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Assessment of vacuum fried beetroot finger chips sensory evaluation processed at various frying conditions

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Abstract
The vacuum frying is alternative technology that might be an option for the production of novel snacks from fruits and vegetables with lower oil content and desired quality attributes. It is the frying process carried out under vacuum pressures well below atmospheric levels therefore, lowering the boiling point of oil, making possible to reduce substantially the frying temperature. Vacuum fried with corn powder coating beetroot finger chips fried obtained high sensory scores with respect to colour (8.36), texture (8.45), flavour (8.32), taste (8.75) and overall acceptability (8.65). Among the vacuum fried chips prepared under different combinations of vacuum (constant 640 mm Hg), frying temperature (3 levels) and frying duration (3 levels), the beetroot finger chips prepared under with corn coating at 110 °C frying temperature for 15 minutes frying time was adjudged to be best in terms of all quality parameters.

Keywords: Beetroot, vacuum frying, finger chips, sensory and corn powder

1. Introduction
Fruits and vegetables are a vital addition to the human diet because they include the vitamins, minerals, and fibre (roughage) needed to sustain good health. India is second in the world for producing fruits and vegetables. According to the Indian Horticulture Database (IHDB), which was issued by the Indian Ministry of Agriculture year 2018–19, the country produced 185.8 million metric tonnes of vegetables and 98.57 million metric tonnes of fruits. Fruits were grown on 6.6 million hectares of land while vegetables were grown on 10.1 million hectares (IHDB). Fruit and vegetable losses are incredibly high in impoverished nations(Kumar *et al*. 2022). Fruit and vegetable post-harvest losses in India are thought to be higher than 25% (Diamante *et al*. 2015) [3]. The integrated action of oxygen radical scavengers like beta-carotene and ascorbic acid, calcium, and dietary fibre in fruits and vegetables reduces the risk of cancer, heart disease, premature ageing, stress, and weariness.
Beetroot (*Beta Vulgaris* L.) is a common root crop grown for its fleshy roots, which are used as cooked vegetables, salad ingredients, pickles, and canning. There are several varieties of beetroot, with bulb colours ranging from yellow to red (Granda *et al*. 2004) [4]. In the Beta genus, there are nine other species, all of which go by the name "beetroot." From the South Indian highlands to the Northern mountainous regions, beetroot is widely grown in India. Haryana, Uttar Pradesh, Himachal Pradesh, West Bengal, and Maharashtra are the primary states where beetroot is grown. 1277.6 Mt of beetroot were produced in Karnataka on 53,800 hectares (Ravi *et al*. 2015) [10]. The most popular beetroot roots for human consumption are those that are deep red, whether they are cooked or eaten raw in a salad or juice (Fadigas and Dias 2009) [5]. The pigment betalein is what gives the coloration its purple-red hue. In the food industry, betanins are extracted from the roots and utilized as red food colorings, for example, to enhance the colour of tomato paste, sauces, desserts, jams, jellies, ice creams, candies, and cereals. Beetroots are abundant in beneficial, active substances like carotenoids (Dueik *et al*. 2010) [4].
Beetroot comes in numerous types, each with a unique flavour and appearance. It is consumed as a dessert and transformed into a variety of high-value products, such as chips, jam, papad, and squash that may be kept and used all year long. The consumption of nutritious meals has received greater attention in recent years as people have become more health conscious and interested in the benefits and drawbacks of the foods they consume.

