

Optimization of Blanching Time-Temperature Combination and Pre-Drying Durations for Production of High Quality Potato Chips

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Abstract

During Experiment I the overall organoleptic acceptability quality (Color, Odor, Crispness, and Taste) of potato chips were studied in relation to pre-frying blanching T°-time combination (70, 75, 80, 85, & 90°C for 2, 3, 4, & 5 minutes). The sensory result showed blanching increase the acceptance of potato chips and helps production of superior quality potato chips. Among the blanching T° -time combinations potato chips from slices blanched at 85°C for 4 minutes got the first rank for color, crispness & odor as well as perceived as superior quality potato chips. During Experiment II the effect of pre-fry drying durations for minimum oil uptake of potato chips during frying was evaluated. During this experiment potato slices blanched at 85°C for 4 minute (optimum blanching T°-time combination obtained from the first experiment) were dried at 75°C for different durations (0, 5, 10, 15, 20, 25, 30, 35, and 40 minutes) and fried. The result revealed a negative linear relationship between pre-fry drying duration and oil uptake percentage by potato chips during frying.

Keywords: potato chips; slices; blanching; T° -time; color; odor; crispness; taste; oil up take.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is grown in 80% of the countries in the world and is consumed daily by millions of people from diverse cultural backgrounds (Kaur *et al.*, 2007). One of the most popular products made of potato are Potato fries. A potato chips is a thin slice of potato, deep fried or baked until crisp. Potato chips were invented in 1853, in the USA, and became popular throughout the world (Kaur *et al.*, 2007). In developing countries such as Ethiopia, they are becoming the most popular potato product.

Potato chips have a unique texture flavor combination, which makes them an important part of the fast food market. In general, during frying process, the physical, chemical and sensory characteristics such as Texture, color and oil uptake of potato chips are modified (Garayo and Moreira, 2003).

Quality of potato chips depends upon variety, storage conditions prior to processing, slice thickness, nature of oil used, T° and period of frying. In food processing, several kinds of potato crisps are distinguished according to their shape and thickness. Yet, regardless of their shape and thickness, Potato chips quality is assessed by the consumers on the basis of color, odor, taste, fat content and texture (crispness) (Salvador *et al.*,2009).

In recent years, several procedures have been proposed pre-frying treatments to reduce the amount of oil uptake such as blanching or pre-drying (drying before frying) (Kaur *et al.*, 2007).

Blanching in hot water, besides inactivating the enzymes responsible for the development of a black color and off flavor in frozen potatoes, serves to leach the reducing sugars from the surfaces of the cut potato strips and could reduce the oil-uptake by gelatinization of surface starch (Califano & Calvelo, 1987). Pre-drying after blanching and before frying using microwave, hot air and baking resulted in lowering the moisture content before frying and significantly reduced in oil absorption while increasing crispness of potato chips (Pedreschi & Moyano, 2005, Lamberg *et.al.*,1990 and Moreria & Barrufet, 1999).

Despite all this beneficial effects of blanching & pre-drying, these unit operations of potato chips processing are not known or overlooked by potato chips producers of Ethiopia as evident from the inferior quality of potato chips marketing in Ethiopia restaurants and fast food retails. Moreover, to the best of our knowledge and from private communications there is a lack of information and awareness regarding the optimum blanching and pre-drying time-T° combination on organoleptic properties (color, odor, taste and texture (crispness)) and oil up take (fat content) of potato chips.

Thus, this research has been therefore conducted to investigate: first to identify the optimum blanching time-T° combination for better organoleptic properties of potato chips. Secondly, to identify the optimum pre-drying time at constant T° for minimum oil uptake (potato chips fat content) by using the optimum blanching

time-T° combination obtained from the first experiment as a standard.

2. Materials and methods

2.1 Preparation of potato slices

To minimize the effect of cultivars, tubers of the same shape and size (*Solanum tuberosum* L.) harvested from one farm as well as free from sprout and wound has been collected from the market place of Bahir Dar. The potato slices were prepared in the laboratory of Food process, Bahir Dar University. Potato tubers were washed, peeled, and cut into uniform thickness slices (2mm), using slicer (ROBOT COUPE, CL30).

