

Relationship of Physical Properties of Fats and Oils with Quality Characteristics of Cookie

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ABSTRACT: Six different fats and oils were analyzed for physical characteristics. All the six fats and oils differed widely in their physicochemical characteristics. The results showed that fats and oils physical properties had appreciable effects on the spread ratio and breaking strength. Slip melting point ($r = -0.990^{**}$), creaming power ($r = -0.901^{**}$), yield value ($r = -0.760^{**}$), viscosity ($r = -0.729^{**}$), and hardness ($r = -0.628^*$) contributed significantly negatively to cookie spread ratio. These are the factors responsible for superior cookie spread ratio produced by sunflower oil and groundnut oil. Statistical analysis showed that breaking strength was strongly positively and negatively correlated to refractive index ($r = 0.766^{**}$), and slip melting point, creaming power ($r = -0.954^{**}$, $r = -0.870^{**}$, respectively). Fats and oils with lower slip melting point and creaming power were not desirable for cookies as they resulted in a stiffer cookie.

KEYWORDS: Fats and oils, Cookie quality, Spread ratio, Breaking strength.

I. INTRODUCTION

Fats and oils are widely used food components. They are the essential ingredients in baked products and influence their microstructure and physical properties. Fats and oils in baking contribute to product characteristics such as tenderness, moisture, mouthfeel, lubricity, flavor, structure, and shelf life. Shortenings which are often produced by partial hydrogenation of oils are commonly used in the baking industry. However, during partial hydrogenation of oil, trans fatty acids are formed, and research has proved the direct connection of trans fatty acids with many health problems [1].

The quality and physical properties of many food products strongly depend upon the physical properties of fats and oils. Physical properties of fats/oils are of critical importance in determining its use. Physical properties of fats and oils are amongst the most important properties that indicate freshness and quality of the fats and oils as well as their functionality in food products. Different physical parameters of edible oil were used to monitor the compositional quality of oils [2, 3]. Physical properties of fats/oils are of critical importance in determining its use. These properties of fats/oils mainly depend on their fatty acid composition [4]. A higher percentage of saturated fatty acids is related with the high melting point fats. The melting point of a lipid describes the temperature point at which it changes its solid states to liquid states. Specific gravity signifies heaviness of fats and oil compared to that of water. The specific gravity of unsaturated glycerides is higher than the corresponding saturated ones. Refractive index of fats and oils is a basic value that relates to molecular weight, fatty acid, chain length, the degree of unsaturation and degree of conjugation. An important functional characteristic required of fat and oil when used in baked products is an ability when beaten with sugar, to retain air. This ability is referred to as the 'creaming power' of fat and oil. These properties assume a noteworthy part in deciding the quality of cookies and other bakery products [5]. Therefore, it is of immense significance to examine the physical properties of fats and oils. Relatively little work has been done on the relationship between physical properties of fats and oils and quality characteristics of cookie. The present investigation was undertaken to investigate the same.

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II. MATERIALS AND METHODS

A. Materials

Six different types of edible fat and oil samples were examined both from plant and animal origin. Palm oil was obtained from Ruchi Soya Industries Ltd., Gurgaon. Butter (Amul), hydrogenated fat (Dalda), sunflower oil (Nature Fresh), groundnut oil (Dhara), and coconut oil (Parachute) were procured from local retailers.

B. Physical Analysis of Fats and Oils

Specific gravity was estimated by the formula: Specific gravity = Density of oil/Density of water. The viscosity measurement was carried out by Brookfield Viscometer (RV Model). The temperature of samples was maintained at $25 \pm 1^\circ\text{C}$ throughout the test. Refractive index was determined using an Abbe Refractometer and white light according to AOAC Standard Method (2000). The slip melting point (SMP) was determined according to the Official Method of AOCS (1989). A column of fat was tempered at $10 \pm 1^\circ\text{C}$ for 24 h in an open capillary tube. The tube was then warmed gradually in a water bath until the fat began to ascend because of hydrostatic pressure. The temperature at which this occurs was determined as SMP using averaging of three replicates. Consistency was measured by Texture Analyzer TA-XT2 (Stable MicroSystems) controlled by a computer. Before measurements samples were melted and tempered for 24 hours at room temperature (25°C). The compression values were converted to yield value, in accord to Haighton [6]. The hardness of fats and oils were measured using a double compression test with a Texture Analyser TA-XT2 (Stable MicroSystems). The hardness of the shortening was indicated by the maximum force detected during compression. The measurements were performed in triplicate for each sample.

