Effects of different pretreatments on physico-chemical properties of potato chips fried in different oils

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ABSTRACT

The objective of this study was to develop potato chips applying deep frying technique. The potato chips were deep-fried at 180ºC for 13-72 sec. Physicochemical properties of the prepared chips, such as moisture content, ash content, pH, acidity, color (L*, a*, b*), and whitening index. Colors of fried in mustard oil, sunflower oil, groundnut oil and canola oil potato chips blackness to lightness, green to red and blue to yellow range of L* (34.08-75.98), a* (-3.32 to + 3.9) b* (7.33- 44.15),. The whiteness index of the potato chips was found 9.50-25.30. The maximum acceptability of potato chips fried at 180 °C in mustard oil, sunflower oil, groundnut oil, and canola oil to consumer panelists was T3 (7.90), T3 (8.00), T3 (7.87), and T4 (7.84), respectively.

Keywords: Potato chips, oil, frying, physic-chemical properties, color, whiteness index

1. INTRODUCTION

Potato (solanum tuberosum) is the worldwide famous tuber vegetable. A raw potato contains 79% water, 17% carbohydrates (88% starch), 2% protein, and negligible fat. Raw potato provides 77 calories of energy and is a rich source of Vitamin B6 and Vitamin C (23% and 24% of the daily value, respectively [1]. Approximately 85% of potato production occurs in the Uttar Pradesh. Uttar Pradesh is the largest producer of potatoes in India, accounting for more than 32 per cent of the country's total potato production. In the year 2019-2020, the National Horticulture Board (NHB) recorded potato production in Uttar Pradesh at 140.49 lakh tones [2]. Potatoes are the third main crop for human nutrition that helps combat poverty and malnutrition in developing countries [3]. The demand for processing potatoes is expected to rise from 2.8 million tons in 2010 to 25 million tons in 2050 [4]. Chips are the most popular potato products and are liked by almost all age groups. Potato chips are thin, fried, baked popular able to eat snacks used both in domestic also as in nutriment at restaurants [5]. 100g potato chips provide about 547 calories of energy with a fat content of 37.47g, total carbohydrate 49.74g, protein 6.56g alongside Sodium (525mg) and potassium (1642mg). In the food processing industry, deep fat frying is a widespread operation that makes potato chips tasty and crispy. According to [6], various treatments including sodium chloride, potassium metabisulfite, and calcium chloride are used to enhance the quality attributes of fried snacks. The fast food snack industry has emerged as an important sector for modern consumers with a special desire for fried snack foods. Fried products are liked by all age groups and play an important role in consumer diets because of their unique flavor and texture. Frying can also affect the nutritional quality of food because the process is based on high temperatures. This changes the structure of labile nutrients, and some water-soluble molecules and unstable vitamins such as thiamine and riboflavin can be lost by evaporation and degradation, respectively [7]. Generally, oils with high amounts of polyunsaturated fatty acids (i.e., corn, sunflower, soybean, rapeseed, and peanut oils) are suitable for domestic cooking. Nonetheless, oils with low linoleic acid content and high oleic acid content (i.e., olive, almond, and canola oils) are reported to be more stable during frying [8, 9]. Frying in hot oil at temperatures between 160-180 ºC is normally characterized by

very high drying rates, which are critical for ensuring favorable structural and textural properties of the final product [10]. Among the different physical properties of food products, color is considered an important visual attribute for the imperceptions quality of a product. Potato chip color is a vital criterion for industrial potato processing and is strictly related to consumer perception. Among the sensory attributes of potato, texture, aroma, flavor, color, and texture are considered the most important [11]. Aim of the research was to study the physicochemical properties of one of the most well-known foods in the world, potato chips. Different oils are used in their preparation in various parts of the world, and the authors set out to compare the results in each situation and support their benefits and drawbacks.

2. MATERIAL AND METHODS

Fresh potato belons to the family solananceae and genus Solanum devoid of any visible microbial infection or mechanical fissures, mustard oil, sunflower oil, groundnut oil, and canola oil were procured from the local market of modipuram Meerut (U.P) India. Potatoes were washed with tap water to remove dust and dirt from the surface. The samples were then peeled, washed with water, and sliced with a chip cutter. The chips were then weighed and pretreated with weighed, and sliced weight samples were prepared for each pretreatment.