Experiment I was designed with one control and four blanching times (2, 3, 4, 5 minutes) and five blanching T° s (70, 75, 80, 85 and 90 °C) and two replications of the entire experiment. Treatments were named by their respective blanching time T° combination

(For instance samples blanch for 2 minutes at 70°C named 70-2). For this experiment the potato slices were divided into 40 portions and blanched by heating at the corresponding T° and time combination in hot water.

During Experiment II, potato slices blanched by the optimum time T° combination obtained from the first experiment (84°C for 2 minutes) were spread on blotting paper to remove excess water from the surface of the slices and dried at 75°C for different durations (0, 5, 10, 15, 20, 25, 30, 35, and 40 minutes) in duplicate using conventional oven prior to frying.

For frying palm oil was purchased from the market place of Bahir Dar, and equal number of slices were deep-fried for each treatment at T° of 180°C in palm oil for 3 minutes using a deep fat fryer (Falcon fryer). All the fried chips for each batch were drained on a wire screen for 5 min and cooled to room T° before analysis.

2.2 Measurement and analysis

For Experiment-I organoleptic qualities (color, odor, taste and texture/crispness) of the potato chips were analyzed by a widely employed method of perception/preference score using trained panelists. All the panelists were staff members and senior students of Food technology and process engineering for better understanding of the standard sensory characteristics of potato chips used for comparison. Preference score of the potato chips organoleptic property (color, odor, taste, and texture/crispness) for each treatment was performed in duplicate and an average value was used in further statistical analysis.

For Experiment II, Oil content of the fried chips was measured by Soxhlet extraction using hexane in duplicate for the 18 samples (9 treatment in duplicate). The extraction was done for 16 hours as per the method recommended by Association of Official Analytical chemists (1990).

3. Data handling and statistical analysis

For Experiment I perceptions score given by the panelists for each sensory characteristics and corresponding treatments were recorded and summary statistics (mean and standard deviation) was computed for each dependent variable.

During experiment II, Oil content of potato chips from each pre-drying durations measured by soxhlet extraction method were recorded and summary statistics (mean and standard deviation) was computed for each dependent variable.

In order to find differences between treatments mean perception score (Experiment I) and mean oil content (Experiment II) was all submitted to General Linear Model (GLM) procedure from SPSS 15.0 (SPSS, 2006) statistical soft ware package to determine optimum blanching time –T° combination and pre-drying durations before frying respectively for the production of Potato chips with Minimum fat content (oil uptake).

The treatments whenever found significant, the tukey test was used for pair wise comparisons among the different treatments at the 5% ($p < 0.05$) significant level.

4. Results and discussions

4.1 Experiment 1: optimization of blanching time-T° Combination for the production of potato chips of superior Organoleptic property

Optimization of blanching T°-time combination for potato chips of superior color

The present study confirm the importance of selecting optimal blanching T° -time combination for efficient inactivation of enzymes and reduction of reducing sugar level to get acceptable potato chips. Mean and standard error of the mean (SEM) of color preference score of potato chips at different blanching time-T° combination is summarized in Table 1. Statistical treatment of the analytical data showed significant ($P < 0.05$) difference among the blanching T°-time combination on color preference score values. According to the result (Table 1) an increased in inactivation of the enzyme and higher loss of reducing sugars (as evident from the higher preference score by panelists) observed as the T° rose. As indicated in the rank given in Table 1, the top eight color preferences scores were given for potato slices blanched at higher T° (85-90°C) for 2 -5 minutes. Where as the

