Effect of preparation, microwave and pressingon quality of carrot powder

ABSTRACT

The experiment was carried out with the aim to study effects of preparation, microwave and pressing on quality of carrot powder. The experiment was conducted at Department of Post Harvest Technology, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat during 2021-22.Single strength pressing was done to fasten the drying rate. The experiment was replicated three times using completely randomised design (CRD) with factorial concept and comprised of18 treatments *viz*. preparation techniques as Factor-1 ["Shredding" (T_1), "Crushing" (T_2) and "Slicing" (T_3)]; microwave pre-treatments as Factor-2 [Control (M_1), Microwave pre-treatment 450 W for 30 seconds (M_2) and microwave pre-treatment 450 W for 60 seconds (M_3)] and pressing as Factor-3 [without pressing (P_1) and pressing (P_2)]. After single strength pressing, the samples were dehydrated in mechanical dehydrator using three stage dehydration temperatures (75 ^{o}C for 2 hours, 65 ^{o}C for 2 hours and 60 ^{o}C for about 11-12 hours) till final moisture content of 5.50 ± 1% following by packing. The results of the investigation revealed that best quality carrot powder can be obtained from carrot which was prepared by dehydrating crushed materials by giving microwave for 60 seconds followed by pressing ($T_2M_3P_2$) and carrot powder obtained from this treatment possess higher rehydration ratio, dehydration ratio and sensory score while lowest drying time, moisture content, water activity, reducing sugars and non-enzymatic browning (NEB). While, the carrot powder which was prepared by dehydrating crushed materials by giving microwave pre-treatment for 60 seconds followed by pressing ($T_2M_3P_2$) exhibited minimum changes in nutritional as well as sensory attributes during six months' storage when packed in polypropylene bags of 400-gauge thickness.It can be concluded that carrot powder can be prepared by dehydrating crushed materials by giving microwave pre-treatment for 60 seconds followed by pressing ($T_2M_3P_2$) and the powder can remain microbiologically safe for storage period of six months.

Keywords: Carrot, Powder, dehydration, Quality, Pre-treatments

1. INTRODUCTION

Among major vegetables, carrot (*Daucus carota* L.) belonging to Apiaceae family is the most important root crop grown throughout the world. It is a root vegetable, usually orange, purple, red, white or yellow, with a crisp texture when fresh. It is a rich source of β-carotene and contains other vitamins, like thiamine, riboflavin, vitamin B-complex and minerals (Jabbar *et al.,*2013)[19]. The carrot is consumed in different forms as raw, juice, salads, cooked vegetable sweet dishes etc. Carrots provide great health benefits to the human body as they are good sources of carotenoids, bioactive compounds, vitamins and minerals (Qin *et al.,* 2005) [31]. Bioactive compounds present in the carrots are α- and β-carotene, phenolic acids and lycopene which are responsible for their antioxidant activity. Carrot contains approximately 86.00 per cent moisture, 10.60 g carbohydrates, 0.20 g fat, 1.20 g fiber, 1890 µg carotene, 0.04 g thiamine, 0.02 g riboflavin, 0.60 g niacin, 530.00 mg phosphorus, 1.10 g minerals, 3.00 mg vit C and 26.60 µg total phenolic content per 100 g (Gopalan *et al*., 2004) [15]. Due to its good flavor and nutrition, carrot is regarded as avery important vegetable owing to its various properties like anticancer, anti-anemic, antioxidant, sedative and healing which are directly related to human health (Shivhare*et al.,* 2009) [40]. Due tothe perishable and seasonal nature of carrots, it is not possible to make fresh carrots available throughout the year. Therefore, consumer demand has increased toward processed foods that have more natural flavour and colour with high nutritional quality and sufficient storage safe for distribution and consumption. This can be achieved by adopting suitable processing methods which inactivate micro-organisms as well as enzymes with little loss of pigments, flavor compounds, and vitamins (Dede *et al.,* 2007) [12].

Dehydrated carrots in the form of grating can be used in the preparation of *halwa*, discs made in to chips (Khan, 2012) [22]. Pre-treatment improvesthe nutritional, sensorial and functional properties of the dehydrated food without changing its integrity. It also improves the texture as well as stability of the pigment during dehydration and the storage of dehydrated product (Kumar and Kumar, 2011)[24]. Carrots are dehydrated in the form of slices, shreds, crushed, cubes and strips. High solids and freedom from woody fiber are desired qualities of carrots to be dehydrated. The low rehydration ratio, discoloration, and development of off-flavour are the commonly reported problems with dehydrated carrot products. Removal of biologically active water is the main task while preserving food (Sra *et al*., 2014) [42] by reducing the moisture contents to a level, that allows safe storage over an extended period of time with microbial safety. During microwave treatment, the generation of heat within tissue could create pressure, which ruptures the cell walls and increases the mass transfer of carotene into extraction solvent. As a result, the time required for microwave-assisted extraction of β-carotene from carrot can be reduced (Hiranvarachat*et al*., 2013) [18]. Microwave treatment also known to enhance juice recovery and decrease dehydration time. Beside, use of different preparation techniques also possess effect on yield and nutritional quality.Very limited literature is available on theeffect of preparation techniques, microwave pre-treatments and preservatives on quality of carrot powder during storage. Thus, the present investigation was carried out to study the effect of preparation, microwave and pressing on thequality of carrot powder.

2. MATERIALS AND METHODS

2.1 Raw materials: Fresh matured but tender, disease, and injury-free, orange-colored carrots (*var.*Chantney) selected and purchased from Morarji yard, APMC, Navsari. The carrots were cleaned and used for further processing into dehydrated powder.

2.2 Location: The experiment was conducted in the Department of Post Harvest Technology, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari-396450, Gujarat (India).

2.3 Experiment detail:A total of 18 treatments were used for dehydration of carrot into powder using combinations of different treatments *viz*. preparation techniques as Factor-1 ["Shredding" (T_1), "Crushing" (T_2) and "Slicing" (T_3)]; microwave pre-treatments as Factor-2 [Control (M_1), Microwave pre-treatment 450 w for 30 seconds (M_2) and microwave pre-treatment 450 w for 60 seconds (M_3)] and pressing as Factor-3 [without pressing- Control (P_1) and pressing for juice extraction (P_2)].

