Effect of Vacuum Frying on Quality Parameters of *Colocasia* Leaves Rolls

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Abstract: *This study aimed to develop a value-added product from Colocasia leaves through the implementation of the vacuum frying technology. In this study fresh Colocasia leafy rolls were made by applying smooth paste of gram flour, rice flour and spices, 4-5 leaves were tightly rolled, steamed, cut into slices and vacuum fried at 9 kpa and temperature 100^{0}C, for 20 minutes. The vacuum fried and atmospherically fried Colocasia leaves rolls were subjected to sensory evaluation for the quality attributes in terms of colour, taste, after taste, texture and overall acceptability using the 9-point Hedonic Scale by semi trained panelists. Results of the sensory evaluation suggest that the quality attributes of the vacuum fried Colocasia leaves rolls were liked very much by the panelists, however, significant differences existed in terms of the colour and general acceptability of the product. Chemical analyses of vacuum fried Colocasia leafy rolls showed moisture 0.69%, oil 28%, crude fiber 2.5%, and total phenolic content 733.16 mg GAE/100gm. The texture was analyzed by TA-XT Stable Micro Texture Analyzer. The force required to cut Colocasia leaves roll was found to be 4.22kg. The L*, a*, and b*values of vacuum fried and atmospherically fried Colocasia leafy rolls were 29.38,-1.252, 17.68 and 19.35, 3.62 and 12.25 respectively. The products overall acceptability was found to be 8.5, like very much on the 9-point hedonic scale. Results suggested that vacuum fried Colocasia leafy rolls are highly acceptable.*

Keywords — *Colocasia leaves, colour, crude fibre, vacuum frying.*

I. INTRODUCTION

Vacuum frying is a new process of deep fat frying of foods under reduced pressure, which can be used to generate fried products with necessary degree of dehydration without affecting the colour of the product, less oil absorption and higher retention of flavours, nutrients, and a lesser amount of oil oxidation because of the low-temperature processing [1] [2]. Vacuum frying process is operated in a closed system, well below the atmospheric pressure, as a result dropping the boiling point of water and the frying temperature. Negligible exposure to oxygen and low frying temperatures aids for reduction in toxic compound generation [3] . *Colocasia esculenta*, is an annual herbaceous plant of the family of Araceae, native to south eastern Asia and the Indian subcontinent. The resourcefulness of this plant can be verified by the fact that all the parts like, tubers , leaves as well as petioles are used as vegetable [4]. Plants are packed with bioactive phytochemicals, in the form of proteins, polyphenols, isoflavones, carotenoids, and sterols [5]. These bioactive compounds provide protection for the health of living beings hence, use of these compounds is encouraged in the diverse fields. Recent consumer trend of products of natural origin has met by the application of bioactive compounds as functional food ingredients. [6]. In Indian subcontinent both leaves and roots of *Colocasia* are used to make different cuisines. In Maharashtra and Gujarat states of India the leaves are used to make a fried snack, known as Alu wadi / Patra. In this study an attempt was made to prepare vacuum fried *Colocasia* leaf rolls (Alu wadi) with better properties than atmospheric fried *Colocasia* leaf rolls.

II. MATERIALS AND METHODS

Fresh, *Colocasia* leaves were purchased from local market at Nagpur, India. Leaves were washed thoroughly with water and blotted with tissue paper. All other ingredients used in the preparation like, Bengal gram flour, rice flour, salt, chilli powder, turmeric powder and vegetable oil, (sunflower oil) were purchased from local market at Nagpur, India.

A. Vacuum frying system

A laboratory scale vacuum fryer constructed using a reaction kettle of borosilicate glass of 2 litre capacity as a vacuum chamber, a heating mantle with thermostatic control as a heating source and two-stage vacuum pump (Edwards) to generate the vacuum pressure up to 9 kPa, was used to carry out the experiments.

