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Effect of Xanthan Gum Content on the Rheological Behaviour of Mayonnaise

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Abstract. This study explores the effect of various concentrations of Xanthan gum on the rheological behaviour of commercial mayonnaise. The various concentrations of Xanthan gum, ranging from 0.1 to 0.5% based on the weight of the mayonnaise which were mixed in the commercial mayonnaise *via* a high overhead stirrer at room temperature. The rheological characterizations were carried out on a Brookfield viscometer. Using Mitschka's method, the recorded data was changed into rheological parameters. Three rheological models, namely the Power-law model, Bingham model and Herschel-Bulkley model, used to determine the flow parameters of the samples. All the samples showed shear thinning behaviour at least in the shear rate used in this study. According to the goodness of fit (regression coefficient), the power law model was the best for determining flow parameters. It was observed that the consistency viscosity (K) increases with an increase in Xanthan gum concentration, at least for the concentration ranges used in this research. The higher value of K indicates that the mayonnaise becomes thick with Xanthan gum and will require higher yield stress to start flow. It was interesting to note that at 0.1% Xanthan gum concentration, the power index reached a plateau value of 0.1135.

Keywords: mayonnaise, mitschka's method, rheological behaviour, viscosity, Xanthan gum, thickeners

Introduction

Rheology studies the deformation or flow of matter when any stress or force is applied to the material. Rheology flow is measured using shear stress and its rate and strain rate calculated from torque and flow rate measurement respectively. The flow can be categorized into Newtonian and non-Newtonian. Plastic fluids, dilatants fluids (shear-thickening) and pseudoplastic fluids (shear-thinning) are time-independent fluids whereas thixotropic, antithixotropic or rheopectic fluids and visco-elastic fluids are examples of time-dependent fluids (Kumar *et al*., 2021; Mozafari *et al*., 2017).

The objective of the study is to compare the rheological behaviour of commercial mayonnaise by varying the concentration of Xanthan gum. Flow curves were developed between shear rate and viscosity to determine the type of flow behaviour. The modeling of the rheological data uses various rheological models such as Herschel-Bulkley, Power-law and Bingham models.

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Rheology of food is the study of the flow under applied force or stress. In food rheology, mechanical properties play an important role in studying how food recipes can be mixed and how they can be further processed during their manufacturing. It highlights the stability and food texture. The application of rheology in food has some important aims. It helps to determine the rheological relationship of foods, while data obtained by rheology which is used to optimize the food product that including mixing, coating, molding, extruding, dispersing and shaking. The measurement obtained by rheology is used in empirical or analytical data. Stability, texture, sensory characteristics, filling, scoping, dosing and portioning characteristics of nutrients are important properties in rheology (Kadian *et al*., 2021; Naji-Tabasi *et al*., 2018).

The factors that affect the rheological behaviour of non-Newtonian fluids are shear rate means the rate at which fluid does work or is sheared. It is the relation between velocity gradient and distance between plates/layers. It is denoted by (gamma) and its unit is one/sec. The concentration of additives affects the viscosity of fluids, thus affecting non -Newtonian fluid. Temperature affects the non-Newtonian fluid's rheological behaviour by changing the viscosity of fluids. It may remain constant either fluid moves fast or slow but it affects the viscosity of the fluid. Industrial manufacturers need rheology in use for (wire coating, extrusion, mixing, injection molding and paint industries) where the process designer uses rheology to manufacture (flow in dies, extruders, screws, molds). Engineer/scientist in different engineering industries such as the cement industry (cement paste and sludge). Also, rheology plays an important part in the food industry and in the cosmetics industry, such as filling, scoping, dosing and portioning of ketchup, mayonnaise and toothpaste (Kadian *et al*., 2021; Orgulloso-Bautista *et al*., 2021).

The different processing stages required rheology from raw materials to processing and production to the formation of the final product. The rheology of the raw materials is used for the characterization of the structure and composition. Processing uses rheology to define flow behaviour and equipment design. The last stage (product formation) uses rheology for product design and characterization of final properties (Kumar *et al*., 2021; Akoglu *et al*., 2018).

Four commercial mayonnaise studied rheological properties that were analyzed using Brook Field Rheometer DVIII. The results were fitted to Hershel (Bulkely) and Casson models, the flow behaviour index of all samples was less than one showing pseudoplastic behaviour. Oil concentration is directly proportional to the viscosity, shear stress and yield stress of mayonnaise (Anamaria, 2018).