The sensory evaluation of the different fried conditions were evaluated to suggest the best suitable fried product of the

2. Materials and Methods

2.1 Preparation of Beetroot for finger chips production

The selected beetroots were thoroughly washed. The skin of beetroot was peeled off manually using a stainless steel peeler and sliced into finger chips shape with the help of a sharp stainless steel knife. These finger chips were carefully handled and later used for production of finger chips. Independent variables: Frying oil temperature - 3 levels (100, 110 &120 ℃), Type of chips - 2 levels (without coating and with corn powder coating)**,** Frying time -3 levels (10, 15 & 20 min) whereas, the Dependent variables: Chips sensory quality- colour, flavour, texture, taste and overall acceptability

2.2 Sensory quality of beetroot finger chips

The sensory evaluation of beetroot chips was carried out using 9-point hedonic scale (Juvvi *et al*. 2016) [7]. Beetroot chips of each treatment were judged for the sensory quality attributes such as colour/appearance, crispiness/texture, taste, flavour and overall acceptability by a panel of 12 semi trained judges. The average score given by all the judges for different quality characteristics were recorded and mean scores were computed**.**

3. Results and Discussion

3.1 Sensory quality of vacuum fried beetroot finger chips

The sensory characteristics of beetroot finger chips such as colour, crispiness, taste, flavour and overall acceptability were tested by the sensory panel of 10 judges and the mean sensory scores of various vacuum frying treatments are given in the Tables 1 to 4.

3.1.1 Colour

The mean sensory scores for colour of vacuum fried beetroot finger chips fried under without corn powder coating and with without corn powder coating condition, frying temperature and time combinations at constant vacuum level of 640 mm Hg are given in Table 1. The mean sensory scores for colour of vacuum fried beetroot chips under without corn powder coating and with corn powder coating were found to be 7.22 and 7.78 respectively. Statistical analysis showed that there was a significant difference between colour of beetroot finger chips with respect to types of chips employed during frying. The mean sensory colour scores of vacuum fried chips at different frying temperatures of 100, 110 and 120 °C were found 6.97, 7.79 and 7.73 respectively. Statistically significant difference was observed in sensory colour scores of chips fried at different temperatures. The mean sensory colour scores of vacuum fried chips for different frying durations of 10, 15 and 20 minutes were found to be 7.43, 7.45 and 7,61 respectively. Statistically vacuum frying time within the experimental range influence the colour of fried chips significantly. The interaction effects between types of chips, frying temperature and frying time were found significant at both 1 and 5% level of significance. The higher frying temperature and time resulted higher colour score for fried chips. Chips fried under vacuum exhibit a lower extent of browning and mere golden yellow colour in comparison to atmospheric fried chips (Basuny *et al*. 2012) [2]. Similarly, (Stančin *et al*. 2020) also reported change in colour of vacuum fried banana chips reduction of L* value and darker colour with increase in frying temperature and time. Pan *et al*. (2015) reported about the effect of temperature and time on colour of breaded shrimps during vacuum frying. Vacuum-fried samples had higher L* values and lower a* and b* values compared to atmospheric fried samples due to lower frying temperature and frying time. Vacuum frying reduced degradation of colour as it lowered the rate of Millard reaction compared to atmospheric frying.

Table 1: Sensory score for colour of vacuum fried beetroot finger chips processed at various frying conditions

Frying conditions @ vacuum (640mm Hg)			**Sensory score for colour**
Types of chips	**Temperature (°C)**	**Time (min)**	
Without Coating(C_w)	100	10	5.54
		15	6.21
		20	7.14
	110	10	7.24
		15	7.86
		20	7.50
	120	10	8.21
		15	7.69
		20	7.60
With Corn coating(C_c)	100	10	7.99
		15	7.04
		20	7.93
	110	10	7.75
		15	8.36
		20	8.06
	120	10	7.87
		15	7.54
		20	7.48
		Grand Mean	**7.50**

ANOVA				
Type of chips (C)	Without coating (C_w)		With corn coating (C_c)	
Mean	7.22		7.78	
Temperature (T)	100 °C	110 °C	120 °C	
Mean	6.97	7.79	7.73	
Time (t)	10 min	15 min	20 min	
Mean	7.43	7.45	7.61	
	F-Value	SEM	CD (@5%)	CD (@1%)
C	6876.740**	0.005	0.014	0.019
T	6190.897**	0.006	0.017	0.024
T	302.473**	0.006	0.017	0.024
C × T	4516.911**	0.008	0.024	0.033
C × t	557.075**	0.008	0.024	0.033
T × t	1854.541**	0.010	0.030	0.041
C × T × t	848.671**	0.014	0.042	0.058