preference score /rank given for blanching T° less than 85°C was less than values/ranks given for slices blanched at higher T° . As indicated in the result there is no significant difference (P>0.05) between blanching T°-time of 85 °C -3 minutes, 85 °C -4 minutes & 90°C at all blanching durations .Whereas there is significant (P< 0.05) difference between 90°C at all blanching durations and blanching T°-time of 85-2 where the higher preference scores was given for 90°C at all blanching duration. These relationships between the two higher T° s (85 & 90°C) signify the combined effect of higher T° and time to inactivate enzymes and reduce the reducing sugar level thereby reducing development of undesirable brown color during frying of potato. Even though it is not statistically significant, the rank given for the higher T° (90°C) at prolonged blanching duration was lower than short durations at the same T° . This lower rank given for 90°C blanching T° at 5 & 4 minutes blanching durations may be due to a reduction in leaching of sugar from the surface because of a higher concentration of the sugar in the blanching water. On the other hand, long durations at 85°C get higher preference score than short durations at the same T° . From this observations the present study suggest blanching at 85°C for 4 minute and 90°C for 3 minute as optimum blanching T°-time combination to produce potato chips of higher color perception score. As the sugar concentration decrease due to optimal blanching time T° combination, the color of the potato chips become light golden and acceptable by consumers. This optimum T°-time combination may also allow optimal Millard reaction needed for the acceptable color formation during frying.

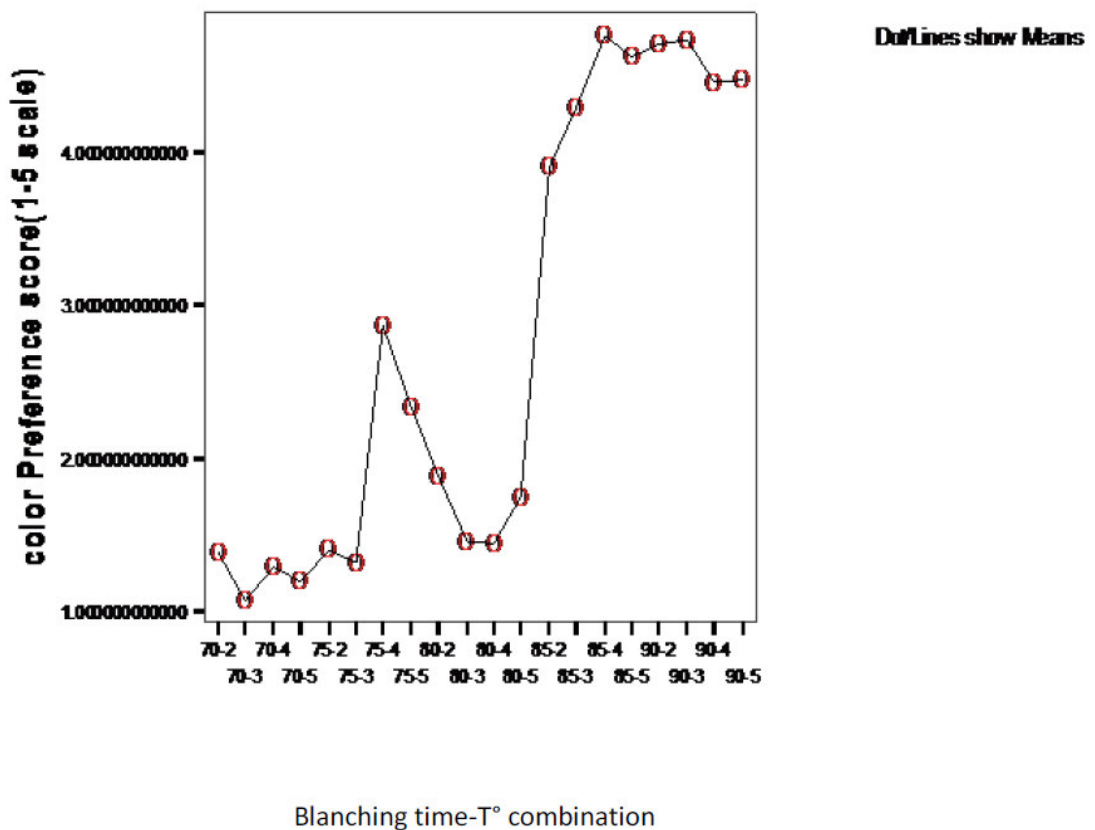


Fig.1. Effect of different blanching time-T° combination on the color of potato chips.

