International Journal of Food Science and Nutrition
ISSN: 2455-4898
Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 3; Issue 1; January 2018; Page No. 68-72

Study on the physico-chemical and sensory characteristics of cookies made using avocado as a fat (Butter) substitute

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Abstract
Cookies are one of the most prominent snacks due to its prolonged shelf life and also aroma, flavor and texture. As baked goods are known to have high percentage of fat, replacing it partially with fruit or vegetable substitutes provide with healthier options. Fat plays an important role in both taste and texture of baked products, especially cookies. In the present study, chocolate cookies were made by replacing butter fat with avocado in three variations (V1, V2 and V3) at 25%, 50% and 75% and were tested for their physical, chemical and sensory characteristics. The physical and overall acceptability were found to be similar for all with improved nutritional content in the variations. The cookie weights were found to decrease and the lowest weight was indicated in the cookie which had highest amounts of avocado puree (V3). The moisture content in the control was lower than that of the avocado cookies and it slowly increased from V1 to V3 whereas, the fat content of the avocado cookies were found to decrease from V1 to V3.

Keywords: avocado, fat substitute, fat replacer, cookies

1. Introduction
Cookies have become one of the most desirable snacks for both youth and elderly people due to their low manufacturing loss, more convenience, long shelf-life and ability to serve as a vehicle for important nutrients [1, 2]. However, this baked product is relatively high in fat providing about 50% of their calories from this nutrient.
Fat plays an important role in both taste and texture of baked products; therefore, choosing the appropriate fat substitute for a product or recipe is a critical step in replacing the fat [3]. According to Position of the American Dietetic Association (2005) Fat replacement in food systems poses a complex problem because fat contributes to sensory and physiological characteristics such as flavor, mouth feel, taste, odor and texture. Effects of product modification on sensory attributes, as well as dietary benefits, must be considered in the development of high-quality, acceptable products [4]. Reducing fat in this low-moisture, high-fat baked product alters appearance, flavor, aroma and texture. These sensory characteristics provided by fat have been found to be difficult to achieve with fat replacers [5]. As baked goods are known to have high percentage of fat, replacement of it with fruits or vegetables contribute to healthier alternatives.
Overweight and obesity are epidemic in many parts of the world [3]. Much evidence suggests that the increases in obesity and overweight were related to the increases in fat and caloric intake [6, 7, 8]. To improve the weight status and overall health, many researchers have focused on reducing the fat content in food products by replacing the fat with fruits or vegetables based ingredients [3]. Replacing dietary fat with fruits and vegetables based ingredients will not only reduce the fat intake, but also provide with nutritional benefits to the product and contribute to increase the consumptions of fruits and vegetables.
There is epidemiological evidence that increasing dietary monounsaturated fatty acids (MUFA) may decrease the risk of coronary heart disease [9]. Avocados are a rich food source of MUFA, with a MUFA content of 15.63 g per 100 g of avocado [10]. Avocado is a nutrient dense, cholesterol-free fruit, which is low in sodium and can be considered to be a source of fibre [9].
Avocado (*Persea americana*) is known for its pleasing taste and predominance of monounsaturated fatty acids [11]. It is also recognized as a functional food that contains health-promoting phytochemicals such as glutathione and beta-sitosterol [12]. From a nutritional point of view, avocado is a highly caloric fruit. A large content in unsaturated fatty acids is one of its distinguishing characteristics [13, 14, 15]. Moreover, avocado is rich in lipo- and water-soluble vitamins, especially A and C [16, 17].
Therefore, this study was undertaken to check the feasibility of butter cookies (chocolate flavored) formulated by substituting fat with avocado puree and to study its physicochemical and sensory attributes.

2. Materials and Methods
2.1 Formulation of chocolate cookies
All the ingredients were procured from local markets in Chennai, Tamil Nadu.