2.1 **Preparation of potato Chips:** Development of potato chips and their frying and quality evaluation were performed in the laboratory at the College of Post Harvest Technology and Food Processing, S.V.P. University of Agriculture and Technology, Meerut. Studies have also been carried out to evaluate the physicochemical properties of potato chips, fried in different oils.

Potato chips were prepared as the following flow chart-

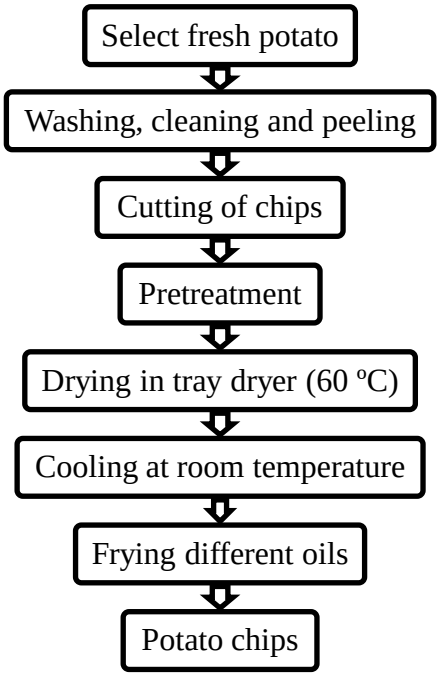

Figure 1. Flow chart for potato chips development

***2.2* Pretreatments:** Pretreatments were applied to the potato slices, and an untreated sample was used as a control. The slices were subjected to pre-treatments using salt (NaCl), potassium meta-bisulphate (KMS), citric acid (CA) and calcium chloride ($CaCl_2$); indicated as follow:

T1: Blanching with 90ºC for 5 min,

T2: Blanching with 1%Nacl at 90ºC for 5 min

T3: Blanching with 0.5% KMS + 1.0 % NaCl at 90ºC for 5 min.

T4: Blanching with 0.5% KMS+1% NaCl, + 0.5% CA at 90 °C for 5 min.

T5: Blanching with 1%$CaCl_2$+1% NaCl at 90 °C for 5 min.

The slices were then removed from the solution, the surface moisture was removed using blotting paper, and then spread in trays subjected to drying in a tray dryer at 60 °C.

***2.3* Moisture Content:** Moisture content % (w.b.) of fresh samples was obtained using the standard AOAC [12] method.

***2.4* pH:** A digital pH meter (Systronics µ pH system, 361) was used to determine the pH of the samples.

***2.5* Acidity:** Acidity of various samples was determined by using the method as recommended by[13]

***2.6* Ash content:** The AOAC [14] method with a muffle furnace (TANCO model) was used to determine the ash contents of the samples.

***2.7* Color value:** Lightness (L*), redness (a*), and yellowness (b*) values of the slices were measured. L*, a*, and b* were measured using a colour meter (3Nh color meter, China) after calibration with a white standard plate.

***2.8* Whiteness index :** Whiteness is the measured amount of light reflected by a support through the visible light spectrum. This value is obtained by calculating the amount of light *White* -that is, the sum of reflected wavelengths of the spectrum- that the surface manifests. Thus, the value is useful in determining how *white* is a support to the human eye. The measurement of whiteness is expressed as a percentage, on a scale of 1-100%, with 100% being the value that should correspond to a perfect white.

***2.8* Sensory Evaluation:** Sensory evaluation indicates the acceptability of the product. Acceptability of chips was judged, on a nine point hedonic scale. The sensory evaluation carried out on the basis of color, texture, taste, crispiness and overall acceptability of the developed product. The sensory evaluation of the treatments for the organoleptic qualities [15]