2.4 Sample Preparation and treatments: Good quality carrots of uniform size were selectedduring experimentation. Then carrots were thoroughly washed to remove any adhering dust and dirt particles. After washing, the carrots were cut from theend and top to remove undesirable portions with astainless steel (SS) knife. Then cut carrots were shredded / crushed / slices (2-3mm) with the help of ashredder/ crusher / slicer machines (Factor 1)as per experiment.The prepared shreds, crushed materials, and slices of carrots (Factor-1) were subjected to microwave pre-treatments (Factor-2). After microwave pre-treatments, the shreds, crushed materials, and slices were subjected to pressing (Factor-3) for single-strengthpressingby hydraulic pressfollowed by loading into amechanical dehydrator using three stage dehydration temperatures (75 ^oC for 2 hours, 65 ^oC for 2 hours and 60 ^oC for about 11-12 hours) till final moisture content of 5.50 ± 1% as reported by Raj *et al*. (2004) [32] for dehydration of onions. After dehydration, dried shreds, crushed materials and slices were ground into powder usinga lab scale mill-grinder. The prepared powder was packed in polypropylene bags of 400-gauge thickness and stored for 6 months at ambient temperature to evaluate the nutritional as well as sensory quality of developed products at every two month intervals. The principal steps used forthe dehydration of carrots into powder are illustrated in Fig.1.

Selection of carrots
↓
Washing
↓
Preparation techniques
↓
Pre-treatment
(As per treatments details)
↓
Dehydration (Three-stage dehydration temperatures of 75^{o}C for 2 hours, 65^{o}C for 2 hours and 60^{o}C till drying approx. 11-12 hours)
↓
Powder preparation and packaging (Polypropylene bag 400 gauge)

↓
Storage (ambient storage) and analysis

Fig 1: Principal steps used for dehydration of carrot into powder

2.5 Physico-chemical parameters

Physico-chemical parameters of fresh carrots used for dehydration (n=10) were recorded. The powder recovery was arrived atby recording the final weight of powder obtained after drying and the total weight of raw materials and expressed as recovery per cent. The moisture was estimated by drying the weighted samples in a hot air oven at 70±2°C to a constant weight (AOAC 1984)[7]. For estimation of β-carotene five-gram sample was crushed into 10-15 ml of acetone followed by addition of anhydrous sodium sulphate crystals. Supernatant was collected into beaker and procedure was repeated twice. Then sample were transferred into separating funnel. After this 10-15 ml petroleum ether was added, mixed thoroughly and make up the volume of 100 ml. Optical density was recorded at 452nm using petroleum ether as blank and contents were calculated by using the using the following formula (Ranganna, 1997) [35].

$$\beta\text{-carotene (mg /100 g)} = \frac{OD \times 13.9 \times 10000 \times 10}{\text{Weight of sample (g)} \times 560 \times 1000} \times 100$$

2.6 Sensory Evaluation

Sensory evaluation of carrot powder was conducted during storage to assess the consumer's acceptance for the products. The prepared samples of powder were evaluated for sensory qualities on based on overall acceptability on 9 Point Hedonic scale (9 mean Extremely liked and 1 extremely disliked) according to the method of Amerine *et al.* (1965) [4]. Sensory panelists (7-9 members) comprised of faculty members and PG students of Department of Post Harvest Technology, NAU, Navsari (Gujarat) were used for sensory analysis throughout the period of storage. Coded samples of products were served. Plain tap water was provided to the panelists for mouth rinsing in between the sensory evaluation.

2.7 Statistical Methodology

Experiment was carried out in Completely Randomized Design with factorial concept (FCRD). The data were collected on physico-chemical parameters of fresh carrot and expressed as mean value. The data on physico-chemical parameters of powder were statistical analyzedfollowing a completely randomized design as described by Panse and Shukhatme (1967) [30. The treatment differences were tested by 'F' test of significance on the basis of null hypothesis. The critical differences (C.D.) at 5 per cent level of probability were worked out to compare treatments mean for predicting significance among treatments.

3.RESULTS AND DISCUSSION

3.1Physico-Chemical Attributes of Fresh Carrots: The physico-chemical characteristics of fresh carrots which were used for the preparation of juice and powder are given in Table 1. The data on physical parameters of fresh carrots revealed the mean weight, peeling, and trimming losses of the carrots in the range of 75.45 g and 7.40 per cent having the orange-color of skin/ peel and flesh. The data on chemical parameters of carrots revealed mean moisture, TSS, acidity, reducing sugars, non-reducing sugars, total sugars, beta-carotene, proteins, crude fibre, ascorbic acid in the range of 9.53 ^{o}Brix, 0.12 %, 2.74 %, 4.15 %, 6.89 %, 38.65 mg/100g, 0.95 %, 1.80 % and 3.91mg/100g, respectively. Our results inthe present investigation for physico-chemical parameters of carrots are similar to earlier studies as reported by Gopalan *et al*. (2004) [15].The chemical constituents of carrot arereported to contain 86 % moisture with 9.55 °Brix TSS, 2.77 % reducing sugars, 6.92 % total sugars, 0.12 % acidity, 10.6 g carbohydrates, 0.2 g fat, 1.2 g fiber, 3965 micro g beta-carotene and 3 mg per 100 g vitamin C (Gopalan *et al*., 2004) [15]. Sharma *et al.* (2012) [39] also reported similar variations for moisture (86 to 88 %), carbohydrate (6 to 10.6 %), crude fiber (1.2 to 2.4 %), total sugars (5.6 %), beta-carotene (39.6 mg/ 100 g).

Table 1: Physico-chemical characteristics of fresh carrot used for dehydration

Parameters*	**Mean**
Weight of carrot (g)	75.45
Peeling and trimming loss (%)	7.40
Peel color, visual	Orange

Flesh color, visual	Orange
Moisture (%)	86.12
TSS(^{o}Brix)	9.53
Acidity (%)	0.12
Total Sugars (%)	6.89
Reducing sugars (%)	2.74
Non-reducing sugars (%)	4.15
Beta-carotene (mg/100g)	38.65
Proteins (%)	0.95
Crude fibre (%)	1.80

3.2QUALITY OF POWDER: As per thedehydration experiment treatment details, one factor was taken to study the effect of pressing along with control (without pressing) on the quality of the dehydrated carrot powder. The factor aimed to evaluate the feasibility of pressing for juice extraction, to utilize left over carrot pomace for dehydration and to evaluate dehydrated carrot powder based onphysico-chemical, sensory and microbial characteristics. Thus, the prepared dehydrated carrot powder was evaluated for physico-chemical, and sensory to study the effect of different treatments during six-month storage.