*,** Significant at 5% and 1% respectively

3.1.2 Flavour

The mean sensory scores for flavour of vacuum fried beetroot finger chips fried under without corn powder coating and with corn powder coating, frying temperature and time combinations at constant vacuum of 640 mm Hg are given in Table 2. The mean sensory scores for flavour of vacuum fried beetroot finger chips under without corn powder coating and with corn powder coating were found to be 7.29 and 7.84 respectively. Statistical analysis showed that there was significant difference between flavour of beetroot finger chips with respect to types of chips during frying.

Table 2: Sensory score for flavour vacuum fried beetroot finger chips processed at various frying conditions

Frying conditions @ vacuum (640mm Hg)			Sensory score for flavour
Types of chips	**Temperature (°C)**	**Time (min)**	
Without corn Coating(C_w)	100	10	5.61
		15	6.85
		20	7.62
	110	10	7.76
		15	7.66
		20	7.32
	120	10	7.72
		15	7.71
		20	7.38
With Corn coating(C_c)	100	10	7.78
		15	7.72
		20	7.82
	110	10	7.95
		15	8.22
		20	7.81
	120	10	7.88
		15	7.53
		20	7.91
		Grand Mean	7.57

ANOVA

Type of chips (C)	Without coating(C_w)		With corn coating(C_c)	
Mean	7.29		7.84	
Temperature (T)	100 ℃	110 ℃	120 ℃	
Mean	7.23	7.79	7.69	
Time (t)	10 min	15 min	20 min	
Mean	7.45	7.61	7.64	
	F-Value	S.Em	CD (@5%)	CD (@1%)
C	298.800**	0.023	0.067	0.092
T	113.630**	0.028	0.082	0.113
T	13.911**	0.028	0.082	0.113
C × T	72.127**	0.039	0.116	0.160
C × t	19.823**	0.039	0.116	0.160
T × t	61.260**	0.048	0.143	0.196
C × T × t	53.006**	0.068	0.202	0.277

*,** Significant at 5% and 1% respectively

The mean sensory flavour scores of fried beetroot finger chips at different frying temperatures of 100, 110 and 120 °C were found to be 7.23, 7.79 and 7.69 respectively. Statistically significant difference was observed in flavour scores of chips fried at different temperatures. The mean sensory flavour scores of vacuum fried chips for frying durations of 10, 15 and 20 minutes were to be 7.45, 7.51 and 7.64 respectively. Statistically vacuum frying time within the experimental range influence the flavour of fried chips significantly. The interaction effects between of types of chips, frying temperature and frying time observed significant at both 1 and 5% level of significance. The corn powder coated beetroot finger chips produced higher flavour values with increase in frying temperature and time that helps to preserve the chips. (Basuny *et al*. 2012) [2] Reported that vacuum frying diminishes most of the oxidative reactions and that helps to preserve the flavour of banana chips. The frying oil temperature and frying time play important role in preserving the natural flavour of food material during frying and also frying in low pressure helps to retain more volatile compounds.

3.1.3 Texture (crispiness)

The mean sensory scores for texture of vacuum fried beetroot finger chips fried under without coating and with coating, frying temperature and time combinations at constant vacuum of 640 mm Hg are given in Table 3.