Table 1. Effect of different time-T° combination on the sensory attributes of potato chips

Tempt. Time combination	Color*	Rank	Odor*	Rank	Crispness*	Rank	Taste*	Rank
70-2	1.385	16	2.308	12	2.827	9	1.962	16
70-3	1.077	20	1.731	9	1.481	18	1.615	18
70-4	1.288	18	2.308	12	1.673	17	1.923	17
70-5	1.192	19	2.000	15	1.769	16	1.615	18
75-2	1.404	15	2.231	14	1.769	16	2.192	13
75-3	1.327	17	2.269	13	1.885	15	2.500	10
75-4	2.865	9	2.808	8	2.885	8	2.962	8
75-5	2.327	10	2.885	7	2.269	12	2.808	9
80-2	1.885	11	2.308	12	2.096	13	2.346	12
80-3	1.462	13	2.346	11	1.404	18	2.077	14
80-4	1.442	14	2.538	10	2.346	11	2.385	11
80-5	1.750	12	2.269	13	1.923	14	2.038	15
85-2	3.904	8	3.615	6	3.346	6	3.692	6
85-3	4.282	7	3.790	4	3.364	5	3.760	4
85-4	4.750	1	4.212	1	4.288	1	4.192	2
85-5	4.615	4	3.731	5	2.731	10	3.654	7
90-2	4.692	3	3.808	3	3.269	7	3.731	5
90-3	4.731	2	4.096	2	4.135	2	4.615	1
90-4	4.442	6	3.731	5	3.423	4	3.769	3
90-5	4.462	5	3.731	5	3.942	3	3.769	3
p-value	0.000		.000		0.000		0.000	
SEM	0.120		0.125		0.234		0.195	

*Values are shown as means.

SEM= Standard error of the means

Optimization of blanching T° -time combination for potato chips of superior Crispness

With regard to crispness this study reveals the importance of selecting optimal blanching T°-time combination for efficient draw out of internal water to get acceptable potato chips. Mean and standard error of the mean (SEM) of crispness preference score of potato chips at different blanching T°-time combination are given in Table 1. Statistical data showed significant (P< 0.05) difference among the blanching time-T° combination on crispness preference score values. As indicated in (Table 1) the draw out of internal water expected as the T° rose gives the top three crispness preferences scores for potato slices blanched at higher T°- time combination of 85°C-4 minutes, 90°C -3 minutes, & 90°C -5 minutes. Whereas the preference score /rank given for all blanching T°-time combinations less than 85°C-3minutes was less than values/ranks given for slices blanched at 85°C-4 minutes and above. This is because of less water drawn out from the center of the slices which affects the

crispness at T°-time combinations below 85°C-3 minutes. On the other hand blanching T°- time combination of 85°C-5 minutes showed statistically significant difference with 85°C -4minutes, this may be due more water comes out which result in crispness of the potato chips. Besides, there is a significant difference between T°-time combination 85°C -4 minutes and 90°C -2 minutes .The reason for this occurrence may be at 90°C-2 appropriate amount of water was not removed due to short duration even if the T° is higher than 85°C. Again the analyzed data shows there is statistically significance (P< 0.05) difference among the blanching combinations of 90°C -3 and 90°C-4 minutes, 90°C-5 minutes. The two combinations (90°C -4 minutes & 90°C -5 minutes) draw much water than 90°C-3 combination because of increased duration; as a result the slices become hard rather than crisp. As indicated in the result there is no significant difference (P>0.05) between blanching T°-time of 85°C-4minutes & 90°C-3 minutes. Even though it is not statistically significant, the rank given (Table 1) by the panelist for T°- time combination 90°C-3minutes is lower than 85°C for 4 minutes. From this observation the present study suggests that the optimum blanching T° -time combination of 85°C for 4 minutes to produce potato chips of higher crispness perception score (Table 1 & Fig. 2).