Table 1: Formulation of the cookies

Ingredients	Control (B:A=4:0)	V1(B:A=3:1)	V2(B:A=1:1)	V3(B:A=1:3)
Refined flour	130 g	130 g	130 g	130 g
Sugar	155 g	155 g	155 g	155 g
Butter (B)	113 g	84.75 g	56.5 g	28.25 g
Avocado puree (A)	-	28.25 g	56.5 g	84.75 g
Cocoa powder	20 g	20 g	20 g	20 g
Baking powder	½ tsp	½ tsp	½ tsp	½ tsp
Baking soda	¼ tsp	¼ tsp	¼ tsp	¼ tsp
Vanilla extract	1 tsp	1 tsp	1 tsp	1 tsp
Salt	1/8 tsp	1/8 tsp	1/8 tsp	1/8 tsp
Milk	3 Tbsp	1.5 Tbsp*	1.5 Tbsp*	1.5 Tbsp*

*amount of milk was reduced as avocado being a fruit has higher water content than butter

The cookies were prepared in three variations (varying the percentage of butter and avocado puree in each) and evaluated against a control (100% butter). The dry ingredients- flour, baking soda, baking powder, salt and cocoa powder were sieved together thrice without any lumps. In a separate bowl, butter and sugar were accurately weighed and creamed together till light and smooth. To this, the sieved dry flour mixture and milk was added in parts alternatively till all the ingredients were combined into a dough. The mixture was scooped using a rounded tablespoon measuring at ~20g each. The shaped cookies were placed onto a greased baking tray lined with butter paper and baked in a preheated oven at 180 ℃ or 350 F for 10 minutes. The cookies were then cooled on the baking tray for 5 minutes, removed to wire rack to cool completely. They were stored in airtight containers for further use and analysis.

2.2 Analytical Procedures
All tests were conducted in triplicates.

2.2.1 Physical Analysis
Weight: The cookies were selected randomly; weighed using analytical balance. The height and diameter were measured with a digital Vernier caliper, both before and after baking. Diameter: To measure the diameter of cookies, each sample was measured along the x- axis initially. All of them were then rotated at 90º and the new diameter was measured. The average of the two measurements was taken as the final diameter of the cookie. Height: Height was measured by stacking three cookies one above the other and restacking three times. (Zoulias *et al*., 2000) [31] Percent increase/decrease in height was determined from initial and final heights. Spread Ratio: Final diameter and final height were used to calculate spread. The spread ratio was calculated using the formula: diameter of cookies divided by height of cookies (Wekwete, and Navder, 2008) [5].

2.2.2 Chemical Analysis
The moisture, ash, fat, and crude protein (% N x 6.25) of the samples were determined by the AOAC method (2000) [18]. Moisture was determined based on AOAC Method 934.01: Air Oven Method (AOAC 2000) [18]. Ash test was carried out based on AOAC Method 923.03: Dry Ashing Method (AOAC, 2000) [18]. Fat was conducted based on AOAC Method 963.15: Soxhlet Extraction Method utilizing petroleum ether as solvent (AOAC, 2000) [18]. Crude protein was determined based on AOAC Method 960.52: Micro-Kjeldahl Method (AOAC, 2000) [18].

2.2.3 Sensory Analysis
The organoleptic attributes of the cookies were studied by a panel of 20 semi-trained panelists. The cookies were assessed for its taste, colour, texture, mouth feel, aroma, flavour, and overall acceptability on a nine- point hedonic scale with 1 being "dislike extremely" and 9 being "like extremely".

3. Results & Discussion
3.1 Physical Parameters
During dough preparation, it was observed that the fat replaced avocado cookies (V1, V2, V3) dough were stickier and more difficult to work when compared to the control dough. Presence of non-cereal protein maybe a reason for sticky dough, due to its higher water holding capacity. In non-wheat protein water holding capacity was higher than in wheat flour (Hoojjat and Zabik, 1984) [21]. This is also the reason why avocado cookies has higher moisture content when compared to control cookies.