3.2.1Powder yield

The perusal of data on theeffect of different treatments on powder yield of carrot powder have been presented in Table 2.

3.2.1.1Effect of preparation techniques:Among different preparation techniques (T), the powder yield of carrot powder varied significantly between 9.09 and 12.38 %, with minimum powder yield (9.09 %) in carrot powder which was prepared by giving crushing treatment (T_2) and maximum powder yield (12.38 %) in slicing (T_3). The minimum powder yield of carrot which was prepared by giving crushing treatment might be attributed to higher juice recovery in carrot juice. Crushing of carrots resulted inimmediate release of the moisture and its soluble compounds upon pressing due to more disintegration of the cell structure. Wilczynski *et al*. (2019)[46] also reported ahigher yield (71.6 %) of apple juice of different varieties in screw type of juice extractor due to thecrushing action of fruit tissues as compared to basket press (61.9 %). Raj *et al*(2011)[34] reported yield of potato flour among different potato cultivars varied from 13.23 to 20.73 per cent, with themaximum yield in Kufri Chipsona-2 followed by Kufri Chipsona-1 (20.63 %) and Kufri Chandramukhi (18.53 %) and minimum in Kufri Jyoti followed by Kufri Badshah (14.70%). The increase in thedehydration ratio of the flour in blanching treatment might be attributed to leaching losses of the nutrients and solids.

3.2.1.2*Effect of microwave pre-treatment:*Data shows that among different microwave pre-treatments grand mean powder yield (M) of microwave pre-treated carrot powder varied significantly between 10.16 and 10.96 %, with minimum powder yield (10.16 %) in carrot powder pre-treated with microwave for 60 seconds (M_3) and maximum powder yield (10.96 %) in carrot powder prepared without microwave pre-treatment (M_1). The differences inpowder yield in carrot under different microwave pre-treatments might be due to the extraction efficacy of soluble compounds owing to variations in pre-treatment time. The exposure to microwave causes disintegration of the cell structure due to vibration of the water molecules and results in higher juice recovery upon pressing and lower powder yield because the juice itself contains soluble solids along with other micro-nutrients. Gerard and Roberts (2004)[14] reported that Fuji and McIntosh apple mashes heated to bulk temperatures of 60 $^{\circ}$C by a2450 MHz microwave oven at 1500 W increased juice yield when themash was treated before pressing. Rayman and Baysal (2011)[36]also reportedan increase incarrot juice yield of 9.7 % (50.90 to 55.84 %) juice yield due to applications of the electrical methods (electroplasmolysis + microwave). The juice yield was found to vary with the variation of voltage and time of EP application. These treatments affect the cell permeability and make the juice extraction process easier.Leeratanarak*et al.* (2006)[25] reported that blanching helps to increase the dehydration ratio of the product which represents the decrease in the yield of the dehydrated product. The decrease in yield of the flour in blanching treatment might be attributed to leaching losses of the nutrients and solids

3.2.1.3*Effect of pressing:*Further, it was observed that themean powder yield (P) of the carrot when dehydrated followed by pressing treatment varied significantly from 9.19 to 11.87 %, with minimum powder yield (9.19 %) in carrot powder when dehydrated followed by pressing treatment (P_2) and maximum powder yield (11.87%)in carrot powder when dehydrated without pressing treatment (P_1).

The minimum powder yield of thecarrot which was prepared for dehydration by giving pressing treatment might be attributed to thetransfer of soluble solids to carrot juice during theextraction process and thus decreasing the weight of soluble solids for dehydration. Wilczynski *et al.* (2019)[46]also reported ahigher yield (71.6 %) of apple juice of different varieties due to higher pressure in screw-type juice extractor as compared to basket press (61.9 %) leaving less pomace for dehydration.Leeratanarak*et al.* (2006)[25] reported that blanching helps to increase the dehydration ratio of the product which represents the decrease in the yield of the dehydrated product. The decrease in yield of the flour in blanching treatment might be attributed to leaching losses of the nutrients and solids.

3.2.1.4*Effect of treatment interactions:*The interaction of microwave and pressing treatments (MP) depicted variation in carrot powder yield from 8.64 to 12.16 %, witha minimum powder yield of 8.64 % in powder which was dehydrated by pressing the raw material followed by pre-treatment with microwave for 60 seconds (M_3P_2) and maximum powder yield (12.16 %) in powder which was dehydrated without pressing and microwave pre-treatment (M_1P_1). Interaction of preparation techniques and pressing technique (TP) depicted variation in carrot powder yield from 6.72 to 12.53 %, with aminimum powder yield of6.72 % in powder which was prepared by crushing technique (T_2P_2) and maximum powder yield 12.53 % in powder which was dehydrated by without pressing and microwave pre-treatment (T_3P_1). Interaction of preparation techniques, microwave and pressing techniques (TMP) depicted variation in carrot powder yield from 6.20 to 12.92 %, with aminimum powder yield of 6.72 % powder which was prepared by dehydrating crushed materials by giving microwave for 60 seconds followed by pressing treatment ($T_2M_3P_2$) and maximum powder yield of 12.92 % in powder which was prepared by dehydrating carrot slices without microwave and pressing pre-treatment ($T_3M_1P_1$). Interactions of TxM,TxP, MxP,andTxMxP were found to have significant effects.

3.2.2Dehydration rate

The perusal of data of theeffect of different treatments on thedehydration rate (g/min) of carrot powder during dehydration has been presented in Table 3.

3.2.2.1*Effect of preparation techniques:*Among different preparation techniques (T), the dehydration rate of carrot powder varied significantly between 6.89 and 8.28 (g/min), with minimum dehydration rate (6.89 g/min) in carrot powder which was prepared by giving crushing treatment (T_2) and maximum dehydration rate (8.28 g/min) in slicing (T_3). The minimum dehydration rate of thecarrot which was prepared by giving crushing treatment might be attributed to less moisture available in thecarrot pomace for drying after pressing because thepressing treatment causes higher yield of the juice and pomace remains with less moisture. Crushing of carrots followed by pressing resulted immediate release of the moisture due to more disintegration of the cell structure and thus less available moisture remained in thecarrot pomace for drying. Leeratanarak*et al.* (2006)[22] reported that blanching time had effect on the drying rates at all drying temperature in hot air drying. The samples prepared by blanching dried faster than the unblanched samples. The increase in thedrying rate of the flour in blanching treatment might be attributed to faster diffusion of the water out of the tissues. Hatamipour*et al.* (2007)[17] reported that anincrease inblanching time decreased thedrying rate. Dinrifo (2012)[13] recorded variations in thedrying rate of sweet potato slices when pre-treated with blanching at 100^{o}C and sulphitation with sodium metabisulphite. The pre-treatment reduces the resistance to moisture transport thereby increasing the drying rates. The drying of sweet potato slices exhibited higher drying rates for pre-treated samples than for untreated samples, especially at higher temperatures.