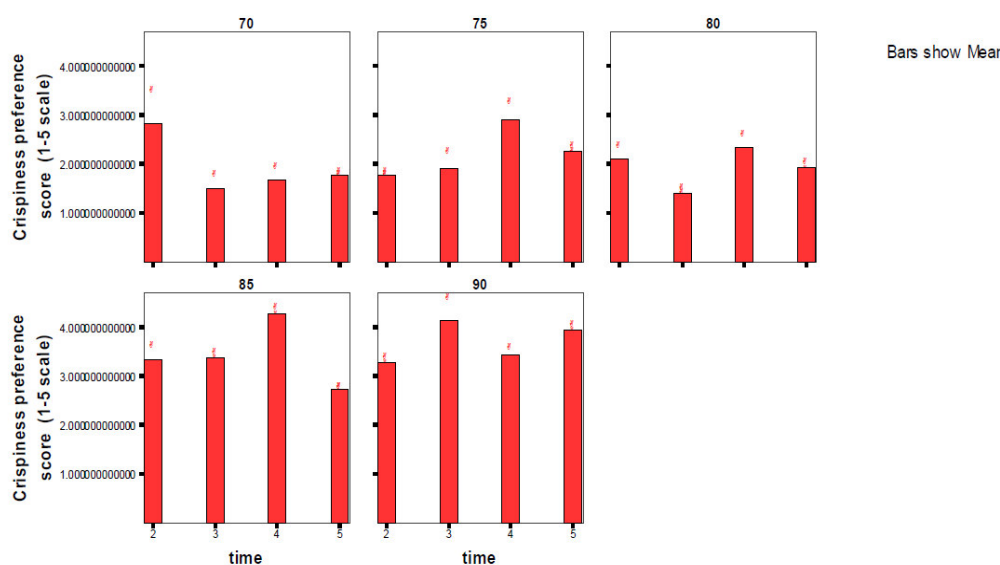


Fig.2. Effect of different blanching time-T° combination on the Crispness of potato chips.

Optimization of blanching T° -time combination for potato chips of superior odor

The occurrence of odor in potato chips mainly related with the interaction of reducing sugar with amino acids, enzymatic browning and the type of oil used. The odor of potato chips also can be influenced by the nature of the oil that are not well deodorized as a result the chips fried in such type of oil will have the odor of frying oil. This study showed statistically significant (P< 0.05) difference among the blanching T° -time combination on odor preference score values. According to the result (Table 1) better reduction of reducing sugar from the surface of slice achieved at higher T° blanching of the potato slices (as evident from the higher odor preference score by panelists). As indicated in the rank given in Table 1, the top eight odor preferences scores were given for potato slices blanched at higher T° (85-90°C) for 2 -5 minutes, but the ranks given for blanching T° below 85°C in all durations were lower. As indicated in the result (Table 1) the rank given to the treatment at T°-time of 85°C-2 minutes is less than to that of 85°C-4 minutes, this may be due to an increase in leaching of the reducing sugars and inactivation of the responsible enzymes resulted in improved odor as duration of blanching extend. Similarly the value/rank given to the combination 90-3 is greater than 85-2 combination, which indicates leaching of reducing sugar increase as T° and time increase. Additionally, as indicated in the mean comparison, blanching T° -time combination of 85-4 showed significant (P< 0.05) difference with the T°-time of 85°C-5 & 90°C at all blanching durations where higher preference score is given for T°-time combination of 85°C-4 minutes. The reason for this phenomenon is that as the duration goes from 4 to 5 minute at 85°C more leaching of reducing sugars which result in unacceptable odor of potato chips (since Millard reaction and enzymatic browning are responsible for the odor formation in potato chips.), and for the combinations of 90°C at all blanching durations the variation may be due to more reducing sugars leached out and result in cooked odor at higher T° and the result was unacceptable by panelists as indicated in (Table1). From this study the optimum blanching T° -time to produce potato chips of higher odor perception score was 85°C-4 minutes (Table 1 & Fig.

3).