B. Experimental conditions

In this study *Colocasia* leaves rolls were vacuum fried at temperature 100^{0}C using vacuum pressure 9 kPa to achieve final moisture content up to 1%. Processing time and temperature for vacuum frying were selected with prior trials based on the maximum sensory acceptability by researchers. *Colocasia* leaves rolls were made by applying a smooth paste of gram flour, rice flour and spices on back side of fresh leaves, 4-5 leaves were arranged one above the other and pile of leaves were tightly rolled and steam cooked. The rolls were cooled and cut into slices and vacuum fried at 9 kilopascals and temperature 100^0C, for 20 minutes. Atmospheric fried *Colocasia* leaves rolls were fried at temperature 170^0C for 5-6 minutes.

III. DETERMINATION OF QUALITY PARAMETERS

A. Moisture content

Moisture content of the vacuum fried *Colocasia* leaves rolls was determined by hot air oven method (AOAC, 1995) [7]. Percent moisture content was calculated by determining the extent of weight loss of vacuum fried *Colocasia* leaves rolls (2-3 gm) after drying in a hot air oven at 105^0C until there was no change in the dried mass of the sample.

B. Oil content

Total oil content determination was carried out by using soxhlet extraction apparatus (AOAC, 1995) [7]. It was measured by extracting the oil from the sample with petroleum ether as a solvent.

C. Crude fibre content

Crude fibre estimation was conducted on crude fibre analyser (FIBRA Plus, Model FES2E Pelican equipment's) [8].

D. Total phenolic content

Total phenolics contents (TPC) of Colocasia leaves rolls were estimated calorimetrically using Folin-Ciocalteu (FC) reagent [9]. The results were reported in terms of gallic acid as mg GAE/100 g db.

E. Colour analysis

The colour was analyzed by Lovibond RT 300 portable reflectance spectrophotometer, using CIE $L^*a^*b^*$ (CIELAB) system. The measurements were taken using D-65 illuminant. The instrument was calibrated using standard black and white tile. Colour of *Colocasia* rolls was measured for each experimental condition measuring colour at different points on the surface. The colour was reported in terms of L^* value lightness, ranging from zero (black) to 100 (white)], a^* value indicate (+a) red to (-a) green and b^* value, (+b) yellow to (-b) blue. The total colour change ΔE, was calculated from L^*, a^* and b^* values [10].

$$\Delta E = [(L_0^* - L^*)^2 + (a_0^* - a^*)^2 + (b_0^* - b^*)^2]^{1/2} \quad (1)$$

Where L_0^*, a_0^*, b_0^* are the initial colour values of steam cooked samples and L^*, a^* and b^* are the final colour values of the *Colocasia leaves* rolls.

F. Texture analysis

Texture analyzer (TA XT; Stable Micro Systems, London, UK),was used to measure texture of the products by cutting blade, using 50 kg load cell and heavy-duty Platform (HDP/90). Pre-test speed was 1.5 mm/s, post-test speed was 5 mm/s, and test speed was 0.5 mm/s. Test results obtained from 5 samples of each type.

G. Scanning electron Microscopy

The fried samples were apparently defatted by dipping them in petroleum ether of boiling point 40-60^0C for 2 h after frying and powder sample directly loaded on carbon coated grid to see images, on SEM instrument, make-TESCAN, and model-Vega 3.

H. Sensory evaluation

Vacuum fried and atmospheric fried *Colocasia* leaves rolls were served to a semi trained panel of 10 members for sensory evaluation. Different sensory attributes like appearance, colour, flavour, taste, after taste, texture and overall acceptability were evaluated by nine-point hedonic scale [11]. The scores were assigned from Extremely liked (9), to Disliked extremely (1).

I. Statistical analysis

Analysis was carried out in triplicates and the mean values were reported. Analyses of variance were performed by one-way ANOVA procedure and Tukey's post test.

IV. RESULTS AND DISCUSSIONS

A. Moisture loss

Parameters of vacuum fried and atmospheric fried *Colocasia* leaves rolls are shown in table 1.Moisture content of vacuum fried *Colocasia* leaves rolls was 0.69% as compared to 5.68% of atmospherically fried rolls. Fig 1 shows the moisture loss of *Colocasia* leaves rolls when vacuum fried at 100^0C at 9kPa. The loss of moisture during frying exhibited a typical drying curve. Initially, the water loss was at higher rate due to vigorous escape of free water. Similar results were reported while studying vacuum frying of apple slices [12].