3.2.2.2*Effect of microwave pre-treatment:*Data shows that among different microwave pre-treatments grand mean dehydration rate (M) of microwave pre-treated carrot powder varied significantly between 7.56 and 7.83 (g/min), with maximum dehydration rate (7.83 g/min) in carrot powder prepared pre-treated with microwave for 60 seconds (M_3) and minimum dehydration rate (7.56 g/min) in carrot powder pre-treated with microwave for 30 seconds (M_2). The differences in drying rate during carrot dehydration under different microwave pre-treatments might be due to the extraction efficacy of soluble compounds owing to variation in pre-treatment time. The exposure to microwave causes disintegration of the cell structure due to vibration of the water molecules and results from easy water removal during dehydration. Sabry *et al.*(2016)[37] reported that microwave treatment of carrot slices (2-3 MM) with 360 watts for 6 min can reduce weight loss from 81.75 % moisture content to 52.32 % on dry weight basis witha slight reduction of drying period as compared to other treatments. Kaur and Singh (2014) [21]reported that drying of beet slices at high air temperature (75°C) followed by high microwave power (1080 W) witnessed increased drying rates and substantial shortening of the drying time. Andres *et al.* (2004)[6] reported that when drying of apple with acombined air microwave system, the drying rate curve could be divided into four periods limited by four critical points resulting faster drying.

3.2.2.3*Effect of pressing:*Further, it was observed that mean Dehydration rate (P) of the carrot powder when dehydrated followed by pressing treatment varied significantly from 6.82 to 8.50 (g/min), with minimum dehydration rate (6.82 g/min) in carrot powder when dehydrated followed by pressing treatment (P_2) and maximum dehydration rate (8.50 g/min) in carrot powder when dehydrated without pressing treatment (P_1). The minimum dehydration rate of thecarrot which was prepared by giving pressing treatment might be attributed to less moisture available in thecarrot pomace for drying after pressing because pressing treatment causes higher juice extraction and pomace remained with less moisture. Pressing of prepared carrots resulted inimmediate release of the moisture due to more disintegration of the cell structure.

3.2.2.4*Effect of treatment interactions:*Interaction of preparation techniques, microwave and pressing techniques (TMP) depicted variation in carrot powder dehydration rate from 5.00 to 9.08 g/min , with minimuma dehydration rate of 5.00 g/min in powder which was prepared by dehydrating crushed materials by giving microwave for 30 seconds followed by pressing treatment ($T_2M_2P_2$) and maximum dehydration rate of 9.08 g/min in powder which was prepared by dehydrating shredded materials by giving microwave for 60 seconds without pressing pre-treatment($T_1M_3P_1$).Interactions of TxM,TxP, MxP,andTxMxP were found to have significant effect. However, interactions of MxP were found to have anon-significant effects. Abano *et al.* (2011)[1] reported improvement in drying rates of the garlic slices followed bya drying temperature of45 ^{o}C compared to control dried samples that were harder than all the pre-treated dried samples. Wu *et al.* (2013) reported higher drying rates and greater effective diffusivities under catalytic infrared (CIR) than hot air (HA) heating before the moisture contents reached the range of 16 to 30% on a wet basis (w.b.).

3.2.3Rehydration ratio

The perusal of data on theeffect of different treatments on therehydration ratio of carrot powder has been presented in Table 4.

3.2.3.1*Effect of preparation techniques:*Among different preparation techniques (T), the rehydration ratio of carrot powder varied significantly between 4.73 and 6.55, witha maximum rehydration ratioof 6.55 in carrot powder which was prepared by giving crushing treatment (T_2) and aminimum rehydration ratio of4.73 in slicing (T_3). Loesecke and Willard (1955)[26] reported that the rehydration characteristics of the dehydrated food are influenced by processing conditions as well as thesample composition used in dehydration.

3.2.3.2*Effect of microwave pre-treatment:*Data shows that among different microwave pre-treatments grand mean rehydration ratio (M) of microwave-pretreated carrot powder varied significantly between 5.54 and 6.08, with maximum rehydration ratio (6.08) in carrot powder pre-treated with microwave for 60 seconds (M_3) and minimum rehydration ratio (5.54) in carrot powder prepared without microwave pre-treatment for (M_1). Pandit (2015) reported similar variations inthe rehydration ratio (2.20 to 2.94) of dehydrated elephant foot yam due to variation in microwave exposure time and power. This can be explained by the high internal pressure produced by microwave heating which can cause thestructure of carrot slices to expand and puff during dehydration and thus cause high rehydration ratio. Similar results were obtained by several researchers in other foods viz. kiwi fruits (Maskan, 2001)[28] and onions (Kalse*et al*., 2012)[18]. Kaur and Singh (2014)[21] reported that therehydration characteristics of beetroot improved for samples dehydrated at 55°C air temperature followed by high microwave power (1080 W) which can be help in thereduction of shrinkage. Zielinska *et al*. (2018)[47] also reported anincrease in therehydration ratio due to microwave treatment in dried cranberries.

3.2.3.3*Effect of pressing:*Further, it was observed that mean rehydration ratio (P) of the carrot powder when dehydrated followed by pressing treatment varied significantly from 5.49 to 6.06, with maximum rehydration ratio (6.06) in carrot powder when dehydrated by pressing treatment (P_2) and minimum rehydration ratio (5.49) in carrot powder when dehydrated without pressing treatment (P_1). Loesecke and Willard (1955)[26] reported that the rehydration characteristics of the dehydrated food are influenced by processing conditions as well as thesample composition used in dehydration.