3. RESULTS AND DISCUSSION

***3.1* Moisture content:** The acceptable range of moisture content for potato chips before they were fried in oil is shown in Table 1 as 81.21) percent water by weight (% w.b.) Treatment T1 had the highest moisture content (82.21) percent water by weight (% w.b.) and T3 had the lowest moisture content (81.19) percent water by weight (% w.b.). The results

showed that treatment T1, which did not receive any chemical treatment, had the highest moisture content, whereas T3, which received chemical treatment (0.5% KMS + 1% NaCl at 90 °C for 5 min), had the lowest moisture content. Following frying in mustard oil of potato chips (table 2.) 2.3 to 7.11 percent water by weight. Treatment T3 had the lowest moisture content (2.32% w. b.) and T4 had the highest (7.11 w. b.).The results were highest in treatment T4 due to the effects of (NaCl + KMS + CA), and the lowest moisture content in T3 due to the effects of (KMS + NaCl) reducing moisture content. The outcome was the highest moisture content in T4 owing to the acidic action of the potato chip. The potato chips were fried in sunflower oil, and the results are shown in Table 3 under moisture content. After being fried in sunflower oil, the potato chips had a moisture level that ranged from 3.16 to 3.58% w.b. Treatment T3 had the highest moisture content (3.58%w. b.) and Treatment T1 had the lowest moisture content (3.16%w. b.).The moisture content of treatment T1 was the lowest due to the effects of frying the potato chips in sunflower oil and the lack of chemical treatment, while treatment T3's moisture content was the highest due to the treatment (KMS + NaCl). After being fried in groundnut oil, the moisture content ranged from 3.29 to 4.15% (Table 4).Treatment T4 had the highest moisture content (4.15% w. b.) and Treatment T1 had the lowest moisture content (3.29% w. b.).The results showed that treatment T1 had the maximum moisture content after being fried in groundnut oil, while treatment T4 had the lowest .Table 5 displays the results for the deep-fried potato chips in canola oil. The range of moisture content was determined 1.77-3.16 % (w. b.). T3 had the highest moisture content (3.16% w. b.), whereas T5 had the lowest (1.77% w. b.).Following the canola oil frying of the potato chips, the outcome revealed that treatment T5 had the greatest effect. It is among the best varieties of vegetable oil.

3.2 Ash content: The ash content range of potato chips (1.38-1.90%) before frying is displayed in Table 1. The treatment with the highest ash content was T3 (1.90%), whereas the treatment with the lowest ash content was T1 (1.38%).Because of the treatment (blanching with 0.5% KMS + 1% NaCl at 90 °C for 5 min), T3 had the highest ash content. Treatment T1 had the lowest amount of ash, because there was no chemical treatment. The results of mustard oil frying of potato chips are displayed in Table 2. potato chips with an ash percentage between 1.97 and 3.50% after being fried in mustard oil. Treatment T5 had the lowest ash content (1.97%), while Treatment T4 had the highest (3.50%).The highest ash content was the outcome of the treatment T4's effect on potato chips after they had been fried in mustard oil. potato chips after being fried in sunflower oil.In table 3, the outcome was displayed. After being fried in sunflower oil, potato chips may include between 0.65 and 1.48% ash. Treatment T1 had the lowest amount of ash (0.65), and Treatment T5 had the highest amount (1.48%).The outcome was maximum ash concentration in treatment T5 and the effect of frying in sunflower oil because treatment T5 (blanching with 1% CaCl2 + 1% NaCl at 90 °C for 5 min) had a greater effect. The conclusion was presented in Table 4, which demonstrates how the ADH (Acryl amide dehydrogen phosphate) content of potato chips is connected to the frying conditions. The Maillard reaction, a chemical interaction between reducing sugars and amino acids that occurs during frying, may cause potato chips cooked in groundnut oil to have an increased ADH level. When starchy foods are cooked at high temperatures, the Maillard reaction results in the chemical acryl amide, which can develop in the meal, and after being fried in groundnut oil, potato chips might include between 0.61 and 2.04% ash. T5 had the highest ash content (2.04%), whereas T1 had the lowest ash content (0.61%).Treatment T5 had a greater impact as a result of the groundnut oil used to fry potato chips. The range of the ash content of potato chips that had been fried in canola oil is displayed in Table 5 (0.60-1.48%). Treatment T5 had the highest ash content (1.48%), and treatment T2 had the lowest ash content (0.60%).As the potato chips were fried in canola oil, treatment T2 had a lower effect, whereas treatment T5 had a higher effect.

Table-1. Moisture content, ash content, pH, color characteristics and whiteness index of different potato chips samples before frying.

