-E model). A sample of 200 ml was used in 250 ml size glass beaker for all experiments. The rheological measurements were carried on at temperatures 5, 15, 25 and 35^0c. Spindle 1 for all samples and spindle 4 for only Agar were used. The spindle speed varied from 5-50 rpm[23].

Generally viscosity of non-Newtonian fluids can be represented by power law model[24].

$$\mu_A = (1/n)^n \; (4\pi N)^{n-1} \; m$$

or, $\log \mu_A = n\log 1/n + \log m + (n-1) \log 4\pi N$ …………..(1)

μ_A = apparent viscosity(Pa.S)

n = flow behavior index (dimensionless)

m = consistency coefficient ($PaS^{n)}$

N = spindle speed (rps)

When n = 1, in equation (1) the fluid is Newtonian and m reduces to viscosity. The results were analyzed using eqn (1).

III. RESULTS AND DISCUSSION

Typical shear stress vs shear rate values for tamarind juice prepared with different hydrocolloids are shown in Fig 1a-1f. The shear stress decreased with increase in shear rate. The same behavior was observed for all juice samples. Increase in temperature resulted decrease in shear stress. These studies concluded that tamarind juice exhibited non Newtonian flow behavior for all hydrocolloids at all temperatures.

Flow behavior was described by the fitting of the power law model to experimental data (shear stress- shear rate) to evaluate the non Newtonian behavior of tamarind juice. The values of $\log(\mu_A)$ was plotted against $\log 4\pi N$ (Eq1) and straight lines with negative slope were obtained for all hydrocolloid mix tamarind juice. The negative slope of straight lines (Eq 1) (Fig 2a-2f) indicate the non Newtonian / shear thinning nature of juice. The flow behavior index (n) and consistency coefficient (m) were calculated from slope and intercept of straight line and are shown in Table 1 for various hydrocolloids (1%) and temperature (35^oc, 25^0c, 15^0c and 5^0c). Viscosity functions data suggested that all juices under examination were non Newtonian fluids, since the values for flow behavior indices 'n' were below 1, indicates pseudoplastic/shear thinning nature of tamarind juices[25]. For a provision of a high viscosity and good mouth feel a hydrocolloids characterized by a low n-value would be required[26]. A decrease in consistency coefficient was observed with the increasing temperature indicating a decrease in apparent viscosity at higher temperature similar observations were reported by Sharoba et al[27]. The flow behavior index also showed a declining trend with temperature which implies higher pseudo plasticity at higher temperature[27] (Table 1). Razavi et al. reported that an increase in temperature decreased the flow behavior index of some commercial ketchup[28]. From the fig 1g and 2g it is evident that the lowest 'n' value is achieved with addition of 1% CMC to the native tamarind juice. Therefore it may be concluded that the pure tamarind juice may be recommended to be processed with addition of 1% CMC for better acceptability to the consumer. Not only that as the 'n' value has achieved an acceptable value at 25^0C, therefore processing at room temperature will be technically feasible.

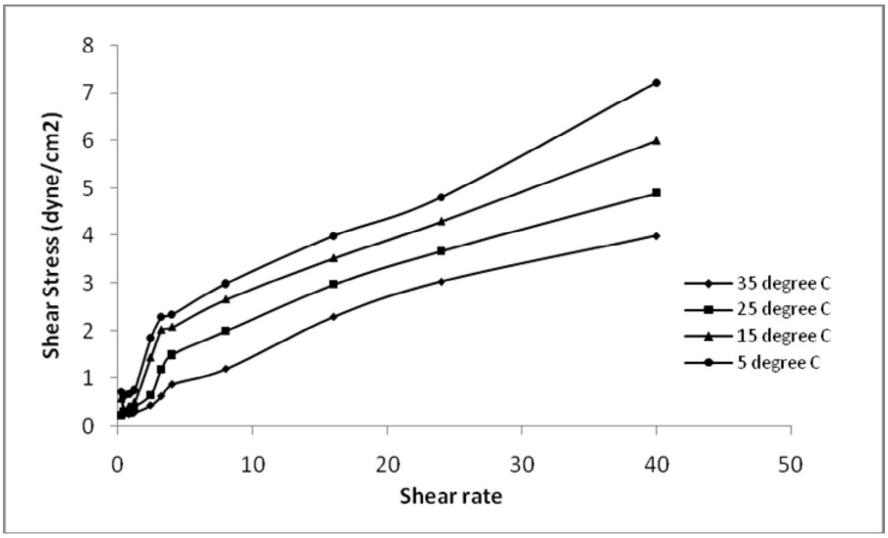

Fig 1a: Profile of shear stress against shear rate at different temperature (5-35^{0}C) of pure tamarind juice (control)