3.2.3.4*Effect of treatment interactions:*The interaction of preparation techniques and pressing technique (TP) depicted variation in carrot powder rehydration ratio from 4.59 to 6.72, with maximum rehydration ratio of 6.72 in powder which was prepared by crushing technique followed by pressing treatment (T_2P_2) and minimum rehydration ratio of 4.59 in powder which was dehydrated by slicing technique without pressing treatment (T_3P_1).

3.2.4Moisture

The perusal of data on theeffect of different treatments onthe moisture content of carrot powder during six months storage period is presented in Table 5.

3.2.4.1*Effect of preparation techniques:*Among different preparation techniques (T), the moisture of carrot powder varied significantly between 5.91 and 7.53 %, with minimum moisture in carrot powder which was prepared by giving crushing treatment (5.97 %) and maximum moisture in slicing (7.53%). The lower moisture in carrot powder prepared using crushing treatment followed by pressing might be attributed to therelease of most of thewater from the tissue due to pressing and higher thedehydration rate for left over carrot pomace which requires less dehydration time for drying. Earlier studies also observed similar results for moisture in treatments that requires less dehydration time for okra, cauliflower, and onions (Anon., 2017)[5]. Lower moisture and water activity were also observed in food products which requires less dehydration time as reported by Vaghashiyaet al (2016)[45] in dehydrated Aloe vera gel and Zinzala (2019)[48] for bael candy. Alam *et al.* (2013)[2] variations in water activity in dried carrot pomace powder prepared using different pre-treatments i.e., water blanching (WB), steam blanching (SB), citric acid blanching (CB), potassium metabi sulphate (KMS) dipping after blanching (WBS) and reported highest water activity (0.558) in untreated samples and lowest (0.379) value in WBS pre-treated samples.

3.2.4.2*Effect of microwave pre-treatment:*Data shows that among different microwave pre-treatments grand mean moisture (M) of microwave- pretreated carrot powder varied significantly between 6.32 and 7.13 %, with minimum moisture (6.32 %) in carrot powder pre-treated with microwave for 60 seconds (M_3) and maximum moisture (7.13 %) in carrot powder prepared without microwave pre-treatment (M_1). Zielinska *et al.* (2018)[47] reported lower moisture content in microwave pre-treated samples compared tothecontrol. Higher levels of moisture could lead to microbial spoilage and subsequent deterioration in quality. Sabry *et al*. (2016)[37] reported variations inthe moisture content of the dried carrot powder due to microwave treatments. Water loss during microwave pre-treatments increased with anincrease in microwave power and time.

3.2.4.3*Effect of pressing:*Further, it was observed that themean moisture (P) of the carrot powder when dehydrated followed by pressing treatment varied significantly from 6.15 to 7.27 %, with minimum moisture (6.15 %) in carrot powder when dehydrated followed by pressing treatment (P_2) and maximum moisture (7.27 %) in carrot powder when dehydrated without pressing treatment (P_1). The lower moisture in carrot powder prepared pressing treatment might be attributed to therelease of most of thewater from the tissue due to pressing and higher thedehydration rate for left over carrot pomace which requires dehydration time for drying. Earlier studies also observed similar results for moisture in treatments that requires less dehydration time for okra, cauliflower and onions (Anon., 2017). Lower moisture and water activity were also observed in food products which require less dehydration time as reported by Vaghashiya (2016)[45] in dehydrated *Aloe vera* gel and Zinzala (2019)[48] for bael candy.

3.2.4.4*Effect of storage:*Storage of the carrot powder for six months resulted significant increase in moisture (S) from aninitial value of 5.35to 7.80 %. Chukwu and Lawal (2015)[11] reported that themoisture content of sweet potato flour increased from 4.32 to 5.36 % within thefirst week of storage but decreased to 5.27 % at the end of two weeks storage period and attributed this to loss of moisture during storage. Alinnor and Akalezi (2014)[3] reported that dehydrated flour can be stored successfully during storage if the moisture content of flour is below 8.3 %. Maneepun*et al.* (1992)[27] reported increased the moisture content of sweet potato flour upto 8 % in four and a half months. Raj *et al.* (2011)[34] registered amoisture content increase in potato flour of different cultivars from 3.07 to 4.78 per cent during storage period of six months. Sra *et al.* (2014)[42] reported that themoisture content of dried carrot slices increased from 6.3 to 8.4 %. Abano *et al.* (2011)[1] reported that KMS pre-treated samples performed better in terms of moisture diffusivity at all drying temperatures. Tiwari and Sarkar (2018)[44] reported 87.02 % moisture content in fresh carrot and 4.2 % in dried carrot powder. Ramachandra and Rao (2011) also reporteda gradual increase in themoisture content of dehumidified air-dried *Aloe vera* gel powder during accelerated storage. Sharada (2013)[37] also reported agradual increase in themoisture content of foam-mat-dried guava and banana powder during storage. The increase in moisture during thestorage period of six months might be attributed toan increase in relative humidity in the atmosphere due tothe continuations of rainy monsoons and due to thepermeability of packaging materials to water vapours. A similar reason for other processed products had been reported by Raj *et al.* (2006)[33] for dehydrated onion rings.

3.2.4.5*Effect of treatment interactions:*Interaction of preparation techniques, microwave pre-treatment, pressing and storage (TMPS) depicted variation in themoisture of carrot powder from 4.15 to 10.41 %, with minimum increase of moisture from 4.15 to 5.85 % ($T_2M_3P_2S_1$ to $T_2M_3P_2S_4$) in powder which was prepared by dehydrating crushed materials by giving microwave for 60 seconds followed by pressing and maximum increase of moisture from 7.30 to 10.41% ($T_3M_1P_1S_1$ to $T_3M_1P_1S_4$) in carrot powder which was prepared by dehydrating carrot slices without microwave and pressing pre-treatment. Interactions of TxM, TxP, MxP, TxMxP, TxS, MxS, PxS, TxMxS, TxPxS, MxPxS, andTxMxPxS were found to have significant effect.

3.2.5β-carotene

The perusal of data on theeffect of different treatments on beta carotene of carrot powder during six months storage period has been presented in Table 6.