Treatment	(M.C.)	(A.C.)	pH	Acidity	Color			(W.I.)
					L*	a*	b*	
T1	82.21±0.73	1.38±0.19	6.56±0.04	0.17±0.01	42.34	1.21	15.13	25.47
T2	81.54±0.45	1.48±0.03	7.02±0.01	0.08±0.00	47.06	-0.98	14.13	25.47
T3	81.19±1.02	1.90±0.03	6.26±0.01	0.05±0.00	54.37	-0.61	19.13	32.57
T4	81.38±0.68	1.46±0.08	5.95±0.00	0.13±0.01	50.14	-0.34	17.79	27.40
T5	81.43±0.50	1.88±0.16	6.33±0.02	0.19±0.02	51.30	-0.23	16.61	33.97

*M.C.: Moisture content, *A.C.: Ash content, *W.I.: Whiteness index ±: Standard deviation

3.3 pH: The pH values before the potato chips were fried are shown in Table 1. The pH range (5.95,7.02).The pH value of the potato chips in treatment T2 was the highest (7.02), whereas treatment T4 had the lowest pH value (5.95).The outcome showed that treatment T4 had more of an impact than treatment T2.the potato chips in Table 2 after they were fried in mustard oil. When compared to not frying the potato chips, there was a decrease in the amount of mustard oil used. This indicates that these oil-fried potato chips have higher acidity values. Impact of chemical treatment of potato chips and type of frying oil, The pH range (5.45-6.02) following frying in mustard oil. Potato chip pH values ranged from 6.02 in treatment T3 to 5.45 in treatment T4, with treatment T3 having the highest pH value. The pH readings of the results are shown in Table 3.The pH range from 5.05 to 5.84.The pH values for treatments T2 and T4 were 5.84 and 5.05, respectively. Potato chips compressed for cooking in mustard and sunflower oils. In comparison to mustard oil, all treatments of the potato chips fried in sunflower oil had low pH. As a result, potato chips fried in sunflower oil will be more acidic. The results are displayed in Table 4. The pH range of potato chips (5.47–6.17) after being fried in groundnut oil.T4 had the lowest pH (5.47) and T2 had the highest pH (6.17) value. The effect of (1% NaCl + 0.5% KMS + 0.5% CA at 90°C for 5 minutes) and frying potato chips in groundnut oil led to the greatest acidity value to emerge in treatment T4.The pH results for the potato chips that had been fried in canola oil are displayed in Table 5. The pH range (5.38-6.18) of potato chips after they were fried in canola oil. The treatment T2 yielded the greatest pH value of canola oil fried potato chips (6.18) and the lowest pH value of T4 (5.38).In compression to be fried in mustard oil, sunflower oil, or groundnut oil, this outcome was very low. The T4 treatment had a very high acidic pH value. Treatment had an impact, as did canola oil used to fry potato chips.

Table-2. Moisture content, ash content, pH, color characteristics and whiteness index of the different potato chips samples after frying in mustard oil.

Treatment	(M.C.)	(A.C.)	pH	Acidity	Color			(W.I.)
					L*	a*	b*	
T1	7.07±0.19	3.03±0.29	5.80±0.08	0.16±0.03	75.98	-0.11	44.15	24.80
T2	3.91±0.36	3.15±1.28	5.86±0.02	0.13±0.02	69.62	-0.68	41.86	19.60

T3	2.32±0.57	2.21±0.51	6.02±0.01	0.15±0.03	45.14	-3.30	38.19	16.50
T4	7.11±0.39	3.50±0.37	5.45±0.02	0.12±0.02	44.55	-2.80	37.16	17.20
T5	3.89±0.17	1.97±0.35	5.75±0.01	0.18±0.02	36.26	+3.9	33.85	09.50