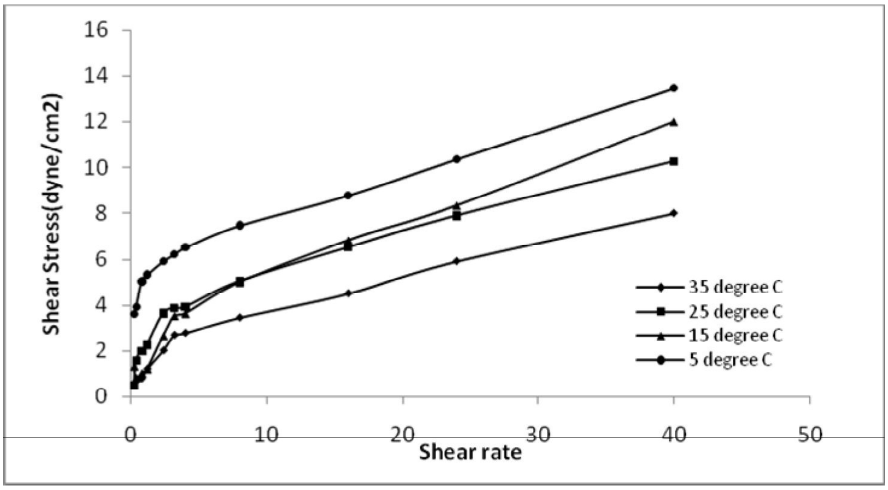

Fig 1b: Profile of shear stress against shear rate at different temperature (5-350C) of pure tamarind juice mixed with 1% Alginate

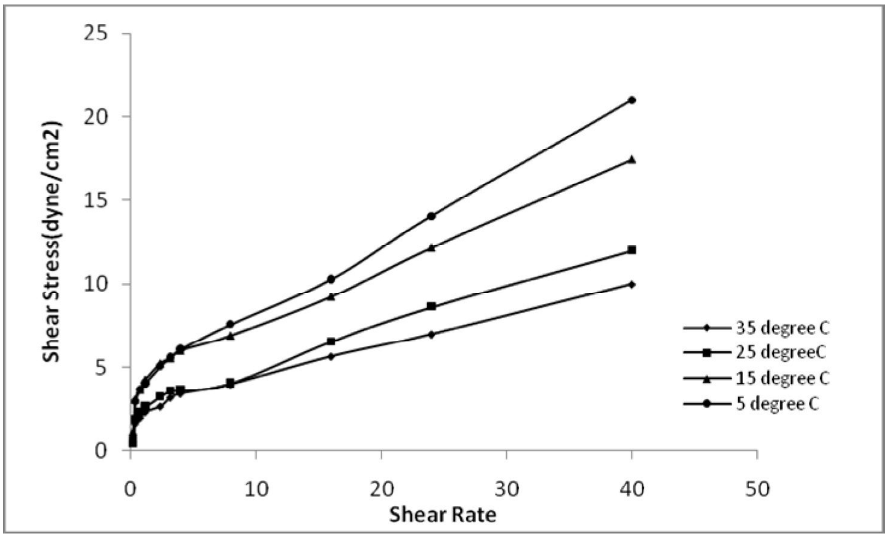

Fig 1c: Profile of shear stress against shear rate at different temperature (5-350C) of pure tamarind juice mixed with 1% CMC