In this research, traditional and light mayonnaise rheological behaviour was observed. All sample fat content ranges were 76% to 48%. The samples show viscoelastic behaviour and oscillatory and creep test was measured. Fat content shows direct relation with storage modulus, compliance and yield strength. The value of G for 1Hz and pseudoplastic number (z) was measured for the emulsion stability. A creep test was used to determine the elastic limit; for light mayonnaise, it was near to normal emulsion (Akoglu *et al*., 2018).

The sample of mayonnaise was used and slip phenomenon and Xanthan gum concentration were observed. The sliding phenomenon is due to the field of stress in in homogeneous and the interaction between field and surface thus was measured by creating different spaces in the rheometer (disk and plate). The sliding velocity was affected by the concentration of Xanthan gum and oil and shear stress. The shear stress that was applied was limited due to the weak mayonnaise structure and the plate geometry measurement range was also limited (Heggset *et al*., 2020).

In another research, hardness (g), adhesiveness (10^{-3} Nm), firmness, cohesiveness and viscosity were measured. Brookfield viscometer MV-E was used for different compositions of samples of mayonnaise of 25 °C at different rpm. Spindle (C-S64) was suitable for the measurement hardness was 1.027-28.86 gm. Sample 2 had high adhesiveness, cohesiveness, firmness and gumminess, concerning sample 1. Because of the high oil content, textural firmness and stickiness and viscosity were increased (Alvarez-Sabatel *et al*., 2018).

Mayonnaise samples with 66% to 82% oil content with two thickening agents were examined at two temperature *i.e*. 10 to 25 °C. Flow curves, apparent viscosity, yield stress and visco-elastic parameters were studied in this research. Sensory characteristics were measured and mayonnaise spreadability, texture and flavour were determined. All the samples showed shear-thinning behaviour as oil concentration increased to increasing the sensory characteristics. Rheological characteristics were highly useful for mayonnaise texture, flavour and acceptability (Chetana *et al*., 2019).

This research used a Brook field viscometer DVIII 17 samples of light mayonnaise and traditional mayonnaise were tested at temperature ranges 10 °C to 25 °C. The relation between yield stress and apparent viscosity was non-linear. There was no relation seen between sensory characteristics and apparent viscosity. Multivariate statistical techniques were considered to be important for the improvement of texture acceptance of mayonnaise (Rodrigues do Carmo *et al*., 2019).

In another research, the time-dependent and steady-state rheological behaviour of two mayonnaise samples were measured by using a concentric cylinder rheometer. Both mayonnaise samples were found to be non-Newtonian (shear thinning) liquid with time-dependent properties. Samples, regardless of test conditions (temperature and shear rates), the steady-state rheological data for all samples best fit the Hurshel-Bulkley model (Taslikh *et al*., 2021).

The relations of tucupi concentrations on the rheological properties of mayonnaise were observed for this reason, three mayonnaise samples were prepared with different concentrations of tucupi (10%, 12.5% and 15%). The Brookfield rheometer determined rheological parameters.

The results conclude that the mayonnaise with all tucupi concentrations exhibits non-Newtonian pseudo plastic behaviour. The Herschel-bulkley model was the best fit for determining the flow curve (Kim *et al*., 2017).

Olive oil used as an emulsifier in their study. The authors reported that the emulsion stability was higher for the control samples when compared to MG-added additives. The rheological behaviour was greatly affected by the mixture of MG and DG addition. Results show that the mono triglycerides show the greatest stability. Without an emulsifier, the viscosity and shear stress values increased (Katsaros *et al*., 2020).

Another research is about the rheological behaviour of mayonnaise and reduced-fat mayonnaise with the substitution of Xanthan gum and 4 (alpha) GTPase-treated starch paste investigated. All samples showed shear thinning behaviour. Elastic and moduli properties were affected in the substituted samples (He *et al*., 2021).

Physical characteristics of mayonnaise were observed, in addition to olive leaf extract. The researcher examines the partial size, viscosity and lubricant properties. The author reported that improved dispersion degree, lower spreadability and high salt with bitter perception were observed in mayonnaise enriched with olive leaf extract (Nguyen *et al*., 2017).