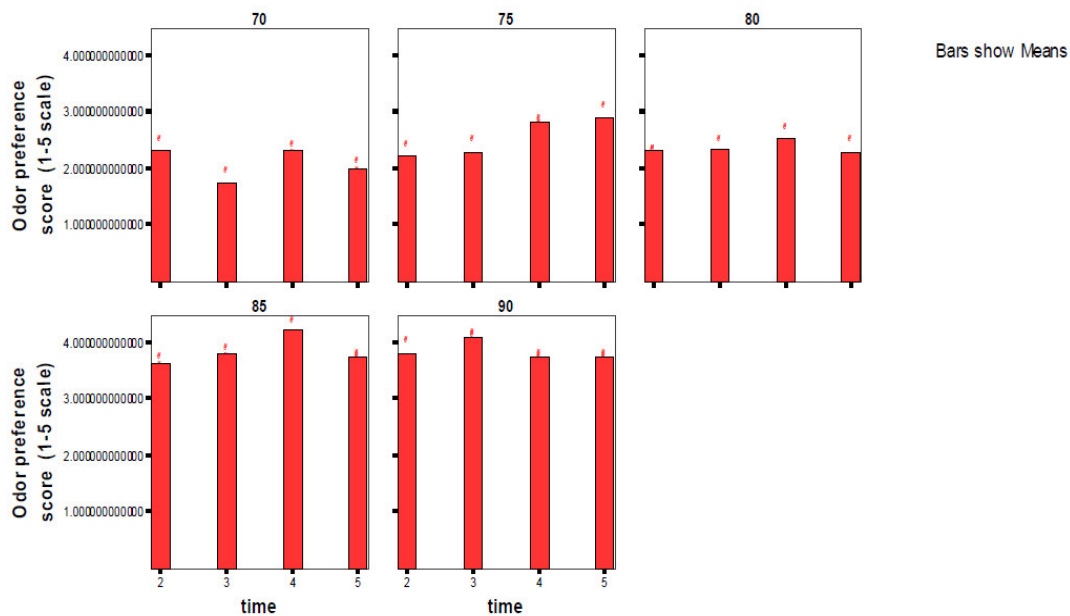


Fig.3. Effect of different blanching T° -time combination on odor perception score of potato chips.

Optimization of blanching T° -time combination for potato chips of superior taste

Mean and standard error of the mean (SEM) of taste preference score of potato chips at different blanching time-T° combination given in Table 1 revealed that the necessity of selecting optimum blanching T° -time combination for effective gelatinizing of the surface starch and leaching out of the reducing sugars from the slices to get acceptable taste of potato chips.

The analyzed data indicates significant ($P < 0.05$) difference among the blanching T°-time combination on taste preference score values. According to the result (Table 1) an increased in gelatinization of surface starch and higher loss of reducing sugars (as evident from the higher taste preference score by panelists) observed as the T° rose. As indicated in the rank given in Table 1, the top eight taste preferences scores were given for potato slices blanched at higher T° (85-90°C) for 2 -5 minutes . While the preference score /rank given for blanching T° s less than 85°C was less than values/ranks given for slices blanched at higher T° s. The reason for this occurrence is less gelatinization of surface starch and lower leaching of reducing sugars at these T° which results in lower taste quality of potato chips. As indicated in the result, there is no significant ($P > 0.05$) difference between blanching T°-time of 85°C & 90°C at all blanching durations except at 90°C-3 minutes . Whereas there is significant ($P < 0.05$) difference between the treatment of 90°C-3 minutes and the rest 85°C at 2, 3, and 5 minutes. This shows that blanching at T°-time of 90°C-3 minutes result in better gelatinization of the surface starch .As a result higher rank was given to T°- time of 90°C-3 minutes treatment as indicated in Table 1. Whereas there is no significant ($P > 0.05$) difference between T°-time combinations of 90°C-3 minutes and T°-time combination of 85°C-4 minutes, but as the result shown in Table 1 the rank given to T°-time of 90°C-3 minutes is higher than that of T°-time of 85°C-4 minutes. This reveals that blanching at T°-time of 90-3 gelatinizes the surface starch and leaches out the reducing sugar which gives acceptable taste for the potato chips than blanching at T°-time of 85°C-4 minutes. Beside, treatments at T°-time of 90°C-3 minutes has significant difference ($P < 0.05$) with the rest combination of T°-time of 90°C. The blanching of the slices at T°-time 90°C-3 minutes has got higher rank than the rest treatments of 90°C. This indicates that blanching at 90°C-2 minutes gelatinizes less surface starch than blanching at 90°C-3 minutes and results in improved taste of potato chips. Whereas blanching at 90°C-4 minutes & 90°C-5 minutes leaches and gelatinize more starch than treating at 90°C-3 minutes which results in inferior taste quality of potato chips. This study suggest blanching at 85°C for 4 minute duration and 90°C for 3 minute as optimum blanching T°-time combination to produce potato chips of higher taste perception score (Table 1 & Fig.4).

