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RHEOLOGICAL PROPERTIES OF FOOD: A REVIEW

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ABSTRACT

Rheology is known to be the science of flow of matter and its deformation. It is the study of the way in which any material responds to the factors like applied stress or strain. Hence, it describes the interrelation between force, deformation and time. The study of rheological properties in the food sciences is of much importance as it got its utility in operations related to food processing and sensory characteristics. This is because textural characteristics of a food material defines its overall quality and unless the major quality attributes of the food product meets the defined quality standards, the product will get rejected eventually regardless of its nutritional count. The science of rheology not only deals with fluids but also with the solid foods. The aim of the present paper is to list out and evaluate the importance of different rheological properties of the food materials whether they are in the form of solids, fluids or frozen foods.

KEYWORDS: *Rheology, Deformation, Stress, Strain, Force, Foods Processing, Sensory Characteristics, Textural Characteristics*

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INTRODUCTION

Rheology, a science, deals with the flow of matter and its deformation, determining the relation between the factors like force, deformation and time for any matter. It is precisely known to be the study of the manner in which any material will react when subjected to any type of stress or strain (Myhan et. al, 2012). The concept of rheology is almost 76 years old and the term was founded by two scientists named Professor Marcus Reiner and Professor Eugene Bingham.

The Rheology has got its application in the food processing operations and sensory characteristics. The science of rheology deals with liquids as well as solids. A force is able to change the shape of a solid food product or direct the flow of the liquid ones.

Rheological Properties of Solid Foods

With the application of first unit of force to any solid food product, the amount of deformation increases equally with addition of each force.But eventually, with continuation of force, the product will reach a yield point, where deformation continues even without input of any additional force. At this point, the change in shape of the product will be permanent and beyond that it will start breaking, known as its rupture point (Dogan et. al, 2007).

Evaluation of Rheological Properties of Solid Foods Can Be Divided into Two Classes:

- **Fundamental Tests:** These tests measure the properties like elasticity, poisson ratio, shear modulus etc. which are inherent to the food material and do not depend upon the geometry of the test sample.
- **Emperical Tests:** These tests measure the properties like puncture force and extrusion energy.

Elastic Behavior of Solid Foods

The pure elastic behavior of a solid can be understood when a force is applied to it and it will instantly deform and when the force is released, it instantly returns back to its original form. Such solids are known as Hookean solids (Krokida et. al, 2001).

There Are Three Types of Moduli That can be Calculated for a Hookean Solid on the Basis of Method of Applying The Force. These Are

- Modulus of Elasticity (E)
- Modulus of Rigidity (G)
- Modulus of Bulkiness (K)

Rheological Properties of Fluids

The rheological properties of fluids are based upon their flow and deformation patterns when subjected to any type of stress (Rao, 1996).The most important factors that determine the properties of fluids are shear flow properties which are based on shear rate and shear stress.

Shear Stress and Shear Rate

Shear Stress (symbol o) is the stress component which is applied tangentially and is equal to the force vector divided by the area of application.

Shear rate (symbol y) is the velocity gradient taken in a fluid as results of shear stress applied on it (Rao, 2014).

On The Basis of Rheological Properties, All Fluids can be Classified In One of the Two Categories. These Are

- Newtonian Fluids
- Non-Newtonian Fluids

LITERATURE REVIEW

Zheng (2019) carried out his research on the measuring the rheological properties of foods. He concluded that rheological measurements of foods can be conducted in rotational or oscillatory modes, and help to provide information about food flow and their visco-elastic behaviors over a varying range of temperatures, time scales and shear conditions. Food rheological properties are of great importance in the food manufacturing industry. Using rheological techniques and information, one can predict the flow behavior of a given raw food material in a particular processing line and can suggest modifications thereby reducing the processing risks.

Myhan et. al (2012)in their study developed a mathematical model which can be used to explain the rheological properties of food materials. It included properties like elastic moduli, index of flow, consistency index and limit of flow. On the basis of the results of the test, a rheological model was designed. The analysis revealed that the model was found to be sensitive to the changes in the values of the elastic modulus; flow limit and flow index, but was found to be less susceptible to the changes in the consistency index.

Wang et. al (2011)in their study, modeled and estimated the rheological properties of the food products. They formulated a 2D/3D dynamic FE model and tested three different types of Japanese sweets and accessed their deformation and force behaviors. An inverse FE optimization approach was then proposed to estimate the rheological properties. The estimated parameters were then used to simulate three-layered food products. The FE model so developed was used to predict the rheological behaviors of the food products during their process of manufacturing.

Demirkesen et. al (2010)in their research studied the rheological properties of rice bread dough which contains different gums, with or without the emulsifiers. Also, they evaluated the quality of the bread in terms of volume, firmness and sensory analysis. They used different gums like xanthan gum, guar gum, locust bean gum (LBG) etc. and in emulsifiers, they usedPurawave and DATEM to find out the best formulation for gluten-free breads.For controlled formulations, rice dough and wheat dough with no gum or emulsifiers were used. In the results, when Purawave was used, dough samples were found to have low consistency index and visco-elastic modulus as compared to DATEM. With the addition of DATEM, the quality of the bread was found to be improved in terms of specific volume and sensory values.

Dogan et. al (2006) in their research, talked about the better measurement techniques are available for the food rheology. They gave an overview of the recent advances in this field which will enable the practitioners to expand further into the field.

MATERIALS AND METHODS

The present paper is a quantitative research in which the supporting data for the information in the related field is gathered from different sources like the literatures of different authors like Sanchez et. al (1995), Myhan et. al (2012), Rao et. al (2014), Campanella et. al (1995), Dogan et. al (2007), Zheng (2019) and others. Overtime, these authors have taken different rheological property parameters and conducted study of different types of foods such as food purees, solid foods, semi-solid foods, fluids, granular foods or powders and others. The main rheological parameters focused upon here aremodulus of elasticity, rigidity, bulkiness, poisson ratio, shear modulus, shear rate etc (Zheng, 2019).

RESULTS AND DISCUSSIONS

The importance of the study of rheological properties of any matter cannot be denied especially when it comes to the case of food materials whether they are solids, fluids or in any other usable form. In this paper, we have reviewed different rheological property parameters that act upon the solid food materials and in case of fluids as well. We have also discussed the categories in which these food materials can be classified on the basis of these parameters. On the basis of certain tests, the food materials can be compared to the requirements of the professional food processing industry and if at first the tested samples do not meet the expectations then they can be altered to meet the industry standards.

CONCLUSIONS

The Rheology is the branch of physics in which it is studied the response of an material when it is subjected to any type of stress or strain and the properties of the material that reign over the specific way in which the deformations or the flow behaviors of any material takes place are its rheological properties. The related study has gained a lot of importance over a longer period of time and has put itself to great use in the applications related to the food processing industry and its associated operations. Especially in the food industry, the study of the rheological properties has helped in controlling many processing parameters, studying the influence on unit operations, selection of harvesting and sorting raw materials, selection of proper ingredients for manufacture of processed foods and selection of proper technology or equipments for manufacturing the processed foods with desired sensory and rheological properties.

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