*M.C.: Moisture content, *A.C.: Ash content, *W.I.: Whiteness index

3.4 Acidity: Prior to being fried in oil, the acidity of potato chips ranged from (0.05–0.19) in Table 1. T5 (0.19) and T3 (0.05) had the highest and lowest acidities, respectively. The treatment with the highest acidity level was T5, which was a consequence of the combined action of calcium and sodium chlorides. Table 2 lists the range of acidity values (0.12-0.18) for fries of potato chips made using mustard oil. The acidic value for treatment T5 was 0.18, whereas that for treatment T4 was 0.12. The results showed that treatment T5 lowered the acidity of potato chips when they were compressed without being fried, whereas another type of treatment caused it to increase when the chips were cooked in mustard oil. The acidity range of potato chips after being fried in sunflower oil is presented in Table 3. Treatment T1 had the lowest acidity (0.07), whereas Treatment T3 had the highest acidity (0.12). These three tables demonstrate the reduction in acidity values that occurred when potato chips were fried in mustard oil. The results of treatment T3 showed that frying sunflower oil and using KMS + NaCl had an effect. after preparation in groundnut oil (Table 4). Acidity range of groundnut oil-fried potato chips (0.09–0.21). After being fried in groundnut oil, treatment T4 had the highest acidity (0.21), whereas treatment T1 had the lowest acidity (0.09). Consequently, with the exception of treatment T5, the acidity of potato chips cooked in groundnut oil increased when compared to those cooked in sunflower oil, but decreased when compared to those cooked in mustard oil. Potato chips that have been deep-fried in canola oil have an acidity range of (0.05-0.16) according to Table 5. The T2 and T4 treatments exhibited the highest and lowest acidic values, respectively, after being fried in canola oil. Treatment T2's acidic value was 0.16 and that of treatment T4 was 0.05. in groundnut, sunflower, and mustard oils, respectively. The acidity of potato chips fried in canola oil increased in treatments T1, T2, and T3, whereas it decreased in treatments T4 and T5. This is in contrast with sunflower and groundnut oils. With the exception of treatment T2, mustard oil improved the acidity of the compressed and fried potato chips.

3.5 Color: Three factors, L* (lightness-blackness), a* (red-green), and b* (yellow-blue), determine the color. The L* color value range (42.34-54.37) before they were fried in oil. T3 had the highest L* color value (54.37), and T1 had the lowest L* color value (42.34). The results are provided in Table 1, together with the maximum and lowest brightness color values for treatment T3 of potato chips. Before being fried in oil, the a* and b* values ranged from (-0.23 to 1.21) and (14.13-19.13), respectively. The highest a* and b* values were found in treatments T1 (1.21) and T3, whereas treatment T5 had the lowest a* value (-0.23) and the highest b* value (14.13). The outcome was a higher value for red color and a lower value for green color, making treatment T2 more greenish in color and treatment T1 less red. The results of b* value if + yellow color and - value blue color are given in Table 1, with greater yellow color in treatment T3 and less yellow color in treatment T2. Table 2 shows the range of color values for L*, a*, and b* after frying potato chips in mustard oil: L* value (36.25-75.98), a* (-3.30 to +3.9), and b* (09.50-24.80). Treatments T1 (75.98), T5 (+ 3.9), and T1 (44.15) had the highest L*, a*, and b* values. After the potato chips were fried in mustard oil, treatment T1 had a darker color, and treatment T5 had a lighter color. For a*, treatment T3 exhibited a greater degree of greenish color, but treatment T5 exhibited a much lower degree of greenish color. The brightest yellow color in treatment T1 and the lowest yellow color in treatment T5 were identified in the analysis of the b* value, which was set to determine the highest value. Table 3 shows the color values of L*, a*, and b* in the potato chip ranges (53.67-70.11), (-3.32-2.89), and (31.36-40.37) after being fried in sunflower oil.