In another research, the Wagner model was used for mayonnaise to observe its transient flow. Two samples were studied at 10 °C and 40 °C. The Soskey-Winter damping function helped obtain the non-linear relaxation modulus of mayonnaise. The study shows that the model fits low shear rates for determining its transient flow (Farahmandfar *et al*., 2017).

In this research, egg yolk replacement from 0-100% with octexyl succinic anhydride (OSA) modified potato starch in mayonnaise resulted in maximum stability at 75% to 100% egg yolk replacements, reduction in cholesterol level and large oil droplets. Concerning the rheological study, the consistent texture was observed using an emulsifier (egg yolk and OSA starch) 25/75. The author reported that the samples were easily emulsified by OSA starch (Nizamuddin *et al*., 2020).

The processing factors show the affect and stability of mayonnaise with the whole egg during long-time storage. Different samples of mayonnaise were prepared with different processing techniques. Lower egg content mayonnaise showed stability at a shorter time. Oil droplet distribution and protein coverage were considered weak at longer-term stability. Flocculation in mayonnaise was highlighted because of the adsorbed egg white protein at the o/w interface (Mozafari *et al*., 2017).

The mayonnaise samples prepared with low cholesterol egg yolk and Xanthan gum content. The samples showed greater rheological characteristics as compared to the control sample of mayonnaise. Egg yolk 6wt% and Xanthan gum 0.7wt% produced good rheological and physico-chemical properties (Yadav *et al*., 2018).

In this research, the rheological behaviour was studied of different sauces, including mayonnaise. Power law, flow behaviour index (n) and flow consistency (K) were determined. Mayonnaise showed Newtonian behaviour. Flow behaviour Index (n) showed linear relation with the temperature, whereas the consistency index (K) decreased with the temperature (Razavi *et al*., 2018). In the last research paper, the physical and flow behaviour of mayonnaise by adding milk and Xanthan gum as a replacement for the egg was studied. High physical stability, heat stability and creaming index were determined after replacement. Power law and Hershel Bulkley's model showed the best fit with R^2 (0.99) for the rheological parameters of mayonnaise (Khushbu and Sunil, 2018).

Material and Methods

Analysis of all rheological are performed in triplicate. The standard deviation and mean values are displayed. ANOVA is performed to determine the differences in the rheological parameters of the gum solutions. According to Duncan, multiple comparison tests are used at a 95% significance level to determine the effect of gum concentration on rheological parameters.

Raw materials. Mayonnaise is an emulsion of oil and water, a highly demanded food product in today's world. Mayonnaise had at least three egg yolks, 65% to 75% vegetable oil or any oil, sugar content of 0.5%, salt of 0.5% and vinegar of 0.5%. Codex commission tells that mayonnaise should have 80% total fat and 5.5% egg yolk. The light product compares with traditional food, the light product should have at least 25% calories. So, it is important to reduce carbohydrates, fat or proteins of high caloric value. The unhealthy relationship between dietary fat and the development of hypertension, cardiovascular diseases and obesity has prompted a consumer to be limited into use of fat products. For producing low fat mayonnaise, the basic fat formula should be replaced by other ingredients. Challenges for preserving the same quality of mayonnaise as the original full fat mayonnaise modified sugar, Xanthan gum, pectin and carboxy methyl cellulose (CMC) are commonly used to stabilize and increase the viscosity of low fat mayonnaise (Sun *et al*., 2021; Nizamuddin *et al*., 2020). The reported commercial ingredients of the mayonnaise used in this research are given in Table 1.

Xanthan gum is a popular food additive, it is a soluble fiber mainly used in food as a thickening and stabilizing agent. When Xanthan gum is added to any liquid and its quickly dispersed and creates a vicious and stable solution. It makes a great thickening and stabilizing of the product. According to the FDA, Xanthan gum is safe, it does not have many bad impacts on human health and just slows down the digestion process in the human body. Xanthan gum was purchased from a local market in Karachi, Pakistan and is the product of Changzhou Kamadi Trading Company, China. Xanthan gum concentration from 0% to 0.5% wt. was mixed in the commercial mayonnaise *via* a high overhead stirrer at room temperature (He *et al*., 2021; Heggset *et al*., 2020). The properties of the Xanthan gum as shown in Table 2.