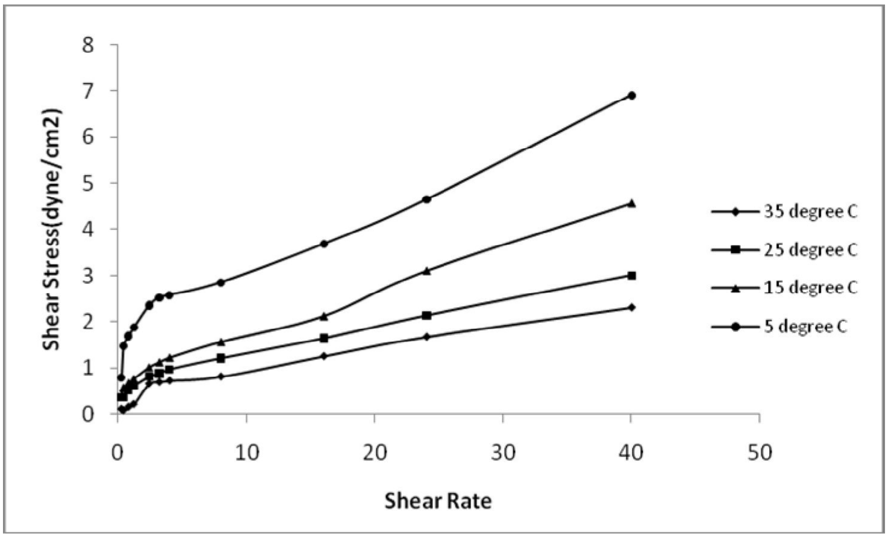

Fig 1d: Profile of shear stress against shear rate at different temperature (5-350C) of pure tamarind juice mixed with 1% Pectin

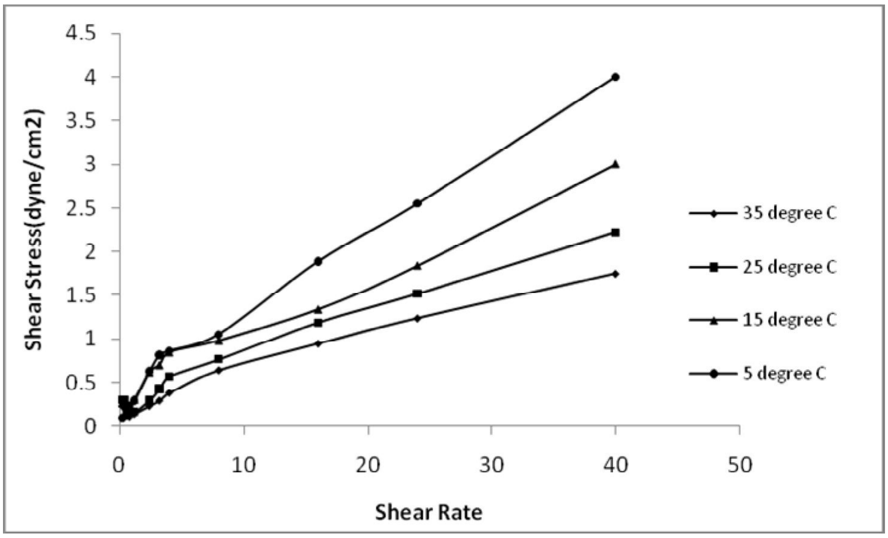

Fig 1e: Profile of shear stress against shear rate at different temperature (5-35^{0}C) of pure tamarind juice mixed with 1% Gum