3.2.5.1*Effect of preparation techniques:*Among different preparation techniques (T), the beta carotene of carrot powder varied significantly between 105.91 and 124.72 mg/100g, with minimum beta carotene (105.91 mg/100g) in carrot powder which was prepared by giving crushing treatment (T_2) and maximum beta carotene (124.72 mg/100g) in slicing (T_3). The food commodity having asmaller size possessesa large surface area andcan release most of the soluble solids along with water. The crushing treatment observed minimum beta carotene in carrot powder which might be attributed to therelease of large amounts ofsoluble solids along with water in the form of juice and thus less beta carotene remained in the dried carrot powder due to pressing treatment.Tadesse *et al.* (2015)[43] reported the highest β-carotene (74.97 ppm) for thecombination of the samples blanched at 55°C and soaked in 5% salt solutions. Alam *et al.* (2013)[2]reported themaximum β-carotene (633.57 µg 100 g^{-1}) value for citric acid blanching (CB) pre-treated samples of carrot pomace followed by solar dried and the minimum value (186.01 µg 100 g^{-1}) for CB pre-treated samples followed by sun-dried.

3.2.5.2*Effect of microwave pre-treatment:*Data shows that among different microwave pre-treatments grand mean beta carotene (M) of microwave-pretreated carrot powder varied significantly between 112.32 and 117.55 mg/100g, with maximum beta carotene (117.55 mg/100g) in carrot powder pre-treated with microwave for 60 seconds (M_3) and minimum beta carotene (112.32 mg/100g) in carrot powder prepared without microwave pre-treatment (M_1). Sabry *et al*. (2016)[37] reported similar variations in beta carotene content of the dried carrot powder due to microwave treatments and higher beta carotene content was observed in the samples treated with microwave as compared to without microwave. Cui *et al*. (2004) also reported higher beta carotene content in dried carrot slices and Chinese chive leaves when given microwave treatment. Arjmandi*et al*. (2016)[8] reported anincrease in phenolics and lycopene contents in smoothie due to microwave treatment.

3.2.5.3*Effect of pressing:*Further, it was observed that themean beta carotene (P) of the carrot powder when dehydrated followed by pressing treatment varied significantly from 100.47 to 128.73 mg/100g, with minimum beta carotene 100.47 mg/100 g in carrot powder when dehydrated followed by pressing treatment (P_2) and maximum beta carotene 128.73 mg/100g in carrot powder when dehydrated without pressing treatment (P_1). The food commodity having smaller size possessa large surface area can release most of the soluble solids along with water due to pressing. The pressing treatment observed minimum beta carotene in carrot powder which might be attributed tothe release of large amounts of soluble solids along with water in the form of juice and thus less beta carotene remained in the dried carrot powder due tothe pressing treatment.

3.2.5.4*Effect of storage:*Storage of the carrot powder for six months resulted significant decrease in beta carotene (S) from aninitial value of 157.29to 59.53 mg/100g. Hal (2007)[16] reported that during storage, auto-oxidation of carotenoids may take place, leading to a loss of color and an undesirable decline in beta-carotene value. The stability of beta-carotene proved to be strongly and adversely affected by storage temperature and light. Chaturvedi *et al.*(2013)[10]reported that carotenoid content decreased during storage from 59.8 per cent to 52 per cent of β-carotene after six months of storage.Sra*et al.* (2014)[42]reported adecrease in the β-carotene content from 69.4 to 49.2 mg/100 g during storage. Carrot slices pre-treated with 6% KMS and packed in AFL pouches were found to retain thehighest carotene content. Singh *et al.* (2013)[41] reported that the pressure-cooking treatment utilized for the preparation of carrot powder and grits revealed that carrot powder had higher β-carotene levels (36.94 mg/100 g) than carrot grits (33.48 mg/100 g) which further showed a gradual loss of β-carotene during storage in all the packaging materials but higher β-carotene content reported to be retained in the aluminium laminated pack and can be stored safely up to 6 months at room temperature. A similar decrease in ß-carotene content (S) from aninitial value of 17.53 mg/100g to 9.84 mg/100g wasobserved during six months ofstorage of the sweet potato flour by Ashuqullah (2017)[9].

3.2.5.5*Effect of treatment interactions:*Interaction of preparation techniques, microwave pre-treatment, pressing and storage (TMPS) depicted variation in beta carotene of carrot powder from 42.16 to 177.28 (mg/100g), with aminimum decrease of beta carotene from 144.90 to 54.80 mg/100g ($T_2M_3P_2S_1$ to $T_2M_3P_2S_4$) in powder which was prepared by dehydrating crushed materials by giving microwave for 60 seconds followed by pressing and maximum decrease of beta-carotene from 171.87 to 50.55 mg/100g ($T_3M_1P_1S_1$ to $T_3M_1P_1S_4$) in carrot powder which was prepared by dehydrating carrot slices without microwave and pressing pre-treatment. Interactions of TxM,TxP, MxP, TxMxP, TxS, MxS, PxS, TxMxS, TxPxS, MxPxS, andTxMxPxS were found to have significant effect.

3.2.6Overall acceptability

The perusal of data pertaining onthe different treatments on theoverall acceptability of carrot powder during six months storage period has been presented in Table 7.

3.2.6.1*Effect of preparation techniques:*Among different preparation techniques (T), the overall acceptability (9-point Hedonic scale) of carrot powder varied significantly between 6.25 and 7.56, with maximum overall acceptability (7.56) in carrot powder which was prepared by giving crushing treatment (T_2) and minimum overall acceptability (6.25) in shredding (T_1). Nath *et al*. (2012) reported variations in taste in ginger candy when prepared using different slice thicknesses (5-25 mm) and blanched for different times (10-30 min).The higher overall acceptability in carrot powder prepared using crushing treatment followed by pressing might be attributed toa higher dehydration rate and requirement of less dehydration time for drying. Earlier studies also observed similar results for overall acceptability in treatments that requires less dehydration time for okra, cauliflower, and onions (Anon. 2017)[5]. Higher overall acceptability was also observed in food products that requires less dehydration time as reported by Zinzala (2019)[48] forbael candy. The higher overall acceptability scorein carrot powder which was prepared by giving crushing treatment attributed to theretention of more colour, taste, flavour, and texture in dehydrated powder. Chaturvedi *et al.* (2013)[10] reported variations in overall acceptability in dehydrated carrots using different pre-treatments and drying techniques i.e., tray dried (TD), tray dried and radiated (TDR), Infra-red dried (IR), Infra-red dried and radiated (IRR). They reported amaximum overall acceptability value (4.93) in IRR andthe lowest value (4.17) in TD. Kukanoor*et al.* (2014)[23]reportedthehighest value (4.46) of texture and overall acceptability (4.55) in the dehydrated carrot slices blanched for 2 minutes and steeped in 300 brix syrup followed by 6% salt for 2 hours. Whereas, Raj et al (2011)[34] reportedsignificant variations in theoverall acceptability of the potato flours of the varieties due to variations in the NEB, sensory color, texture score, and these scores of the product directly correlated with the overall acceptability of the product.