Table 1. Composition of mayonnaise used in this study

Ingredients (%)	
Oil	66
Water	4.55
Vinegar	6
Egg	10
Milk	8
Xanthan gum	0
Sugar	3
Salt	1.2
Mustard	0.3
CMC	0.2
Potassium sorbate and sodium benzoate	0.75

Table 2. Properties of the Xanthan gum used in this study

Xanthan gum properties	
pH	6.0 – 8.0
Ashes	< 12
Particle size	200 (mesh) food grade

Sample preparation. Xanthan gum with different compositions (0.1% to 0.5% w/v) was mixed in commercial mayonnaise at room temperature under vigorous mixing using an overhead stirrer. This blended mixture was stored at room temperature in PVC bottles for rheological characterization. The compositions of samples, as shown in Table 3.

Rheological characterization. The relationship between shear rate and shear stress is very important. Rheological estimations were performed at 30 °C (room temperature), utilizing Brookfield RV viscometer, USA. All the ketchup samples were covered with aluminum foils during rheological estimations to avoid dampness, misfortune and other unwanted changes in the mixture. Flow curves were made for all the ketchup samples utilizing Mitschka's strategy. All of the estimations were repeated three-fold for each sample. The Brookfield viscometer makes it conceivable to quantify thickness by utilizing strategies in the viscometer. Viscometer can quantify consistency through the shifting stream states of the example material being tried. They utilize an axle on a pole intended to be plunged or in undated into a fluid and then turned. The revolution makes the liquid produce a drag, which is estimated by the connected torque on the fluid's consistency. They are not intended to gauge numerous stream conditions yet are conceivable with the utilization of a rheometer. For the option to gauge the sample's thickness in the Brookfield viscometer, the material should be stationary inside a compartment, while the axle moves when soaked in the liquid. Another conceivable alternative is to move the holder with a stationary axle. Whatever alternative is

Table 3. Compositions of the samples

Ingredients (%)	Samples			
	1	2	3	4
Oil	66	66	66	66
Water	4.55	4.55	4.55	4.55
Vinegar	6	6	6	6
Egg	10	10	10	10
Milk	8	8	8	8
Xanthan gum	0	0.1	0.3	0.5
Sugar	3	3	3	3
Salt	1.2	1.2	1.2	1.2
Mustard	0.3	0.3	0.3	0.3
CMC	0.2	0.2	0.2	0.2
Potassium sorbate and sodium benzoate	0.75	0.75	0.75	0.75

being utilized, the material must probably create a laminar stream over the axle, while moving. It is just conceivable with a low Reynolds number. There are two types of spindles for Brookfield viscometer, LV spindles and RV spindles. In this experiment, RV spindles are used and spindle number 05 is best used for all commercial mayonnaise samples (Kumar *et al*., 2021; Rodrigues do Carmo *et al*., 2019).

It can be seen from Fig. 1 that the measured viscosity of a fluid behaves in these ways, Newtonian behaviour is shown by a straight line which means that viscosity remains the same. Pseudo plastic shows that viscosity decreases with increasing share rate, whereas dilatant shows that viscosity rises with increasing share rate. Bingham plastic shows Newtonian behaviour after applying yield stress. The shear stress and shear rate relationship is related to flow and determines the flow behaviour of the material by plotting share stress versus share rate, so this type of figure is known as a flow curve.

Non-Newtonian materials show a rise or fall in viscosity when the share rate increases. The power law is suitable for small ranges of shear rates. It is the fluid in which the relation between shear rate and shear stress is not linear. Therefore, the viscosity of the material is affected by the change in shear rate (Katsaros *et al*., 2020; Nguyen *et al*., 2017).

Non-Newtonian fluids: $\eta = \eta\ (\gamma)$ .... (1)

In this type of fluid viscosity of the materials is the same and independent of the shear rate. Newtonian liquids obey the law of viscosity ascribed by Isaac Newton. Some examples of Newtonian materials are oil, water and dilute solutions of polymer.

Newtonian fluids: $\eta \neq \eta\ (\gamma)$ .... (2)

where:

n = power law index of the material, also known as the flow behaviour index of the material and γ shear rate.

n > 1 = dilatant and n < 1 = pseudo plastics.