B. Oil content

Oil uptake of vacuum fried *Colocasia* leaves rolls during frying increased initially for first 5 minutes and then decreased progressively as shown in figure 2. The results are in accordance with reported results for the vacuum frying of breaded shrimps [13]. Final oil content of *Colocasia* leaves rolls was significantly affected ($P<0.05$) by frying time. Similar results were observed while vacuum frying of potato [2] and vacuum frying of jackfruit chips [14]. In vacuum frying oil absorption occurs at the pressurization step since the rapid increase in pressure after releasing vacuum is higher than atmospheric pressure forcing the surface oil into the product. Therefore centrifugation after frying is necessary in vacuum frying [15].

C. Crude fibre content and TPC

As seen from table I, no significant differences were seen between crude fibre content and TPC of vacuum fried and atmospherically fried *Colocasia* leaves rolls.

D. Colour analysis

L^* is a decisive parameter as it is the first observed and evaluated quality feature for the product acceptance by the consumer [16]. Initially, L^* value of steam cooked Colocasia leaves rolls decreased quickly from 39.69 to 27.21 for the first 5 minutes of vacuum frying, and finally decreased to 29.38 after 20 minutes. Immediate decrease in L* value after 5 minutes may be due to the non uniformity

Table I: Quality parameters of vacuum fried and atmospherically fried *Colocasia* leaves rolls

Parameter	Moisture%	Oil %	Crude fibre%	TPC mg GAE/100gm	Hardness Kg	L*	a*	b*	ΔE
Vacuum fried	0.69	28	2.58	733.16	4.4	29.38	-1.252	17.68	14.83
Atmospherically fried	5.68	30	2.24	752.43	1.089	19.35	3.62	12.25	26.35

of the steam cooked rolls prepared and also due to variation in spreading the batter. Statistical analysis showed that there were significant differences ($P<0.05$) among the final and initial values at 5, 10, 15 and 20 minutes for L^* value. But there were no significant differences ($P>0.05$) between the L^* values of rolls vacuum fried at 5, 10, 15 and 20 minutes. Vacuum frying did not affect significantly a^* values ($P>0.05$) and remained negative for all the samples fried at 5, 10, 15 and 20 minutes. A comparison of colour attributes of *Colocasia* leaves rolls fried under vacuum and atmospheric conditions, Fig 4, showed significant ($P<0.05$) differences. Atmospheric fried rolls showed significantly higher a* values than vacuum fried rolls, indicating more Maillard reaction occurred. To analyze overall impact of frying process on colour of product, the change in colour between steam cooked *Colocasia* leaves rolls (L_0^*, a_0^*, b_0^*), vacuum fried and atmospheric fried *Colocasia* rolls (L^*, a^*, b^*) was determined according to equation no (1). Lower ΔE values obtained for vacuum fried rolls compared to atmospheric fried rolls and the ΔE values were affected significantly ($P<0.05$). The results of colour analysis, lightness and redness determined by colorimeter were also confirmed by results of sensory evaluation given by the members of panelist. Results of sensory evaluation revealed that vacuum fried *Colocasia* leaves rolls were light in colour and redness as compared to atmospheric fried. This might be due to reduced colour degradation because of absence of Maillard reactions and oxidation during vacuum frying.