Table 3: Sensory score for texture of vacuum fried beetroot finger chips processed at various frying conditions

Frying conditions @ vacuum (640mm Hg)			Sensory score for texture
Types of chips	**Temperature** (°C)	**Time (min)**	
Without Coating(C_w)	100	10	5.79
		15	6.73
		20	6.50
	110	10	7.70
		15	6.59
		20	7.60
	120	10	7.55
		15	7.58
		20	7.17
With Corn coating(C_c)	100	10	7.83
		15	7.89
		20	7.94
	110	10	8.04
		15	8.50
		20	8.21
	120	10	7.75
		15	8.14
		20	7.98
		Grand Mean	**7.52**

ANOVA

Type of chips (C)	Without coating(C_w)		With corn coating(C_c)	
Mean	7.02		8.03	
Temperature (T)	100 ℃	110 ℃	120 ℃	
Mean	7.11	7.77	7.69	
Time (t)	10 min	15 min	20 min	
Mean	7.44	7.57	7.56	
	F-Value	S.Em	CD (@5%)	CD (@1%)
C	534.051**	0.031	0.092	0.125
T	91.015**	0.038	0.112	0.154
T	3.721*	0.038	0.112	0.154
C × T	46.365**	0.053	0.159	0.217
C × t	5.653*	0.053	0.159	0.217
T × t	13.426**	0.065	0.194	0.266
C × T × t	26.527**	0.092	0.275	0.376

*,** Significant at 5% and 1% respectively

The mean sensory scores for texture of vacuum fried beetroot chips under without coating and with coating were found to be 7.02 and 8.03 respectively. Statistical analysis showed that there was significant difference between texture of beetroot finger chips with respect to types of chips during frying. The mean sensory texture scores of fried beetroot chips at different frying temperatures of 100, 110 and 120 °C were found to be 7.11, 7.77 and 7.69 respectively. Statistically significant difference was observed in texture scores of chips fried at different temperatures. The mean sensory texture scores of vacuum fried chips for frying durations of 10, 15 and 20 minutes were to be 7.44, 7.57 and 7.56 respectively. Statistically significant difference was found in texture of chips at different frying time. The interaction effects between types of chips, frying temperature and frying time were observed significant at both 1 and 5% level of significance. The sensory score for texture of vacuum fried beetroot finger chips was mainly related to “crispiness”. The porous structure of chips was due to fast moisture evaporation that leave vacuoles in the product matrix. The snapping and crumbling

of fried chips was attributed to this porous structure. Frying temperature and duration most probably affect the crispiness as well as level of moisture loss during frying and therefore the product structure and sensory texture scores. Corn powder coated fried beetroot finger chips produced higher values of crispiness as compared to the without coating chips with respect to temperature and time. (Bae *et al*. 2014) [1] observed crispier banana chips relatively at higher frying temperature (100 and 120 °C than at 80 °C) under vacuum frying.

3.1.4 Taste

The mean sensory scores for taste of vacuum fried beetroot finger chips fried under without corn powder coating and with corn powder coating, frying temperature and time combinations at constant vacuum of 640 mm Hg are given in Table 4.

Table 4: Sensory score for taste vacuum fried beetroot finger chips processed at various frying conditions

Frying conditions @ vacuum (640mm Hg)			Sensory score for taste
Types of chips	**Temperature (°C)**	**Time (min)**	
Without Coating(C_w)	100	10	5.72
		15	5.84
		20	7.62
	110	10	7.69
		15	7.63
		20	7.21
	120	10	8.02
		15	7.59
		20	7.31
With Corn coating(C_c)	100	10	7.60
		15	7.72
		20	8.23
	110	10	8.03
		15	8.78
		20	8.05
	120	10	8.16
		15	7.83
		20	7.84
		Grand Mean	7.60

ANOVA				
Type of chips (C)	Without coating (C_w)	With corn coating(C_c)		
Mean	7.18	8.02		
Temperature, ^{0}C	100 °C	110 °C	120 °C	
Mean	7.12	8.00	7.79	
Time (t)	10 min	15 min	20 min	
Mean	7.53	7.56	7.71	
	F-Value	SEM	CD (@5%)	CD (@1%)
C	929.364**	0.020	0.058	0.080
T	309.992**	0.024	0.071	0.098
t	14.912**	0.024	0.071	0.098
C × T	145.622**	0.034	0.101	0.138
C × t	21.482**	0.034	0.101	0.138
T × t	179.338**	0.042	0.123	0.169
C × T × t	43.537**	0.059	0.175	0.239