C. Creaming Test

It was performed according to Nor Aini et al. [7] method with slight modifications. A Kenwood Junior mixer was used with a K beater and a static scraper blade. Icing sugar (72g) and fat/oil (45 g) were mixed using a K beater for 30s at speed 1, adding water (12g) during that time. Mixing was continued for 2 min at speed 4. The aerated cream was filled into cups of known volume in duplicate, avoiding the inclusion of void spaces during filling. The weight of the cup with cream was taken. This process was repeated at 2 min intervals until creaming time reached 12 min. Creaming power was calculated in terms of specific volume of cream ($\text{cm}^3 \text{g}^{-1}$).

D. Cookies making

Cookies were prepared according to AACC approved method 10-50D [8] with slight modifications. The ingredients used were flour (225 g), sugar (130 g), shortening (64 g), dextrose solution (33 ml), sodium bicarbonate (1.6 g), ammonium bicarbonate (0.9 g), sodium chloride (2.1 g) and distilled water according to requirement. The dough was prepared and sheeted to a thickness of 5 mm on a dough sheeter, and round shaped cut was given using a cutter of 50 mm diameter. Cookies were baked in a lightly greased tray in the baking oven at 205°C for 15 min followed by cooling and subsequently measured for diameter and thickness and average was calculated. The spread ratio was calculated by dividing diameter (mm) with thickness (mm). Cookies were prepared in triplicate.

E. Texture analysis

Textural analyzer (Stable Micro Systems TA-XT 2i, U.K.) was used to measure the hardness of the cookie. The probe used was Knife Edge Insert (HDP/BS) in order to apply braking force required to fracture the cookies with 5 kg load cell Heavy Duty Platform (HDP/90) at pre-test speed, test speed and post-test speed of 1.5, 2.0 and 10.0 mm/s respectively with a data acquisition rate of 400 pps.

F. Data Analysis

The experimental data collected were analyzed for significant differences with the help of analysis of variance (ANOVA) conducted using SPSS 16.0 software. The correlation matrix was obtained using SPSS 16.0.

III. RESULTS AND DISCUSSION

Physical Properties of Fats and Oils

Significant variation was observed in the fats and oil physical attributes, such as slip melting point, refractive index, viscosity, yield value, and hardness. Slip melting point (SMP) of fats and oils ranged from -18 to 38°C . Hydrogenated fat had the highest SMP while sunflower oil had the lowest SMP owing to its most unsaturated fatty acid composition [5]. Refractive index of fats and oils, a measure of unsaturated nature, ranged from 1.3294 to 1.3478. It was evaluated

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from the observations that the specific gravity was the least for palm oil i.e. 0.9110 g/cm^3 while it was maximum for hydrogenated fat i.e. 0.9219 g/cm^3 . Viscosity varied from 42.81 cP in coconut oil to 82 cP in hydrogenated fat. The maximum yield value was observed in butter (366.73 g/cm^2) while coconut oil (38.41 g/cm^2) had the lowest. The least hardness value of 0.29 N was reported for sunflower oil whereas coconut oil scored a maximum of 41.40 N . Results are in line with [9].

Creaming Power

The capability to trap air is an immensely influential aspect in establishing the significance of fat and oil as a shortening agent. The volume of air that can be assimilated into a fat-sugar mix when beaten together under standard conditions can be brought out by measuring the specific volume of the cream, i.e. the volume per unit mass, the value of which is generally known as the creaming power of the fat and oil. The creaming power ranged from 0.827 to $1.037 \text{ cm}^3 \text{ g}^{-1}$ after 2 min of beating and from 0.829 to $1.197 \text{ cm}^3 \text{ g}^{-1}$ after 12 min of beating. Results of the creaming power test (Fig. 1) indicated that palm oil had the best creaming performance. There was no substantial difference between creaming performance of palm oil and hydrogenated fat. Sunflower oil and groundnut oil had the poor creaming power.