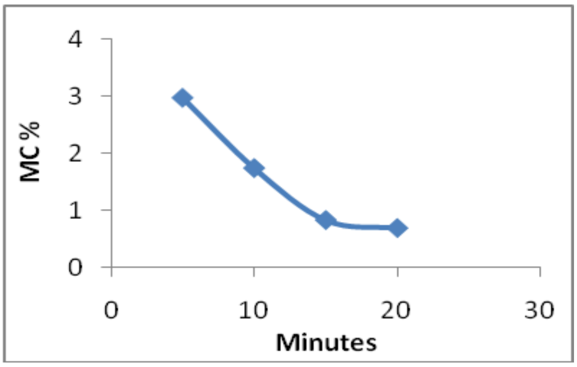

Fig. 1: Moisture loss of vacuum fried *Colocasia* leaves rolls

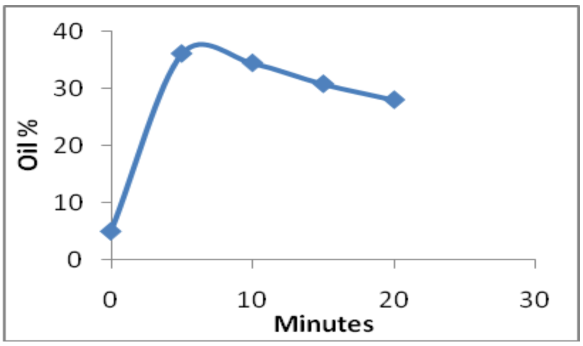

Fig 2: Oil content of vacuum fried *Colocasia* leaves rolls

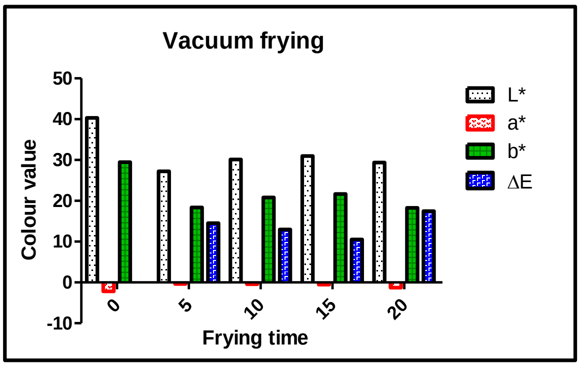

Fig 3: Effect of frying time on L*, a*, b*and ΔE values of vacuum fried *Colocasia* leaves rolls

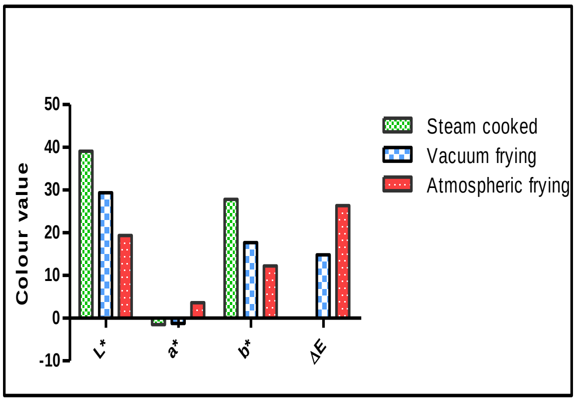

Fig 4: Effect of processing on L*, a*, b*and ΔE values of vacuum fried *Colocasia* leaves rolls

E. Texture analysis

Texture is a significant characteristic for the acceptance of fried food, and it depends on raw material and process conditions [13]. During frying most of the moisture is removed from the *Colocasia* leaves rolls resulting in texture development. *Colocasia* leaves rolls textural properties were calculated in terms of hardness. Fig.5. shows the consequence of frying time on the hardness of the rolls. Formation of crust starts very quickly right from the beginning of vacuum frying process [17]. This can be observed as hardness of the *Colocasia* leaves rolls increased with frying time. This may be credited to the reduction in moisture content. There were significant differences (P<0.05) among hardness of the vacuum-fried samples at different time and atmospheric frying process.

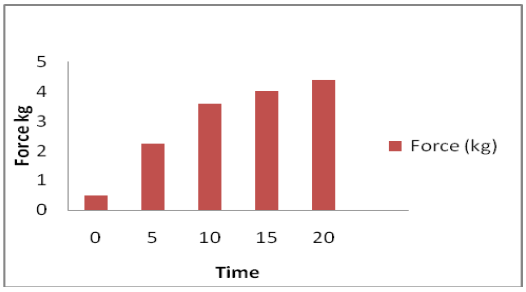

Fig 5: Effect of frying time on hardness of vacuum fried *Colocasia* leaves rolls

F. Structural changes

The atmospherically fried Colocasia leaves rolls showed a continuous closed network structure Fig 6-7, as compared to vacuum fried samples. This may be ascribed to the boiling point of water, being lower than the temperature required for starch gelatinization under vacuum [18]. At these conditions, there is a possibility that major portion of the starch being unable to gelatinize forms weaker structure, leading to oil absorption. Protein denaturation and starch gelatinization simultaneously contribute to development of pores, shrinkage of foods and forms starch protein matrix.