Non-Newtonian fluids are of three types. Bingham plastics, this type of fluid shows a straight line with a τy intercept on the shear stress axis. The yield underscores the magnitude of the stress, that surpasses before flow begins. Viscosity is the ratio of stress and share rate. The Power law is used to determine the type of fluids (Kadian *et al*., 2021; Anamaria, 2018).

$$n = \frac{d(\log_{10} \sigma)}{d(\log_{10} \omega)} \quad (3)$$

If n < 1 for pseudoplastic, the viscosity function reduces as shear speed increases. This behaviour is characteristic of polymer solutions, high polymers and many suspensions. Dilating fluid (shear thickener), dilating fluid is congruent to pseudo plastics but the viscosity of these materials rises with rising shear rates. It is n > 1 for dilatant fluid, the viscosity of these fluids will grow with an increasing shear rate. Examples of pseudoplastic are commercial mayonnaise, paints, inks, ketchup, yogurt and sauce.

Viscosity measurement. The viscosity of each mayonnaise was scaled at different shear rates from 0 shear rates to 2 shear rates. It can have measured the viscosity with different ranges as the torque of the spring and viscosity is proportional to each other. The torque is proportional to spindle speed, size and shape. The minimum viscosity is determined using the smallest spindle with minimum speed and submerged in the fluid under test, the instrument will consistently show (as chosen) rate force. To freeze the presentation and hold a perusing, press the hold switch. The axle keeps on pivoting, however, the showcase holds the last perusing. The speed and spindle chosen are shown at the initiation of the revolution or after a speed/axle change to permit the user to look at settings. The right axle should be chosen, in any case, centipoises or the designing unit changes will be negligible.

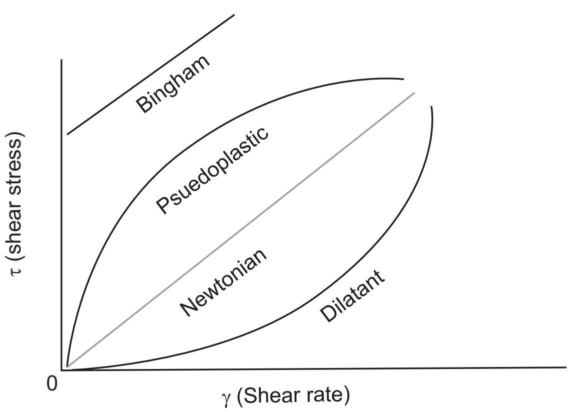

Fig. 1. Newtonian and non-Newtonian behaviour of the fluid.

Mitschka's method. Mitschka proposed a basic system to figure out normal shear stress and normal shear rate from information acquired using Brookfield viscometers. It is used to determine the flow behaviour index, the apparent viscosity and the consistency coefficient of power law fluids. Mitschka, in 1982 built up a straight forward strategy to decide the rheological parameters of intensity law liquids. It utilized a Brookfield viscometer, basic in an enormous section of the food industry (Kumar *et al*., 2021; Mozafari *et al*., 2017).

$$\delta = K, \gamma^n \quad (4)$$

Briggs and Steffe improved the technique by displaying the Mitschka information and growing the secured Brookfield models. They came about the Mitschka-Briggs-Steffe technique, the consistency and the flow behaviour index (n). The index (K) of power-law fluids is acquired utilizing the accompanying system. Shear pressure (σ) is acquired utilizing the spring torque and factors related to the spindle and Brookfield model. The graph is plotted between the logarithm of shear pressure and the logarithm of rotational speed = (ω), the flow behaviour index = (n) is acquired as the slope of the graph. The average shear rate = (γ) which is gotten by equation 3 (Khushbu and Sunil, 2018; Nguyen *et al*., 2017).

$$\gamma = (0.263.\ n^{-0.77})\ w \quad (5)$$

Power law model. This model gives a simple relationship between viscosity and shear rate. It is limited to small shear rates. The relationship is given (Kumar *et al*., 2021; Nizamuddin *et al*., 2020).

$$\tau = K\gamma^n \quad (6)$$

where:

γ = strain rate SI units/s; n = flow behaviour index. Based on the flow behaviour index, n = if 0<n<10<n<1, it represents shear thinning behaviour (pseudo plastic), if n=1n=1; it shows Newtonian behaviour and if 1<n1<n, it shows shear thickening behaviour.

