Tribology and Its Significance in Food Industries

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The perception of food texture is influenced by the arrangement and properties of food components at molecular, microstructural, and macroscopic levels. It is experienced through the senses of sight, taste, touch, and hearing. While seeing, hearing and touching all contribute to texture perception, the most valuable and dominating signal comes from oral sensation. From the oral perspective, food texture can generally be defined as the "sensation from the ingestion, mastication and swallowing of the food, which is influenced by the physical properties of the food being masticated" (Chen, 2009; De Wijk et al., 2006).

The act of eating is a constantly changing experience, just like sensory perception. While consuming food, the intensity of specific sensory attributes varies, and the overall profile of the dominant sensory characteristic may shift accordingly. Textural aspects detected early in the oral processing process are primarily dominated by bulk phase qualities, whereas textural features detected later in the process are related to a thin film of product and/or a product-saliva combination that impacts oral surface properties and lubrication (Engelen and De Wijk, 2012).

Tribology-Principle, Operation and Types of Tribometers Used for the Measurement of Lubrication Properties

Generally, the word Tribology is obtained by the combination of two different greek word, "tribo" and "logy". The word "tribo" means rubbing whereas "logy" means to study. Thus, it is defined as "science of rubbing" or "study of rubbing". In other word Tribology is the science of friction, wear and lubrication between the interacting surfaces which are in relative motion, with or without them and the instruments used to measure the tribological properties are called tribometers (Sangeeta et al., 2016). Tribometers in food industries are important to determine the oral perception of food products between the tongue, palate and tooth with or without the lubricants (or saliva) between them (Dresselhuis, 2008).

Nowadays, tribometers are becoming more important due to its ability to measure certain food properties during oral processing which are usually cannot determined by the textural as well as rheological measuring instruments. Generally, there are many techniques or instruments has been developed to measure the Mechanical deformation and flow (rheology) behaviour of food products. But properties like comminution, lubrication, creaminess, and change in surface roughness of foods occurred during oral-processing are usually neglected. Hence here comes tribometers to measure these above properties. Consider an example of biscuit, Mechanical properties like hardness, crunchiness, etc usually determined but mouthfeel properties such as graininess, smoothness, slipperiness, cohesiveness usually neglected. However, some of the above properties can be measured by rheometer, but others properties like smoothness, slipperiness, creaminess, and fat-perception can be measured with the help of tribometers.

As discussed above, tribology is the science of friction between two interacting surfaces with or without lubrication. In the given fig.1.1, two bodies is in relative motion where body A is moving with a velocity 'v' and 'F_L' is the normal force acting perpendicular to the surface. Also 'F_R'is the frictional force acting opposite to'v'. Hence,

$$F_R = \mu \times F_L,$$

where μ = coefficient of friction

$$\mu = F_R / F_L$$

Coefficient of friction (μ) is mainly depended on - surface properties, surface load, moving speed, and lubricant property.

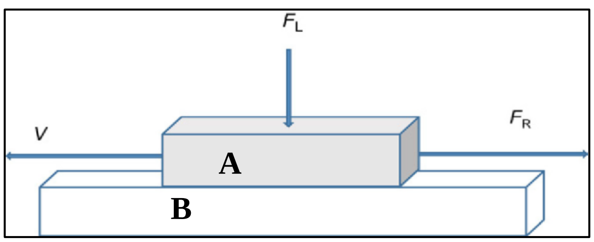

Fig 1. Body A and B are in relative motion (*Source: Sangeeta et al., 2016*)

Conclusions

To understand & quantify a range of different aspects of mouthfeel by using various type of instruments known as tribometers. These tribometers play important role to develop food with improved formulations having low calories with improved consumer acceptability. It is useful to analyse sensory perception which is usually not determined by rheometers. These instruments are able to mimic the fat related sensory perception which includes creaminess as well as fattiness. There is no risk of hazard.

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Table 1. Types of tribometers used to measure the lubrication properties of food

Tribometer	Attachments	Working principle	Food application	Reference
Friction tester	Consist of rubber band, a load cell and a metal cylinder along with an electric motor	Spherical ball revolving against in-house developed rubber band	Roughness and creaminess of Vanilla custard with varying starch type, starch concentration and fat concentrations were measured	de Wijk et al. (2006)
Optical tribological configuration	Consists of two interacting surfaces, a glass platform and a confocal scanning light microscopy (CLSM)	In-house developed detachable surface that applies force against an oscillating glass surface	Roughness and fatty mouthfeel of Emulsions prepared from whey protein isolate and sunflower oil was measured	Dresselhuis et al. (2008)
Mini-traction machine	Consists of a rotating ball and disk in enclosed insulated chamber	Spinning disk against rotating ball	Slipperiness and fattiness ofGuar gum solutions and sunflower oil was measured	Malone et al. (2003)
Mounted tribological device	Consists of a spherical ball attached to a shaft which rotates on three small motile plates	Ball rotating on three motile plates	Creaminess of Heavy cream, milk with different fat percentage, skim milk, dairy emulsions thickened with maltodextrin and xanthum gum was measured	Baier et al. (2009)
Tribology cell	Consists of a rotating disk, two cylinders having same contact point and it can be attached to a rheometer	Two cylindrical contact points rotating against annular disk developed in–house	Different concentrations of corn syrup	Goh et al. (2010)

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