G. Sensory evaluation

Vacuum-fried *Colocasia* leaves rolls were subjected to sensory analysis to determine the consumer preference. Sensory acceptability assessed in terms of appearance, colour, flavour, taste, after taste, texture and overall acceptability. The panelists preferred the vacuum fried *Colocasia* leaves rolls for colour, texture, flavour, taste and overall quality. The results of sensory evaluation, Fig 8, showed that most of the panelists considered texture and colour as the premium factor and scored highest points 8.5 and 8.4 on the Hedonic scale. The quality of chips is determined by its crispiness [19]. Sensory evaluation scores showed significant differences (P<0.05) for *Colocasia* leaves rolls fried at vacuum and atmospheric conditions. Frying process significantly affected the quality attributes of *Colocasia* leaves rolls

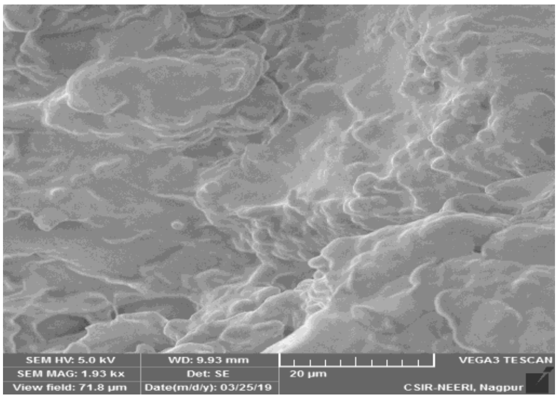

Fig 6: Effect of frying on microstructure of Vacuum fried *Colocasia* leaves rolls

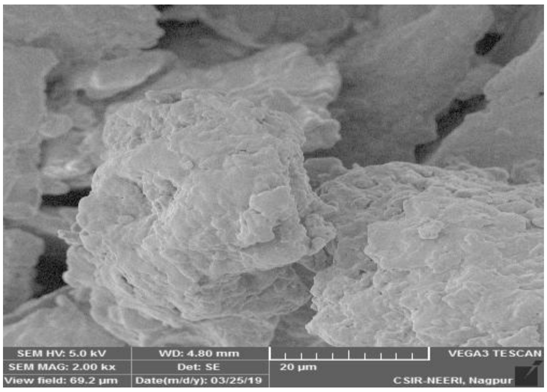

Fig 7: Effect of frying on microstructure of Atmospheric fried *Colocasia* leaves rolls

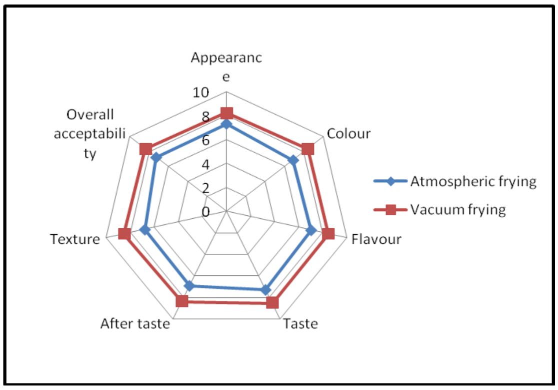

Fig 8: Sensory scores of vacuum fried and atmospherically fried *Colocasia* leaves rolls

V. CONCLUSION

The results of the present study revealed vacuum frying to be a promising technology to produce *Colocasia* leaves rolls with better sensory attributes in terms of appearance, colour, flavour, taste, after taste and overall acceptability.

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