Herschel-Bulkley model. The Herschel–Bulkley liquid is likewise a summed-up, non-linear model of non-Newtonian liquids. This model consolidates Bingham and forces law liquids in a solitary equation. Shear rate ranges are between low to high. The model equation is given (Orgulloso-Bautista *et al*., 2021; Nguyen *et al*., 2017).

$$\tau = \tau_0 + K\gamma^n \quad (7)$$

where:

n is the power/flow index, K is the consistency index with units m^2/s and τ_0 is the yield stress. Further, if $\tau > \tau_0 > \tau_0$, the Herschel-Bulkley fluid behaves as a fluid, if 0< n< 10< n< 1 it shows shear thinning behaviour (pseudo plastic). If n=1 and τ_0=0, it shows Newtonian behaviour and if 1< n1< n, it shows shear thickening behaviour.

Bingham model. The Bingham plastic model is a well-known rheological model utilized in the drilling industry. It has a two parameter model that incorporates yield pressure and the plastic thickness of the liquid. The model equation is given (Kumar *et al*., 2021; Taslikh *et al*., 2021).

$$\tau = \tau_0 + n\gamma \quad (8)$$

where:

τ_0 = yield stress; n = plastic viscosity (Pa.s)

Results and Discussion

The flow behaviorus of the samples were modeled by the Bingham model, Herschel-Bulkley model and the power-law model. The parameters of the samples were determined by non-linear curve fitting in Origin 9.1® (software).

Power law model. The flow curve as represents in Fig. 2 for all the samples prepared in this study. All the samples show shear-thinning behaviour and yield stress. A similar shear thinning behaviour is reported

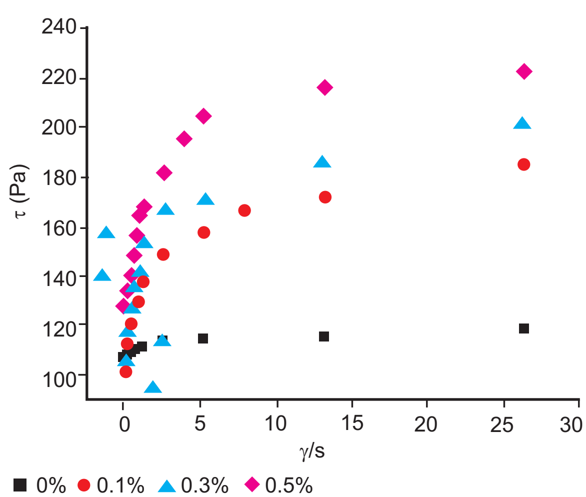

Fig. 2. Effect of different concentrations of Xanthan gum on the flow behaviour of various samples.

by many researchers in the study of the rheological characterization of their food products, such as mayonnaise, ketchup and chocolate flow behaviour. Xanthan gum concentration varied from 0.1 to 0.5% (He *et al*., 2021; Katsaros *et al*., 2020; Alvarez-Sabatel *et al*., 2018; Yadav *et al*., 2018).

A typical representative curve is shown in Fig. 3 to calculate fitting parameters (K and n) along with the regression coefficient (R^2). The lines are fitted power-law curves to the flow behaviour of the control sample, with 0% Xanthan gum and 0.5% sample containing 0.5% of Xanthan gum by weight to the mayonnaise sample. It is obvious from the regression coefficient (R^2) that the power law model gives the best fit to the samples used in this research. It is very obvious from the regression coefficient (R^2) that the power law model gives the best fit to the samples at least used in this study when compared to the other models, as shown in Fig. 4. The fitting parameters K and n, along with the regression coefficient (goodness of fit) are also shown in Fig. 3 (Khushbu and Sunil, 2018; Nguyen *et al*., 2017).

Bingham model. The lines fitted Bingham model curves to the flow behaviour of the samples with 0%, 0.1%, 0.3% and 0.5% of Xanthan gum by weight to the mayonnaise sample as shown in Fig. 5. It is obvious from the regression coefficient (R^2) that the Bingham model gives the least fit to the samples used in this study, showing less adequacy of the model (Katsaros *et al*., 2020; Akoglu *et al*., 2018; Alvarez-Sabatel *et al*., 2018).