L* values for treatments T1 and T4 were respectively 70.11 and 53.67%, respectively. Following potato chip frying in sunflower oil, the results showed that T4 produced lighter chips than T1, and vice versa. Treatment T1 had the highest a* and b* values (2.89) and (40.37), whereas treatment T3 had the lowest values (-3.32) and (31.36), respectively. The outcome was that after being fried in sunflower oil, potato chips treated with T3 (-3.32) had a greenish hue, and T1 had a more red hue. Treatment T1 had a stronger yellowish color in the b* value of the outcome, whereas Treatment T3 had a less yellowish color. Table 4 displays the range of color values L*, a*, and b* for groundnut oil-fried potato chips (46.52-61.20), (-3.15 to 2.70), and (18.59-36.66). After being fried in groundnut oil, potato chips had the highest L* value (61.20) and lowest L* value (46.52). After being fried in groundnut oil, potato chips had a lower color value and higher lightness in T2. The lowest a* and b* values of T3 (-3.15) and (18.59), and treatment T1 (36.66) had the highest a* and b* values of potato chips after being fried in groundnut oil. A* and B* appeared greenish and yellowish in T3 and T1, respectively. Table 5 shows the L*, a*, and b* color value ranges for potato chips that have been fried in canola oil, which are (34.08-70.80), (-2.34 to 2.23), and (7.33-31.19). The highest L*, a*, and b* values were in treatment T1 (70.80), T2 (2.34), and treatment T1 (31.19), while the lowest values were in treatment T5 (34.08), T3 (-2.49), and T5 (7.33). As a result, treatment T5's color became lighter, treatment T3's color turned greener, and treatment T1's color turned yellow. There were more changes in the color value after frying than previously, but the quality of the potato chips remained suitable for consumer demand. All varieties of frying oils used for potato chips were found to be effective. Treatment T5, which was deep-fried in canola oil, had the lightest color. After frying potato chips in sunflower oil, T3 showed the highest percentage of greenish hues. Following the frying of potato chips in mustard oil, the color was the most yellowish among all frying oil treatments. Most of the time serves as the foundation for the consumer's decision to choose or reject a brand of chips. Consumers always seriously assess this issue. The color of potato chips is the result of the Maillard reaction, which depends on the content of reducing sugars and proteins, temperature, and frying time. Reducing sugar levels is especially critical when crisp color is desirable [16] and is a concern not only for farmers but also for potato products [17]. The result that canola oil fried potato chips was greener in color followed by mustard oil, groundnut oil, and sunflower oil. In case of b* mustard oil of potato chips was more yellowish in color less yellowish color was found canola oil fried potato chips. The color of potato chips is an extremely important quality attribute and a fundamental criterion for the potato-processing industry, since it is strictly related to consumer perception, the Maillard reaction, and acryl amide formation [18].. The color of fried potatoes is usually measured usually in the unit of L* a*b*, using either a colorimeter or specific image-acquisition and processing systems. Parameter L* is the luminance or lightness component, which ranges from 0 to 100, and parameters a* (from green to red) and b* (from blue to yellow) are the two chromatic components, which range from -120 to 120 [19]..

3.6 Whiteness index: Table 1 shows the (25.47-33.97) range of the whiteness index of potato chips prior to cooking in oil. The treatment T5 had the highest whiteness index (33.97), and the T1 treatment had the lowest whiteness index (25.47). The range of the whiteness index for the potato chips in table 2 after they had been fried in mustard oil was (9.50-24.80). The results showed that Treatment T1 had the highest whiteness index (24.80), while treatment T5 had the lowest whiteness index (9.50). When potato chips were compressed before and after being fried in mustard oil, the whiteness index decreased (T1-T5). The whiteness scores of the fried sunflower oil potato chips in Table 3 are indicated. (09.90–23.90) was within the range of the whiteness index. T4 had the lowest whiteness index (9.90), whereas T2 had the greatest whiteness index (23.90). The results showed that frying potato chips with mustard oil, sunflower oil, or compression treatments T2, T3, and T5 improved the whiteness index, whereas treatments T1 and T4 decreased it. After being fried in groundnut oil, the potato chips in table-4 had a whiteness index ranging from 12.70 25.30.

T3 had the highest whiteness index (25.30), whereas T2 had the lowest (12.70). The outcome was that when potato chips were fried in groundnut oil, the whiteness index increased for treatments T1, T3, T4, and T5, but decreased for treatment T2 when compared to sunflower oil. The whiteness index of canola oil-fried potato chips (12.70–14.60) is illustrated in Table 5. Treatment T5 had the highest whiteness index (14.60), whereas treatment T4 had the lowest (12.70). Decreases in the whiteness index for treatments T1, T3, T4, and T5, and increases for T2 in comparison to potato chips fried in groundnut oil.

Table-3. Moisture content, ash content, pH, color and whiteness index of different potato chips samples after frying in sunflower oil.