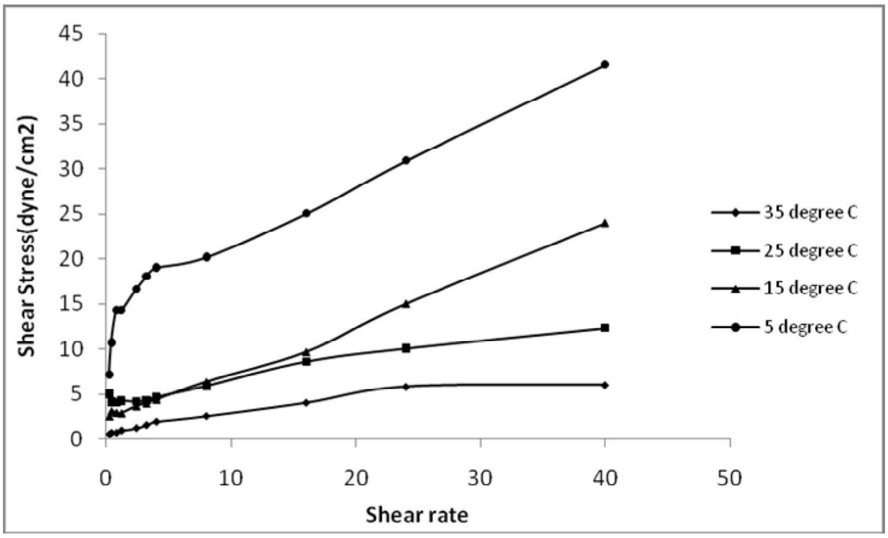

Fig 1f: Profile of shear stress against shear rate at different temperature (5-350C) of pure tamarind juice mixed with 0.5% Agar

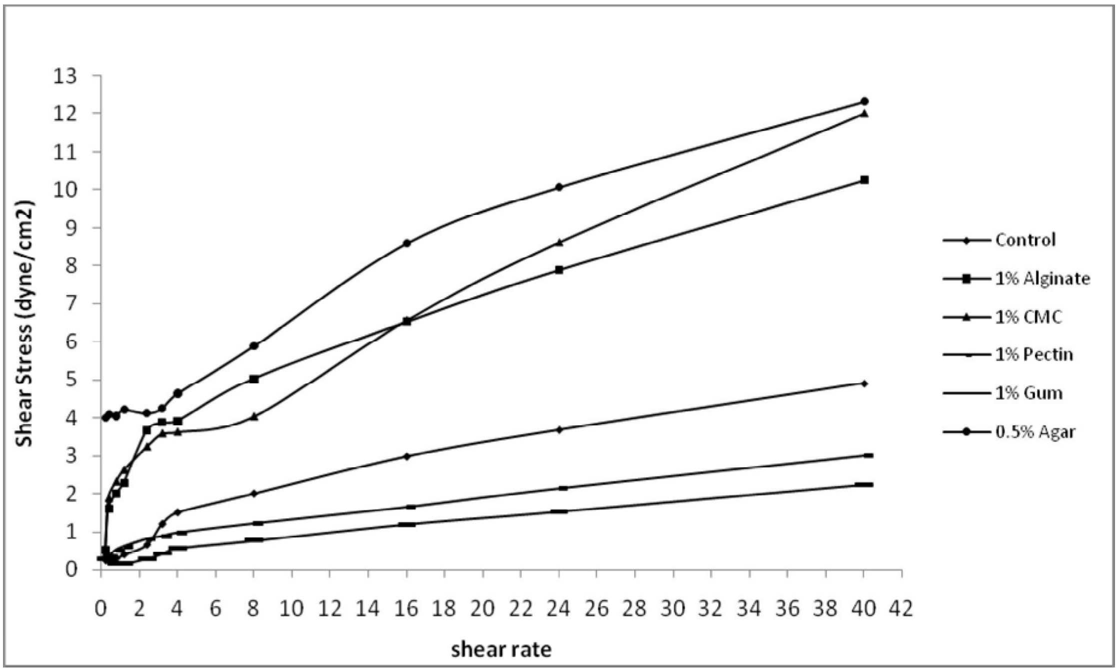

Fig 1g: Profile of shear stress against shear rate for pure tamarind juice at 250C (a) Control,(b) tamarind juice mixed with 1% Alginate,(c) tamarind juice mixed with 1% CMC,(d) tamarind juice mixed with 1% Pectin,(e) tamarind juice mixed with 1% Gum, (f) tamarind juice mixed with 0.5% Agar