Herschel-Bulkley model. A typical representative curve is shown in Fig. 6. The lines are fitted with Herschel-Bulkley model curves to the flow behaviour of the samples with 0%, 0.1%, 0.3% and 0.5% of Xanthan gum by weight to the mayonnaise sample. It is evident from the regression coefficient (R^2) that the Herschel-Bulkley model gives a good fit to the samples but the

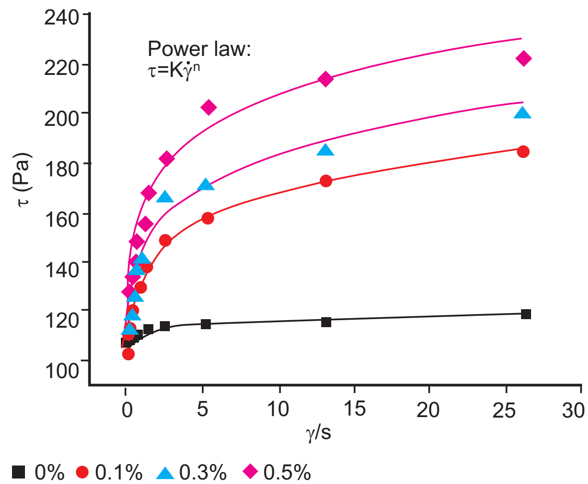

Fig. 4. The power Law model fits the samples with the Xanthan gum percentages of 0%, 0.1%, 0.3% and 0.5%.

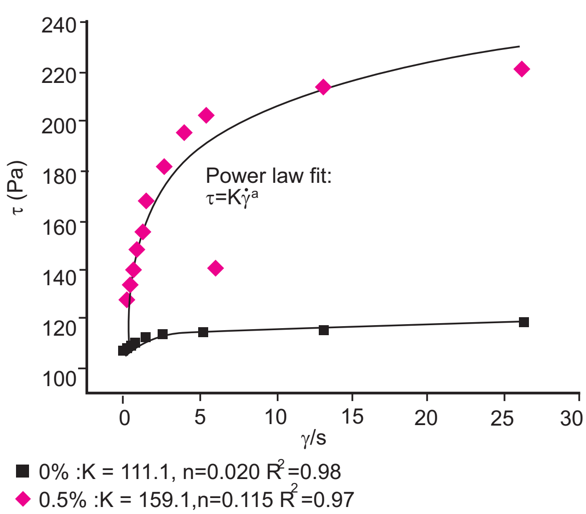

Fig. 3. Power-law model fits the control sample with 0% Xanthan gum and 0.5% sample.

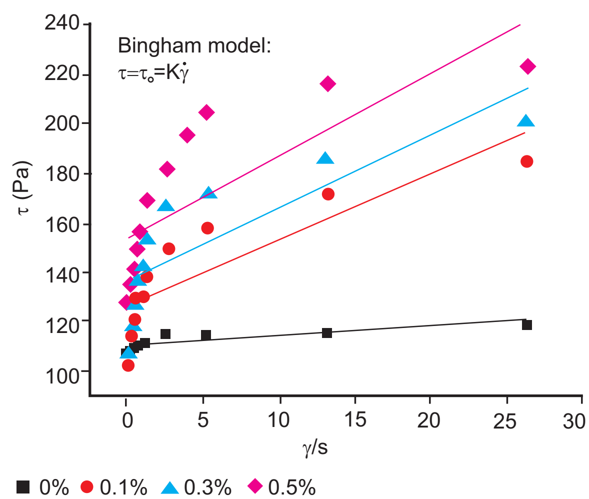

Fig. 5. Bingham model fit the samples with the Xanthan gum percentages of 0%, 0.1%, 0.3% and 0.5%.

fitting parameters (K and n) are scattered values. Hence, this model is not showing 100% accuracy and does not best-fitting parameter values for the samples used in this study (Heggset *et al*., 2020; Akoglu *et al*., 2018; Farahmandfar *et al*., 2017).

Comparison of K with Xanthan gum (%). It is clearly shown in Fig. 7, that an almost linear increase in the K (consistency viscosity) values was observed, as to an increase in Xanthan gum concentration, the sample becomes viscous. The value of the regression coefficient (R^2) is 0.942. The red line shows the linear fit to the data (Kumar *et al*., 2021; Razavi *et al*., 2018).