Treatment	(M.C.)	(A.C.)	pH	Acidity	Color			(W.I.)
					L*	a*	b*	
T1	3.16±0.26	0.65±0.20	5.42±0.06	0.07±0.01	70.11	2.89	40.37	16.60
T2	3.26±0.26	0.92±0.18	5.84±0.03	0.08±0.02	58.40	1.26	40.01	23.90
T3	3.58±0.26	1.09±0.10	5.72±0.02	0.12±0.00	66.85	-3.32	31.36	18.40
T4	3.52±0.26	0.96±0.09	5.05±0.04	0.08±0.01	53.67	0.28	39.96	09.90
T5	3.53±0.26	1.48±0.20	5.58±0.02	0.09±0.03	68.79	-0.77	34.63	17.60

*M.C.: Moisture content, *A.C.: Ash content, *W.I.: Whiteness index

Table- 4. Moisture content, ash content, pH, color and whiteness index of different potato chips samples after frying in groundnut oil.

Treatment	(M.C.)	(A.C.)	pH	Acidity	Color			(W.I.)
					L*	a*	b*	
T1	3.29±0.12	0.61±0.02	5.83±0.03	0.09±0.01	59.91	2.70	36.66	21.10
T2	3.58±0.09	1.19±0.38	6.17±0.01	0.11±0.00	46.52	0.06	19.46	12.70
T3	3.80±0.15	1.16±009	6.03±0.02	0.10±0.00	61.20	-3.15	18.59	25.30
T4	4.15±0.12	1.03±0.07	5.47±0.01	0.21±0.00	59.49	-2.31	29.25	18.70
T5	3.30±0.15	2.04±0.03	5.76±0.02	0.14±0.00	59.01	-1.63	27.15	18.20

*M.C.: Moisture content, *A.C.: Ash content, *W.I.: Whiteness index

3.7 Sensory Evaluation: The Consumer preference for deep-fried potato chips was determined by sensory analysis. The color, texture, taste, crispiness, and overall acceptability of the potato chips were evaluated for sensory acceptance. For color, texture, taste, crispiness, and overall quality for the sample fried at 180°C for a brief period of time, the panelists preferred the vacuum-fried potato chips above mustard oil, sunflower oil, groundnut oil, and canola oil. The panelists' total acceptance scores are presented in Tables 6 and 7. According to the sensory evaluation findings, the majority of panelists regarded the color of potato chips as a premium characteristic. The process temperature had a significant impact on the sensory evaluation of potato chips (P 0.05). When frying at a higher temperature of 180 °C, the sensory scores for the color of the potato chips were (7.30-8.0),

(6.70-8.10), (6.12-8.50), and (7.37-7.87), respectively. The results of the panelists' sensory evaluations are presented. This could be a result of less color deterioration caused by deep frying Maillard reactions and oxidation. On a 9-point hedonic sensory scale, treatment T3 (8.30) had the highest sensory score for texture when it came to potato chips that were fried in mustard oil at 180°C, as opposed to treatments T3 (7.70), T3 (7.62), and T5 (7.75), which were cooked in canola oil. The T3 treatment had the highest taste rating (8.20) after frying potato chips in sunflower oil, and treatments T4 and T5 had the lowest taste rating (6.25) after frying in groundnut oil, as shown in Tables 6 and 7. The T2 treatment of potato chips received the highest score for crispiness (8.30) and the T5 treatment received the lowest score (7.00) after being fried in groundnut oil. Crispiness is an important textural attribute that determines chip quality [20]. The higher the temperature, the less the oil absorbed and the higher the water evaporated from crisp slices; the crispier the slices become [21]. The findings of the sensory evaluation indicated that treatment T3 (8.00) after sunflower oil was used to fry the potato chips had the highest overall acceptance, whereas treatment T5 (6.46) after groundnut oil had the lowest.

Table- 5. Moisture content, ash content, pH, color and whiteness index of different potato chips samples after frying in canola oil.