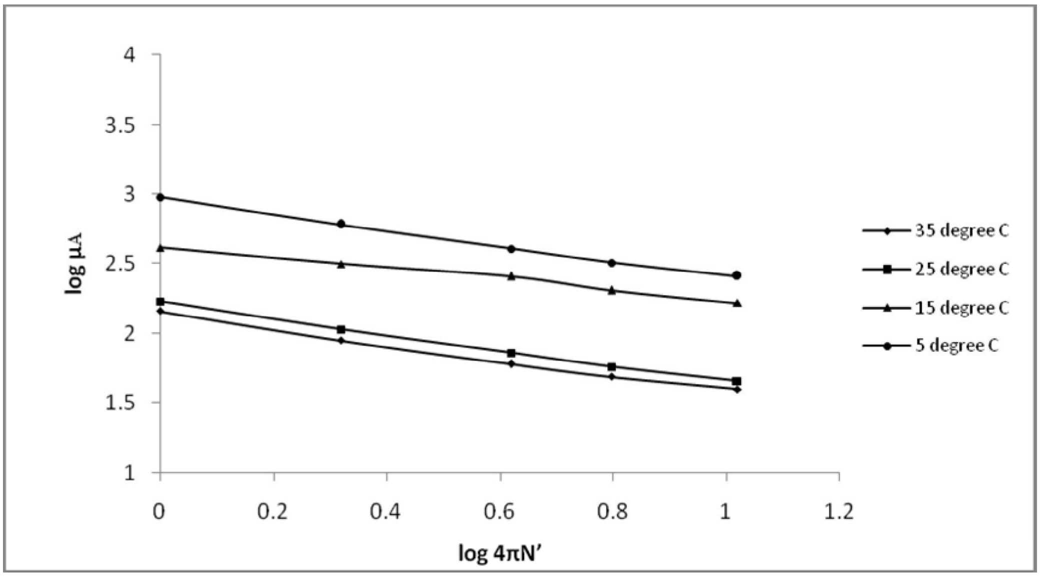

Fig 2a: Profile of log μA against log 4πN' at different temperature (5-350C) of pure tamarind juice (control)

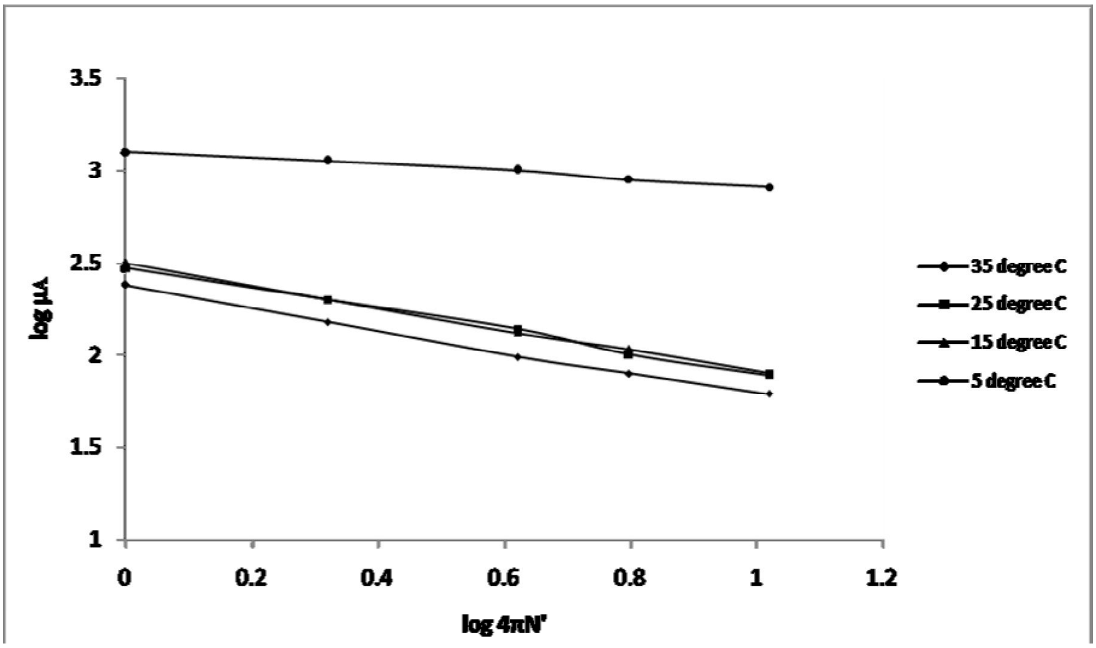

Fig 2b: Profile of log µA against log 4πN’ at different temperature (5-350C) of pure tamarind juice mixed with 1% Alginate