3.2.6.2*Effect of microwave pre-treatment:*Data shows that among different microwave pre-treatments grand mean overall acceptability (M) of microwave-pretreated carrot powder varied significantly between 6.56 and 7.04, with maximum overall acceptability (7.04) in carrot powder pre-treated with microwave for 60 seconds (M_3) and minimum overall acceptability (6.56) in carrot powder prepared without microwave pre-treatment (M_1). Pandit (2015)[29] reported similar variations in theoverall acceptability of dehydrated elephant foot yam due to variations in microwave exposure time and power. This can be explained by the high internal pressure produced by microwave heating which can cause thestructure of carrot slices to expand and puff during dehydration which provides a more porous structure in the food product. Zielinska *et al.* (2018)[47] alsoanreported improvement in color due to microwave treatment in dried cranberries.

3.2.6.3*Effect of pressing:*Further, it was observed that themean overall acceptability (P) of the carrot powder when dehydrated followed by pressing treatment varied significantly from 6.59 to 7.00, with maximum overall acceptability (7.00) in carrot powder when dehydrated followed by pressing treatment (P_2) and minimum overall acceptability (6.59) in carrot powder when dehydrated without pressing treatment (P_1). The higher overall acceptability in carrot powder prepared using pressing treatment might be attributed to ahigher dehydration rate and requirement of less dehydration time for drying.

3.2.6.4*Effect of storage:*Storage of the carrot powder for six months resulted significant decrease in overall acceptability (S) from aninitial value of 7.31to 6.09. The decrease in overall acceptability score might be attributed to anincrease in moisture content, water activity and NEB in dehydrated carrot powder during storage. Sra *et al.* (2014)[42] reportedadecrease in theoverall acceptability ofdried carrot slices from 8.2 to 7.1 during six months storage period. Chaturvedi *et al.* (2013)[10] reportedadecrease in theoverall acceptability of dehydrated carrots during six months of storage. Pandit (2015)[29] reported similar variations in theoverall acceptability of dehydrated elephant foot yam due to variations in microwave exposure time and power during six months ofstorage. This can be explained by the high internal pressure produced by microwave heating which can cause thestructure of carrot slices to expand and puff during dehydration which provides a more porous structure in the food product.

3.2.6.5*Effect of treatment interactions:*Interaction of preparation techniques, microwave pre-treatment, pressing and storage (TMPS) depicted variation in overall acceptability of carrot powder from 4.81 to 8.65, with minimum adecrease of overall acceptability from 8.65 to 7.78 ($T_2M_3P_2S_1$ to $T_2M_3P_2S_4$) in powder which was prepared by dehydrating crushed materials by giving microwave for 60 seconds followed by pressing and maximum decrease of overall acceptability from 6.95 to 5.15 ($T_3M_1P_1S_1$ to $T_3M_1P_1S_4$) in carrot powder which was prepared by dehydrating carrot slices without microwave and pressing pre-treatment. Interactions of TxM,TxP, MxP, TxMxP, TxS, MxS, PxS, TxMxS, TxPxS, MxPxS, andTxMxPxS were found to have significant effect.

4.CONCLUSION

It can be concluded that carrot powder prepared by dehydrating crushed materials by giving microwave pre-treatment for 60 seconds followed by pressing (after single-strengthjuice extraction) can remain safe for six months in PP bags (400 gauge) with minimum changes in chemical and sensory quality. This technique possessestheadditional benefit of preparing two products simultaneously i.e. juice and powder instead of theproduct either alone. Thus, the developed technologies can commercially be explored by thefood processing industry. Therefore, profitable utilization of carrots grown in India by processing can ensure better returns to the growers, processors and consumers.

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Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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Table 2: Effect of preparation, microwave, and pressing on the dehydrated powder yield of carrot (10 kg tray load) during preparation of powder

Storage Intervals(S)	Preparation techniques (T)	Pressing (P)								Grand Mean (T)
		P_1: Without pressing - (Control)				P_2: Pressing				
		Microwave pre-treatment (M)				Microwave pre-treatment (M)				
		M_1:control	M_2: 30 S	M_3: 60 S	**Mean**	M_1:control	M_2:30 S	M_3:60 S	**Mean**	
Powder yield (%)	T_1: Shredding	11.97	11.43	11.51	**11.64**	9.47	8.60	7.80	**8.62**	10.13
	T_2: Crushing	11.58	11.41	11.38	**11.46**	7.26	6.70	6.20	**6.72**	9.09
	T_3: Slicing	12.92	12.51	12.16	**12.53**	12.53	12.23	11.93	**12.23**	12.38
	Mean (M, P of S_1)	**12.16**	**11.78**	**11.68**	**11.87**	**9.75**	**9.18**	**8.64**	**9.19**	
Grand Mean		**10.96**	**10.48**	**10.16**						
			S.Em. ±	**$CD_{0.05}$**		**S.Em. ±**	**$CD_{0.05}$**			
		T	0.042	0.121	**T_XP**	0.060	0.171			
		M	0.042	0.121	**MxP**	0.060	0.171			
		P	0.034	0.099	**T_XM_XP**	0.103	0.297			
		T_XM	0.073	0.210						
		CV%	1.70							

Table 3: Effect of preparation, microwave, and pressingon the dehydration rate of carrot (10 kg tray load) during preparation of powder