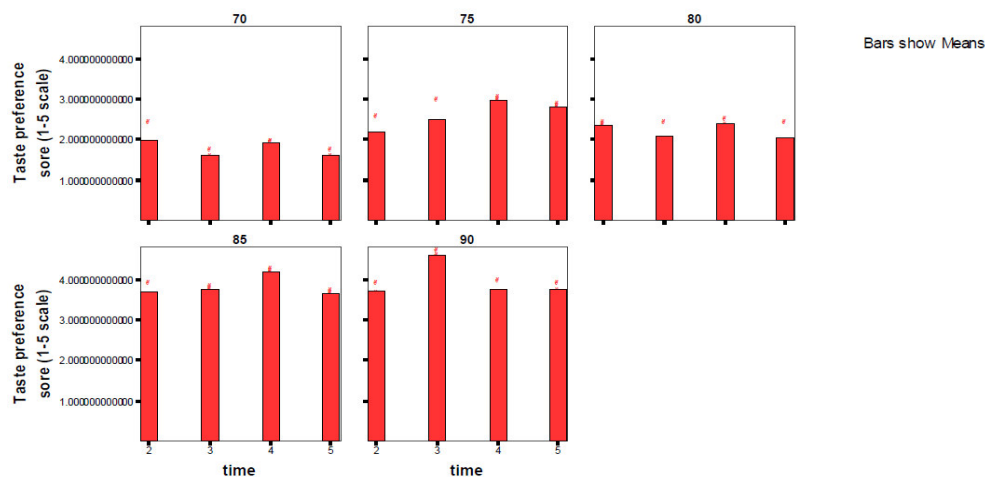


Fig.4. Effect of different blanching time-T° combination on the taste of potato chips.

4.2 Experiment II: optimization of pre-fry drying duration at uniform T° for the production potato chips with minimum fat Content (oil up take)

Mean and standard error of the mean (SEM) fat content of potato chips fried after different pre-drying duration indicated in Table 2 revealed an inverse relationship between the oil absorbed during frying and pre-drying duration. Statistical treatment of the analytical data showed a continuous and significant ($P < 0.05$) decrease in oil absorption for an increased pre-drying time was observed. As indicated in Table 2 as drying time increase from zero to 40 minutes the oil absorbed by the potato chips decreased from 46.04 to 24.242%.

Pair wise comparison result showed significant difference ($P < 0.05$) between drying times 0 minute (blank) with all duration. Similarly, there is a significant difference between pre-drying duration of 5 minute with all except 10 minutes; pre-drying duration of 10 minute with all except 5 and 15 minutes, pre-drying duration of 15 minute with all except 10 and 20 minutes. Whereas there are significance difference between 25, 30, 35, and 40 minutes with all durations. As indicated in Table 2 the relationships between lower duration (5, 10, 15, and 20 minutes) showed no significant difference. This is due to less moisture removal from the blanched slices. On the other hand the relationship between higher durations (25, 30, 35, and 40 minutes) with all duration showed significant ($P < 0.05$) difference, and this also related with higher removal of moisture from the slices. As indicated in Fig. 5, faster decrement in absorbed fat content observed in the first treatment (5 minutes with 75°C) as compared to the control followed by a decrease rate in absorbed fat content as pre-drying time increase. This faster decrement observed at the beginning may be due to the faster removal of moisture from the surface of the slices, but as the drying time increase the rate of moisture removal decreased and as a result the rate of oil absorption decreased.

Table 2. Effect of different pre-drying durations on fat content (oil uptake) of potato chips

Drying time(minutes)	Oil (%)**	Rank*	Moisture (%)
0	46.040 ± 0.758 ^a	9	75.0412
5	41.891 ± 0.758 ^{bc}	8	73.0583
10	40.458 ± 0.758 ^{be}	7	72.6758
15	38.988 ± 0.758 ^{ed}	6	71.8847
20	37.159 ± 0.758 ^d	5	69.9391
25	34.412 ± 0.758 ^f	4	67.1896
30	29.960 ± 0.758 ^g	3	63.9975
35	26.704 ± 0.758 ^h	2	56.3942
40	24.242 ± 0.758 ⁱ	1	48.2877
p-value	0.000		

Means followed by different superscripts within columns show statistically significant ($p < 0.05$) differences.