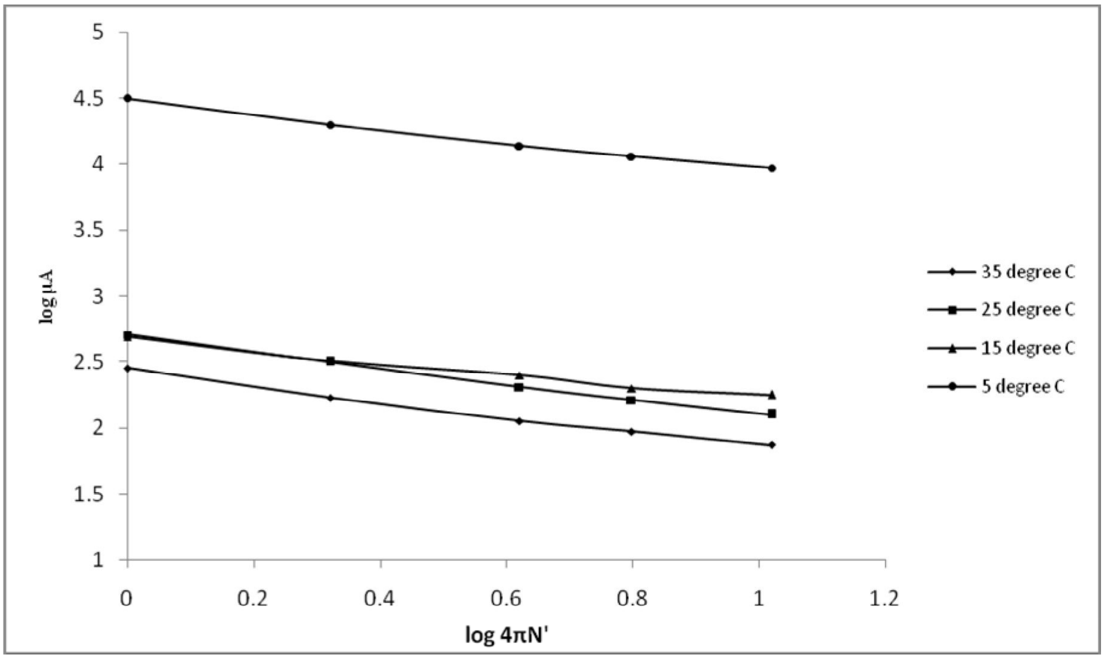

Fig 2c: Profile of log µA against log 4πN’ at different temperature (5-350C) of pure tamarind juice mixed with 1% CMC

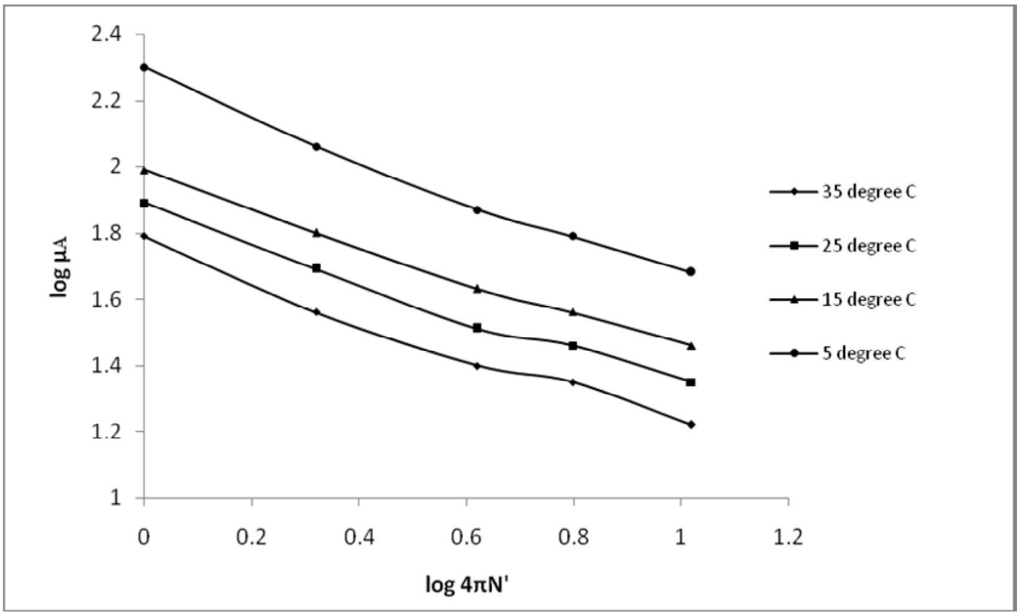

Fig 2d: Profile of log µA against log 4πN' at different temperature (5-350C) of pure tamarind juice mixed with 1% Pectin