Treatment	(M.C.)	(A.C.)	pH	Acidity	Color			(W.I.)
					L*	a*	b*	
T1	2.38±0.14	0.62±0.18	5.46±0.02	0.10±0.01	70.80	-0.51	31.19	13.60
T2	2.64±0.14	0.60±0.14	6.18±0.03	0.16±0.01	45.53	-2.34	19.08	14.10
T3	3.16±0.08	1.27±0.41	5.87±0.01	0.10±0.01	48.13	-2.49	15.96	13.60
T4	3.08±0.06	1.24±0.14	5.38±0.01	0.05±0.01	42.25	-1.45	16.63	12.70
T5	1.77±0.08	1.48±0.35	5.49±0.02	0.08±0.01	34.08	-1.14	7.33	14.60

*M.C.: Moisture content, *A.C.: Ash content, *W.I.: Whiteness index

Table 6. Sensory evaluation of potato chips after frying in mustard oil and sunflower oil for different treatment

Treatment	Mustard oil					Sunflower oil				
	Color	Texture	Taste	Crispiness	Overall Acceptability	Color	Texture	Taste	Crispiness	Overall Acceptability
T1	8.00	7.30	7.30	8.10	7.67±0.37	7.50	7.60	7.90	8.10	7.77±0.23
T2	7.50	8.10	7.60	7.50	7.67±0.24	7.80	7.40	7.60	8.30	7.77±0.33
T3	8.00	8.30	7.50	7.80	7.90±0.29	8.10	7.70	8.20	8.00	8.00±0.18
T4	6.80	7.30	7.30	7.50	7.22±0.25	7.10	7.10	7.20	8.10	7.37±0.42
T5	7.30	7.80	7.50	8.10	7.67±0.30	6.70	6.50	7.10	8.10	7.10±0.61

Table 7. Sensory evaluation of potato chips after frying in Groundnut oil and Canola oil for different treatment

Treatment	Groundnut oil					Canola oil				
	Color	Texture	Taste	Crispiness	Overall Acceptability	Color	Texture	Taste	Crispiness	Overall Acceptability

T1	7.25	7.25	7.50	7.62	7.40±0.16	7.87	7.37	7.37	7.37	7.24±0.21
T2	6.75	7.37	7.37	7.50	7.24±0.29	7.50	7.25	7.52	8.00	7.59±0.27
T3	8.50	7.62	7.87	7.87	7.96±0.32	7.75	7.12	7.75	8.00	7.65±0.32
T4	7.00	7.00	6.25	7.50	6.93±0.44	7.62	7.62	8.12	8.00	7.84±0.22
T5	6.12	6.50	6.25	7.00	6.46±0.33	7.37	7.75	8.00	7.50	7.65±0.24

4. CONCLUSION

In conclusion, moisture was lost from potato chips before and after they were fried in mustard, sunflower, groundnut, and canola oils. Treatment T5, which was cooked in canola oil, showed the highest moisture loss, whereas treatment T4, which was fried in mustard oil, showed the lowest moisture loss. For the (T1-T5) treatment, the ash content before frying increased after frying in mustard oil and canola oil, but decreased after frying in sunflower and groundnut oil. After frying in canola, mustard, sunflower, and groundnut oils, the pH of the potato chips decreased. In comparison to potato chips fried in mustard oil, groundnut oil, and canola oil, sunflower oil-fried potato chips had the lowest pH value among the treatments (T1-T4). T4, which had the lowest pH (5.05), was fried in sunflower oil. Treatment T3 had the lowest acidic value (0.05) before cooking in oil, and treatment T4 had the lowest acidic value (0.05) after being fried in canola oil. T4 had the highest acid value (0.21) and was fried in groundnut oil. The L* value rises after being fried in canola, mustard, sunflower, and groundnut oils in comparison to that before being fried in potato chips. Increased lightness value when cooked in sunflower oil in compression to before fry in treatment (T1-T5). Fried potato chips had a greener color when treated with mustard oil, sunflower oil, groundnut oil, and canola oil. Similar to the treatment, T4 increased the green color of fried mustard, groundnut, and canola oils, with the exception of potato chips cooked in sunflower oil. When fried in mustard oil, sunflower oil, groundnut oil, and canola oil, T1 and T2 potato chips were yellow in color. The yellow color of the potato chips was reduced when they were fried in mustard oil (T1-T5). Whiteness index of the treated (T1-T5) potato chips was found lower in canola oil as compared to mustard, sunflower and groundnut oil, after frying. T4 sample of potato chips fried in canola oil was found best in pH, acidity and color value in compression to other types of treatments and frying oils; but, economically chips fried in mustard oil was best.

COMPETING INTERESTS

"Authors have declared that no competing interests exist."

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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