The three variations, V1 was found to be the least viscous and the stickiest, followed by V2 and V3. Dough with lower viscosity cause cookies to spread at faster rate (Hoseney and Roger, 1994; Hoseney *et al*., 1988) [22., 23]. In the avocado cookie formulation, the quantity of milk was reduced from the control to help increase the viscosity of cookie dough furthermore decrease the spread rate even though the protein content is high. Cookie spread rate appears to be controlled by dough viscosity (Yamazaki, 1959, Hoseney *et al*., 1988, Hoseney and Rodger, 1994; Miller, 1997) [30, 23, 22]. When more water is present in the dough, more sugar is dissolved during mixing. This lowers the initial dough viscosity and the cookie is able to spread at a faster rate during heating. The flour components that absorb large quantities of water reduce the amount of water that is available to dissolve the sugar in the formula. Thus, initial viscosity is higher and the cookies spread less during baking (Hoseney and Rodger, 1994) [23].

Table 2: Physical parameters of the cookies

Sample	Weight (g)	Diameter (mm)	Height (mm)	Spread ratio	% Decrease in Height
Control	20.37±0.09	54.90±0.42	16.62±0.90	3.25±0.13	-0.27±0.03
V1	18.04±0.39	65.76±0.04	9.01±0.92	7.70±0.23	-0.56±0.06
V2	17.36±0.71	53.17±0.72	14.35±0.63	3.60±0.11	-0.26±0.07
V3	16.25±0.37	41.86±0.66	21.55±0.41	1.95±0.23	-0.07±0.04

The physical parameters of the cookies are shown in Table 2. Results of the studies indicated that there is a difference between each samples in terms of weight, diameter, height and spread ratio. All the four cookie samples showed a decrease (-) in their height after baking. The cookie weights were found to decrease and the lowest weight was indicated in the cookie which had highest amounts of avocado puree (V3). This result suggested that the cookie V3 had high water holding capacity (WHC) as compared to V1, V2 and control cookies due to the higher avocado content. The natural moisture and proteins present in the fruit, results in higher initial weight of the cookies and there is a lower final weight observed as most of the moisture is evaporated during baking. In non-wheat protein water holding capacity was higher than in wheat flour (Hoojjat and Zabik, 1984) [21].

As the avocado content increased in the cookies, they were more cake-like. Similar results were observed by B. Wekwete and K.P. Navder (2008) [5]. The cookie set time and texture is determined by an apparent glass transition of the gluten protein present in the ingredients as reported by Doescher *et al*. (1987) and Miller *et al*. (1996) [25].

There was also an increase in height and decrease in diameter and spread in avocado cookies from V1 to V3 even though all cookies had uniform initial diameters prior to baking. Significantly lower spread ratios were noted in the avocado and Oatrim cookies compared with the control cookies after baking (B. Wekwete, K.P. Navder, 2008) [5]. Perry *et al.* (2003) [26] similarly reported fat substitutions to result in minimal cookie spread. Swanson and Munsayac (1999) [28] also found fruit puree fat substitutes to restrict dough flow during baking and give a reduced spread.

3.2 Chemical Parameters

Table 3: Chemical parameters of the cookies

Sample	Moisture (%)	Ash (%)	Fat (%)	Crude protein (%)
Control	5.56±0.12	1.37±0.06	18.29±0.001	4.44±0.13
V1	7.35±0.13	1.71±0.09	18.80±0.01	4.5±0.10
V2	8.88±0.17	1.76±0.28	13.86±0.04	5.19±0.20
V3	11.39±0.20	1.78±0.10	9.14±0.004	5.5±0.23

The moisture content of the control was found to be lower than that of the avocado cookies and it slowly increased from V1 to V3, because of the higher moisture content in the avocado fruit. The % moisture loss from the control cookie was significantly lower than that of the avocado cookies resulting in lower cookie weights (Table 2). Zoulias *et al.* (2000) [31] also found that fat substitutes in the form of gels prepared with increased amounts of water, lost more weight during baking.