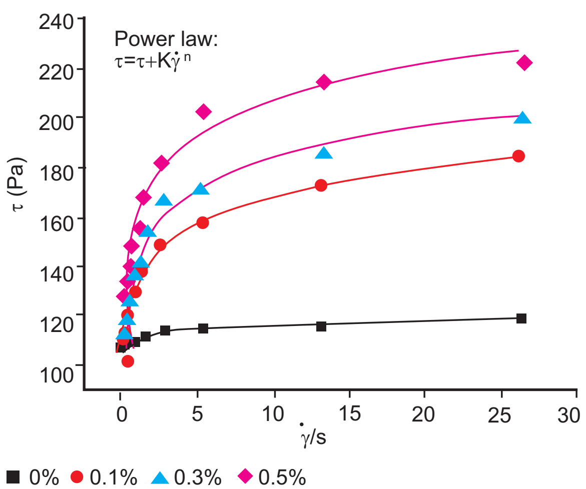

Fig. 6. Herschel Bulkley model fit the samples with the Xanthan gum percentages of 0%, 0.1%, 0.3% and 0.5%.

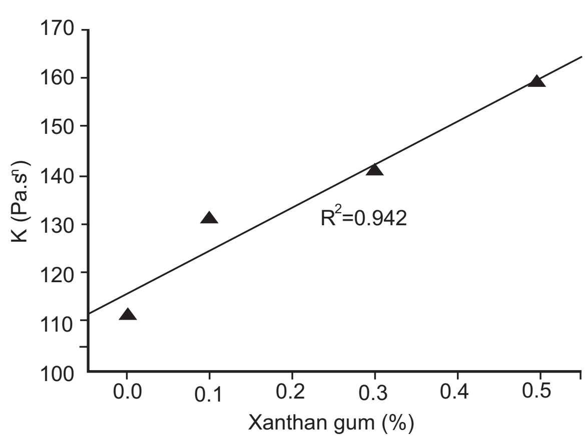

Fig. 7. K (consistency viscosity) with the Xanthan gum percentage increase in the samples.

Comparison of n with Xanthan gum (%). The values of n and Xanthan gum (%) in Fig. 8 fit the Gompertz growth model, which gives us a plateau value of 0.1135 and a regression R^2 value of 0.999. The value of n is drastically increased after adding Xanthan gum to the sample and then it shows a linear increase with a further increase in the percentage of Xanthan gum in the sample. The line shows the growth trend. The red line shows the growth trend, the plateau value is 0.1135 and the regression coefficient (R^2) is 0.999 (Akoglu *et al*., 2018; Anamaria, 2018; Naji-Tabasi *et al*., 2018; Mozafari *et al*., 2017; Nguyen *et al*., 2017).

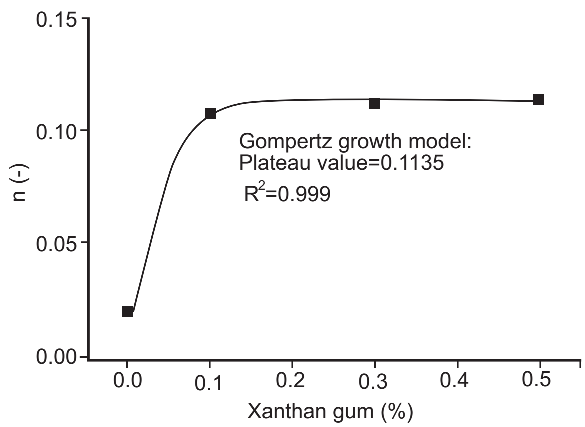

Fig. 8. Behaviour of n with the percent increase of Xanthan gum in the samples.

Conclusion

Brookfield viscometer data was successfully transformed into the rheological parameters utilizing Mitschka's method. The viscosity vagaries with the shear rate. This behaviour specifies that the commercial mayonnaise samples are non-Newtonian. All the samples of commercial mayonnaise samples were shear thinning with n 0.02 to 0.114. The power-law model is best fitted among all the models having a regression value of 0.999. Values of n increase as Xanthan gum concentration increases and it follows the growth trend behaviour. It is recommended to perform the same study on vegetable mayonnaise or tomato sauce at various temperatures considering a higher deformation rate than 100 rpm in the future.

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Conflict of Interest. The authors declare that they have no conflict of interest.

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