* Rank given based on minimum fat content

** Values show mean value and standard error of the mean

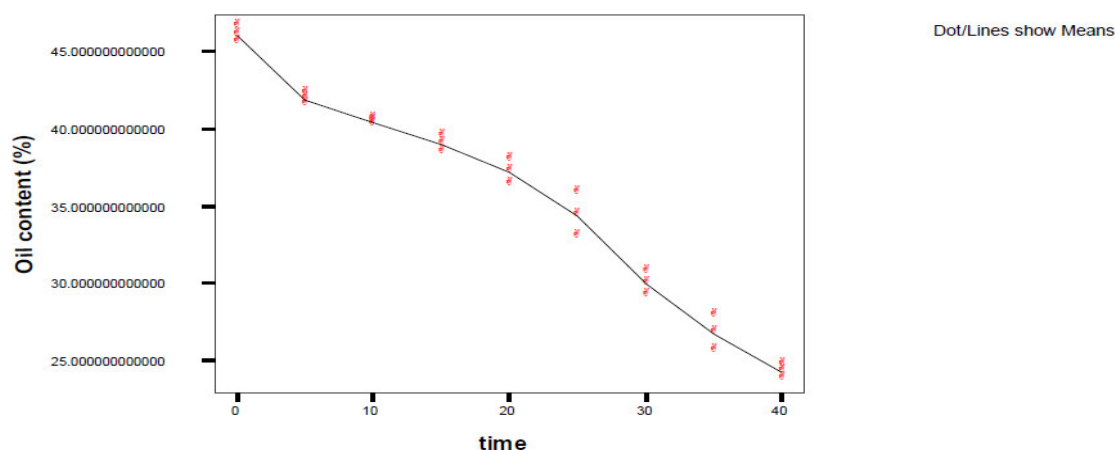


Fig.5. Effect of different pre-drying durations on fat content (Oil up take) of potato chips.

5. Conclusion

During the first trial the present study confirms that blanching potato slices with water in different T°- time combination has direct relationship with organoleptic quality (color, crispness, taste, & odor) of potato chips. The result showed the inactivation of the enzyme and reduction of reducing sugars increased as the T° rose (from 70 to 90°C), and significant ($p < 0.05$) difference between combinations observed. As the enzyme inactivated sensory characteristics (color, taste, crispness, & odor) improved and the acceptance of the potato chips by panelists increased. Reducing sugar level which is responsible for the formation of Millard reaction also decreased as T° rose, and this draw advantage for optimal Millard reaction thereby the quality of the potato increased. The slices that were blanched at lower T° (70, 75, & 80°C) with all duration (2, 3, 4, & 5 minutes) were got inferior score as compared to high T° (85 & 90°C) treatments due to minimum inactivation of enzyme and less amount of reducing sugar washed from the surface. Even though higher T° treatments got maximum perception score, the rank showed there is difference between combinations. For the sensory attributes color, crispness, & odor of potato chips blanched at 85°C with 4 minutes ranked as first, but for the case of taste the rank showed second position. Generally 85°C with 4 minutes selected as optimum blanching T° time combination for all sensory characteristics (color, taste, crispness, & odor) of potato chips.

The second trial demonstrates the possibility of reducing the fat content of potato chips by pre-drying the blanched potato chips before frying. According to the study the amount of fat absorbed by potato chips during frying decreased as the pre-drying duration increase (Table 2) and the study suggest 40 minute (the

maximum pre-drying time in this study) as optimum pre-drying time to have potato chips of minimum fat content. The oil content of potato chips should be as minimal as possible, because high oil contents have adverse health effect like obesity. So to reduce the oil absorption there are things to be considered such as dry matter contents of the potato tubers and the moisture contents of the slices to be fried. The moisture contents of the slices can be reduced by pre-fry drying treatment, and the treatment time T° combination should be optimized.

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