The fat content of the avocado cookies were found to decrease from V1 to V3. This shows that avocado also helps in preparing a cookie with lower fat content. When compared between control and V1, the fat content of V1 was slightly higher than that of control. This would be of a concern, if the physical and sensory parameters of cookie V1 are within acceptable limits. Nevertheless, the type of fat is unsaturated and is beneficial for human health. (M. L. Dreher and A. J. Davenport, 2013) [20].

The protein content of the cookies were found to be similar, with a slight increase is seen from control, V1, V2 to V3. Protein content influences the viscosity of dough cookies. This is because the expansion of protein gluten is not resumed in the making of cookies. Inverse correlation was obtained between diameter and protein content (Leon, 1996) [24]. Protein gluten in flour will form a web in cookie dough when heated. During baking, the gluten goes through an apparent glass transition, thereby, gaining mobility that allows it to interact and form a web. The formation of continuous gluten web increases the viscosity and stops the flow of cookie dough (Miller and Honeney, 1997) [25].

3.3 Sensory Parameters

Table 4: Sensory parameters of the cookies

Sample	Taste	Aroma	Flavor	Appearance	Colour	Texture (Hardness)	Overall Acceptability
Control	7.533333	7.266667	7.4	7.466667	7.266667	7.6	7.333333
V1	7.4	7	7.066667	6.933333	7.333333	6.8	7.133333
V2	7.533333	7.066667	6.866667	7.266667	7.2	7.333333	7.266667
V3	6.933333	6.466667	6.266667	6.4	7.066667	6.6	6.666667

The Table 4 gives the sensory parameters of the cookies. There was no significant difference ($p<0.05$) observed in texture scores of control cookies with V2 and V3. V3 having the highest % of avocado puree and being the most viscous had the lowest organoleptic scores. Cookies V2 and V3 had cake-like texture and softness in the crumb giving V2 highest score for texture and taste. V3 formed a distinct crust which is undesirable for a cookie. This was probably the reason, for poor texture and taste. The organoleptic scores for aroma and flavor decreases from control to V3 because avocado does not have a distinct flavor or aroma of its own and also the amount of butter decreases from control to V3. Wekwete and Navder (2008) [5] in their study with avocado puree at 25, 50 and 75% replacement levels, showed no significant difference between the control, 25 and 50% replacements, but the 75% substitutions were rated significantly different. The overall acceptability scores range from 7 – "like moderately" to 6 – "like slightly", which suggests that all the experimental cookies were accepted by the panelists.

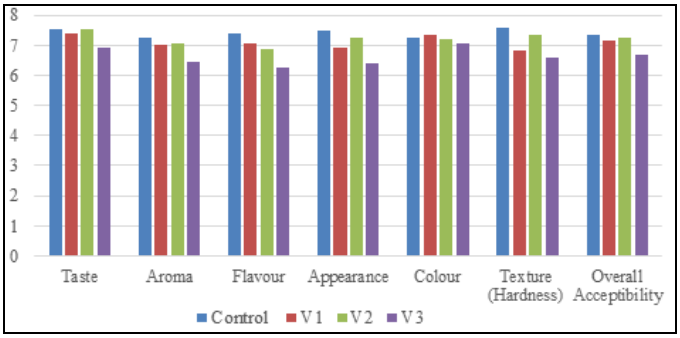

Fig 1: Sensory Parameters of the cookies

4. Conclusion

The study shows the various physical, chemical and organoleptic properties of a chocolate cookie, with avocado as a fat substitute. The physical and overall acceptability were found to be similar for all with improved nutritional content in the variations. The cookie weights were found to decrease and the lowest weight was indicated in the cookie which had highest amounts of avocado puree (V3). The moisture, ash and protein content in the control was lower than that of the avocado cookies and it slowly increased from V1 to V3 whereas, the fat content of the avocado cookies were found to decrease from V1 to V3. The organoleptic tests showed highest acceptability for V2 (50% fat substitution with avocado). Also V2 showed a 5% decrease in the total fat content compared to the control. This study thus suggests the use of avocado puree as a potential fat replacer for bakery or similar products.

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