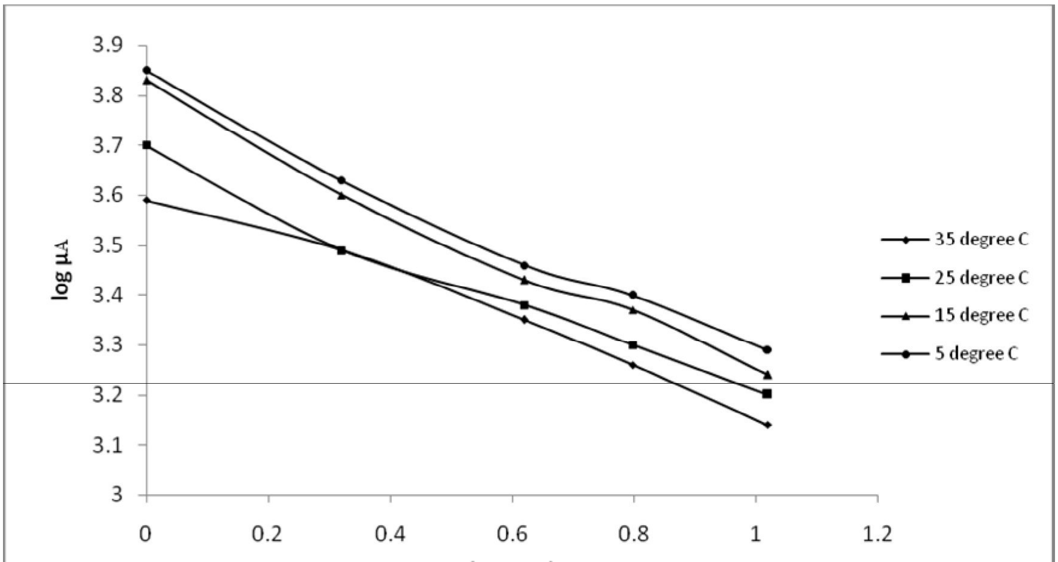

Fig 2e: Profile of log µA against log 4πN' at different temperature (5-350C) of pure tamarind juice mixed with 1% Gum

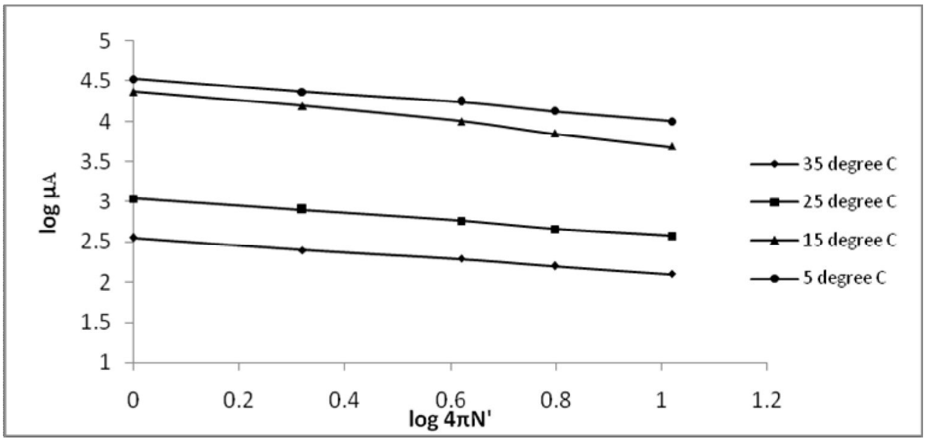

Fig 2f: Profile of log µA against log 4πN' at different temperature (5-350C) of pure tamarind juice mixed with0.5% Agar