*,** Significant at 5% and 1% respectively

The mean sensory scores for taste of vacuum fried beetroot chips under without coating and with coating were found 7.18 and 8.02 respectively. Statistical analysis showed that there was significant difference between taste of beetroot finger chips with respect to types of chips during frying. The mean sensory taste scores of fried beetroot chips at different frying temperatures of 100, 110 and 120 °C were found to be 7.12, 8.00 and 7.79 respectively. Statistically significant difference was observed in taste scores of chips fried at different temperatures. The mean sensory taste scores of vacuum fried chips for frying durations of 10, 15 and 20 minutes 7.53, 7.56 and 7.71 respectively. Statistically vacuum frying time within the experimental range affect the taste of fried chips significantly. The interaction effects between types of chips, frying temperature and frying time were affects significantly at 1 and 5% level of significance. The corn powder coated vacuum fried beetroot finger chips resulted higher taste values with increasing temperature and time than without coating chips. The variation in taste scores may be attributed to variation in level of oil and moisture present in the fried chips owing to vacuum frying conditions. (Nagarathna 2017) [9] also reported variation in texture scores at different vacuum frying conditions for jackfruit chips.

3.2 Overall acceptability

The mean sensory scores for overall acceptability of vacuum fried beetroot finger chips fried under without corn powder coating and with corn powder coating, frying temperature and time combinations at constant vacuum of 640 mm Hg. The mean sensory scores for overall acceptability of vacuum fried beetroot chips under without coating and with coating were found to be 6.91 and 7.77 respectively. Statistical analysis showed that there was significant difference between overall acceptability of beetroot finger chips with respect to types of chips during frying. The mean sensory overall acceptability scores of fried beetroot chips at different frying temperatures of 100, 110 and 120 °C were found to be 6.83, 7.63 and 7.57 respectively. Statistically significant difference was observed in overall acceptability scores of chips fried at different temperatures. The mean sensory overall acceptability scores of vacuum fried chips for frying durations of 10, 15 and 20 minutes were to be 7.00, 7.56 and 7.47 respectively. Frying time within the experimental range influence the overall acceptability of fried chips significantly. The interaction effect between types of chips, frying temperature and frying time were also found significant at 1 and 5% level of significance.

The sensory parameter 'overall acceptability', is an important chips characteristic to make the final decision on whether to accept or reject the product. It intrinsically encompasses all the other sensory characteristics like colour, flavor, texture and taste to arrive at the comprehensive value. As the vacuum frying process parameters affected all the sensory attributes which obviously influence" overall acceptability" of vacuum fried beetroot finger chips. The chips fried under with corn powder coating at 640 mm Hg vacuum at relatively at higher frying temperatures for longer time obtained better acceptability scores. Likewise, (Basuny *et al*. 2012) [2] reported better sensory scores for vacuum fried potato chips when compared to atmospheric frying (overall quality).

4. Conclusion

The fresh vegetable were taken for preparation of beetroot finger chips. The slices were vacuum fried using refined sunflower oil. Frying was done under 2 types of chips (without corn powder coating and corn powder coating). Three different frying temperatures of 100, 110 and 120 °C and frying times of 10, 15 and 20 min were tried vacuum was kept constant at 640 mm Hg. After frying the chips were de-oiled by centrifugation at 500 rpm for 5 min in a basket

centrifuge, salt (2%) and chilli powder (1%) were added and packed. For different frying combinations the sensory quality characteristics were studied. Vacuum fried with corn powder coating beetroot finger chips fried obtained high sensory scores with respect to colour (8.36), texture (8.45), flavour (8.32), taste (8.75) and overall acceptability (8.65).

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