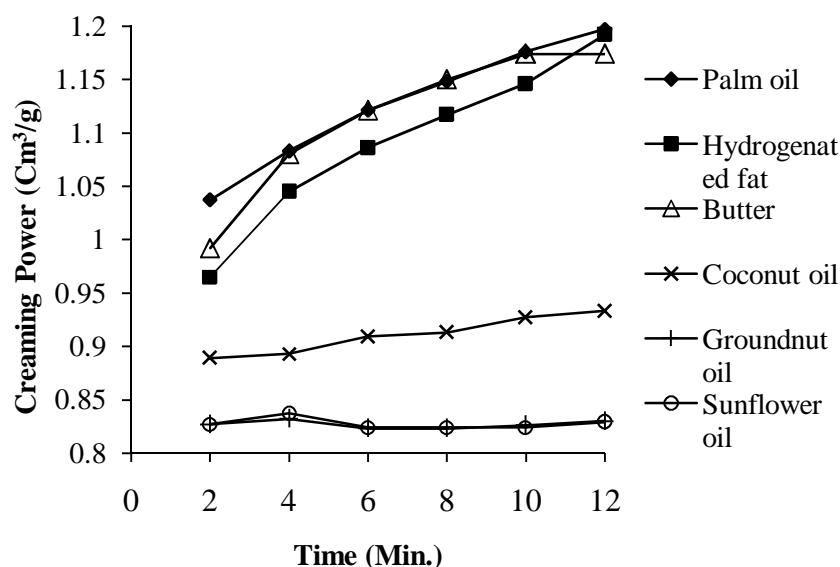


Fig. 1. Creaming power of fats and oils

Results of the creaming test obtained in this investigation (Fig.1) indicated that palm oil had the best creaming performance. There is no substantial difference between creaming performance of palm oil and hydrogenated fat. Although, butter had relatively lower value than palm oil and hydrogenated fat nevertheless in the good range of creaming performance. Sunflower oil had the poorest creaming power, and groundnut oil had the similar creaming power to sunflower oil. It might be due to their fatty acid composition and crystal characteristics.

Physical Characteristics of Cookies

The quality of cookie was evaluated in terms of diameter, thickness, spread ratio, and cookie breaking strength. Cookie quality parameters prepared from different fats and oils differed significantly (Table 1). The diameter of cookies varied from 55.20 and 62.50 mm , for butter and sunflower oil, respectively. The thickness of cookie ranged from the lowest of 6.00 mm for cookies made using sunflower oil to the highest of 6.60 mm for cookies prepared using hydrogenated fat. Higher cookie spread ratio is considered as the desirable quality attributes [10]. Cookie spread was

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aligned from 8.45 to 10.42 in increasing orders from hydrogenated fat, followed by butter, palm oil, coconut oil, groundnut oil, and sunflower oil. Cookies made using palm oil, and butter respectively had similar spread values. Knightly [11] speculated that the poor spread ratio delivered by cookies containing hydrogenated fat might be due to its tendency to form beta crystals which do not favour aeration.

The textural property is one of the crucial factors to evaluate the quality of cookies. Hardness, the most imperative textural characteristics for cookies, measured in terms of breaking strength, as the peak force to snap the cookie. Cookie breaking strength was significantly affected by different fats and oils. The hardness of cookies ranged from 4982 to 7257 g. Results were in agreement with an earlier investigation done by Barak et al. [12]. The data obtained (Table 1) showed that the cookies made using the sunflower oil were the hardest, while cookies made using hydrogenated fat were found the most tender as indicated by their least hardness value. On the other hand, the hardness of cookies prepared using butter and palm oil was not remarkably different from each other. Cookies made using sunflower oil resulted in the superior spread but extremely stiff texture; however, cookies made using hydrogenated fat were tender with lower spread ratio. It was inferred from the data that the cookies containing oils delivered larger diameter, lower height, higher spread, and stiff texture. Analogous remarks were laid by Mert & Demirkesen [13].

Table 1 Cookie quality characteristics of fats and oils.