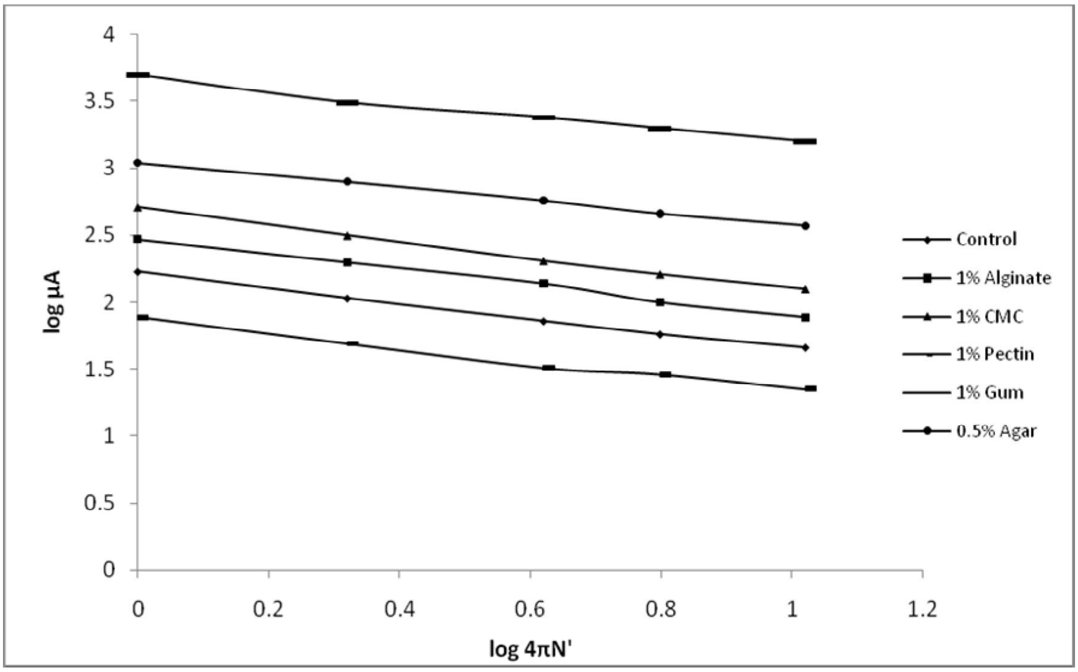

Fig 2g: Profile of log µA against log 4πN' for pure tamarind juice at 250C (a) Control,(b) tamarind juice mixed with 1% Alginate,(c) tamarind juice mixed with 1% CMC,(d) tamarind juice mixed with 1% Pectin,(e) tamarind juice mixed with 1% Gum, (f) tamarind juice mixed with 0.5% Agar

Table 1: Values of consistency coefficient (m) and flow behavior index(n) for pure tamarind juice(control)and mixed with different hydrocolloids(1%Alginate, 1%CMC, 1%Pectin, 1%Gum, 0.5%Agar) at different temperature(350C,250C,150C,50C)

Temperature	Consistency coefficient(m)		Flow behavior index(n)
35^0C	Control	96.60	0.447
	1% Alginate	162.55	0.417
	1% CMC	186.21	0.43
	1% Pectin	40.55	0.458
	1% Gum	2937.65	0.556
	0.5% Agar	255.86	0.565
25^0C	Control	115.08	0.438
	1% Alginate	208.92	0.424
	1% CMC	345.94	0.397
	1% Pectin	51.99	0.474
	1% Gum	3380.65	0.524
	0.5% Agar	788.86	0.533
15^0C	Control	312.6	0.611
	1% Alginate	215.77	0.415
	1% CMC	338.84	0.564
	1% Pectin	66.37	0.479
	1% Gum	4456.56	0.434
	0.5% Agar	16982.44	0.331
5^0C	Control	647.14	0.438
	1% Alginate	1078.95	0.812
	1% CMC	21281.39	0.479
	1% Pectin	130.32	0.394
	1% Gum	4677.35	0.458
	0.5% Agar	24210.29	0.488

IV. CONCLUSION

The study shows that pure tamarind juice may enhance its acceptability in terms of consistency if mixed with edible polysaccharides at different concentration level. However, 1% CMC addition to the native tamarind juice imparted maximum pseudo plasticity to the juice with acceptable consistency at room temperature.

V. ACKNOWLEDGEMENT

The financial assistance of University Grant Commission in carrying out this work is gratefully acknowledged.

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