Fats and oils	Cookie Quality			
	D (mm)	T (mm)	SR (D/T)	BS (g)
Butter	55.20a	6.30d	8.76b	5050b
Hydrogenated fat	57.75 c	6.60f	8.45a	4982a
Palm oil	58.00d	6.50e	8.92c	5094b
Coconut oil	57.25b	6.25c	9.16d	5221c
Groundnut oil	61.25e	6.20b	9.88e	7146d
Sunflower oil	62.50f	6.00a	10.42f	7257e

Values followed by different letters are significantly different from each other ($p \leq 0.05$).
D- Diameter; T- Thickness; SR- Spread ratio; BS- Breaking strength.

Relationships among Cookie Quality and Physical Properties of Fats and Oil

Cookie diameter was strongly negatively linked with SMP ($r = -0.906^{**}$), YV ($r = -0.740^{**}$), and CP ($r = -0.777^{**}$). RI induced significant positive association with cookie diameter ($r = 0.844^{**}$). Cookie thickness followed the contrary trend with diameter. The degree of air incorporation also contributes to cookie thickness as indicated by the strong positive relation with CP ($r = 0.856^{**}$). Fats and oils that begin melting too early in the baking process are not able to absorb to the bubbles, which allows air to escape before dough expansion, resulting in bubble rupture and lower cookie thickness. Similar results sought in this study as slip melting point displayed strong positive relation with cookie thickness ($r = 0.872^{**}$). Spread ratio, which is one of the important quality parameters, was significantly negatively influenced by SMP ($r = -0.990^{**}$), CP ($r = -0.901^{**}$), YV ($r = -0.760^{**}$), and V ($r = -0.729^{**}$). RI established a positive relation with SR ($r = 0.659^*$). These are the factors responsible for superior cookie spread ratio produced by sunflower oil and groundnut oil. Sunflower oil and groundnut oil with lower SMP values melt quickly during baking and yield cookies with increased spread and decreased thickness. Hardness is an undesirable characteristic of cookie product [14]. Cookie hardness, measured as breaking strength, was significantly negatively related to slip melting point ($r = -0.954^{**}$),

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creaming power ($r = -0.870^{**}$), and strongly positively associated with RI ($r = 0.766^{**}$), highlighting tender cookies delivered by dough formulated with hydrogenated fat, butter, and palm oil. Yield value contributed negatively to breaking strength ($r = -0.657^*$).

Table 2 Correlation among physical characteristics of fats and oils and cookie quality attributes

Physical Properties of Fats and Oils	Cookie Quality Parameters			
	D	T	SR	BS
SMP	-0.906**	0.872**	-0.990**	-0.954**
RI	0.844**	-0.355*	0.659*	0.766**
SG	ns	ns	ns	ns
V	-0.552*	0.776**	-0.729**	-0.596*
YV	-0.740**	0.591*	-0.760**	-0.657*
HD	-0.582*	0.460*	-0.628*	-0.692*
CP	-0.777**	0.856**	-0.901**	-0.870**

*Correlation is significant at the 0.05 level **Correlation is significant at the 0.01 level. D- Diameter; T- Thickness, SR- Spread ratio; BS- Breaking strength; SMP- Slip melting point; RI- Refractive index; SG-Specific gravity; V- Viscosity; YV-Yield value; HD- Hardness; CP-Creaming power; ns- not significant.

Higher the creaming power, more air got incorporated during mixing stage that released during baking resulting in tender cookies. Lower SMP of fats and oils would melt faster during baking, thus facilitating more gluten interactions resulting in stiffer cookies. Among the various physical characteristics of fats and oils studied, it was observed that slip melting point and creaming power were the most important predictors of cookie quality. Specific gravity did not show any remarkable relation with cookie quality parameters.

IV. CONCLUSION

The study revealed that quality attributes of cookies were significantly affected by physical properties of fats and oils. The reason for the difference in performance of different fats and oils in cookie making in terms of their physical properties is far better understood now. Refractive index influenced cookie diameter, spread ratio, and breaking strength positively, whereas cookie thickness related negatively with it. Sunflower oil possessing the lowest slip melting point and creaming power produced the cookie with utmost spread and breaking strength.

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