Storage Intervals(S)	Preparation techniques (T)	Pressing (P)								
		P_1: Without pressing - (Control)				P_2: Pressing				Grand Mean (T)
		Microwave pre-treatment (M)				Microwave pre-treatment (M)				
		M_1: control	M_2: 30 S	M_3: 60 S	**Mean**	M_1: control	M_2:30 S	M_3:60 S	**Mean**	
Dehydration rate (g/min)	T_1: Shredding	8.88	8.97	9.08	**8.98**	7.04	6.76	6.15	**6.65**	7.81
	T_2: Crushing	8.38	8.55	8.62	**8.52**	5.24	5.00	5.54	**5.26**	6.89
	T_3: Slicing	7.97	8.02	8.07	**8.02**	8.04	8.08	9.49	**8.54**	8.28
	Mean (M, P of S_1)	**8.41**	**8.51**	**8.59**	**8.50**	**6.77**	**6.61**	**7.06**	**6.82**	
Grand Mean		**7.59**	**7.56**	**7.83**						
			S.Em. ±	**$CD_{0.05}$**		**S.Em. ±**	**$CD_{0.05}$**			
		T	0.060	0.172	**TxP**	0.085	0.243			
		M	0.060	0.172	**MxP**	0.085	NS			
		P	0.049	0.140	**TxMxP**	0.147	0.421			
		T_X M	0.104	0.298						
		CV %	3.32							

Table 4: Effect of preparation, microwave, and pressingon the rehydration ratio of carrot of powder

Storage Intervals (S)	Preparation techniques (T)	Pressing (P)								
		P_1: Without pressing - (Control)				P_2: Pressing				Grand Mean (T)
		Microwave pre-treatment (M)				Microwave pre-treatment (M)				
		M_1:control	M_2: 30 S	M_3: 60 S	Mean	M_1:control	M_2:30 S	M_3:60 S	Mean	
Rehydration ratio	**T_1:** Shredding	5.31	5.42	5.74	**5.49**	6.27	6.58	6.98	**6.61**	6.05
	T_2: Crushing	6.12	6.33	6.7	**6.38**	6.48	6.58	7.11	**6.72**	6.55
	T_3: Slicing	4.39	4.55	4.84	**4.59**	4.65	4.81	5.12	**4.86**	4.73
	Mean (M, P of S_1)	**5.27**	**5.43**	**5.76**	**5.49**	**5.80**	**5.99**	**6.40**	**6.06**	
Grand Mean		**5.54**	**5.71**	**6.08**						
			S.Em. ±	**$CD_{0.05}$**		**S.Em. ±**	**$CD_{0.05}$**			
		T	0.035	0.100	**TxP**	0.049	0.141			
		M	0.035	0.100	**MxP**	0.049	NS			
		P	0.029	0.082	**TxMxP**	0.086	NS			
		TxM	0.060	NS						
		CV%	2.56							

Table 5: Effect of preparation, microwave, and pressingon the moisture content (%) of carrot powder during storage

Storage Intervals(S)	Preparation techniques (T)	Pressing (P)									
		P_1: Without pressing - (Control)				P_2: Pressing				Grand Mean (S, TS)	Grand Mean (T)
		Microwave pre-treatment (M)				Microwave pre-treatment (M)					
		M_1:control	M_2: 30 S	M_3: 60 S	Mean (P_1, S)	M_1:control	M_2: 30 S	M_3: 60 S	Mean (P_2, S)		
S_1: Initial	T_1: Shredding	5.98	5.82	5.46	5.75	4.97	4.65	4.44	4.69	5.22	**6.69**
	T_2: Crushing	5.63	5.52	5.45	5.53	4.53	4.42	4.15	4.37	4.95	**5.91**
	T_3: Slicing	7.30	6.24	5.71	6.42	5.82	5.35	4.85	5.34	5.88	**7.53**
	Mean (MP of S_1)	**6.30**	**5.86**	**5.54**	**5.90**	**5.11**	**4.81**	**4.48**	**4.80**	**5.35**	
S_2:2 Months	T_1: Shredding	7.62	7.46	7.10	7.39	6.61	6.04	5.94	6.20	6.80	
	T_2: Crushing	6.27	6.16	6.09	6.17	5.67	5.36	5.19	5.41	5.79	
	T_3: Slicing	8.94	7.88	7.35	8.06	7.46	6.99	6.49	6.98	7.52	
	Mean (MP of S_2)	**7.61**	**7.17**	**6.85**	**7.21**	**6.58**	**6.13**	**5.87**	**6.19**	**6.70**	
S_3:4 months	T_1: Shredding	7.86	7.70	7.34	7.63	6.85	6.28	6.18	6.44	7.04	
	T_2: Crushing	6.51	6.40	6.33	6.41	5.71	5.57	5.33	5.54	5.98	
	T_3: Slicing	9.18	8.12	7.59	8.30	8.70	7.23	6.73	7.55	7.93	
	Mean (MP of S_3)	**7.85**	**7.41**	**7.09**	**7.45**	**7.09**	**6.36**	**6.08**	**6.51**	**6.98**	
S_4:6 months	T_1: Shredding	8.80	8.23	7.93	8.32	7.22	7.13	6.88	7.08	7.70	
	T_2: Crushing	7.85	7.78	7.63	7.75	6.27	6.12	5.86	6.08	6.92	
	T_3: Slicing	10.41	9.65	8.27	9.44	8.88	8.18	7.34	8.13	8.79	
	Mean (MP of S_4)	**9.02**	**8.55**	**7.94**	**8.51**	**7.46**	**7.14**	**6.69**	**7.10**	**7.80**	
Grand Mean (P)		**7.70**	**7.25**	**6.85**	**7.27**	**6.56**	**6.11**	**5.78**	**6.15**		
Grand Mean (M)		**7.13**	**6.68**	**6.32**							

	S.Em. ±	$CD_{0.05}$		S.Em. ±	$CD_{0.05}$		S.Em. ±	$CD_{0.05}$		S.Em. ±	$CD_{0.05}$
T	0.021	0.061	**T_XP**	0.030	0.086	**S**	0.025	0.071	**TxMxS**	0.076	0.213
M	0.021	0.061	**MxP**	0.030	0.086	**TxS**	0.044	0.123	**TxPxS**	0.062	0.174
P	0.017	0.049	**TxMxP**	0.052	0.148	**MxS**	0.044	0.123	**MxPxS**	0.062	0.174
T_XM	0.037	0.105				**PxS**	0.036	0.100	**TxMxPxS**	0.107	0.301
CV %	2.67					**CV %**	2.77				

Table 6: Effect of preparation, microwave, and pressingon the β- carotene (mg/100g) of carrot powder during storage

Storage Intervals(S)	Preparation techniques (T)	Pressing (P)									
		P_1: Without pressing - (Control)				**P_2: Pressing**				**Grand Mean (S, TS)**	**Grand Mean (T)**
		Microwave pre-treatment (M)				**Microwave pre-treatment (M)**					
		$M_{1:}$control	**$M_{2:}$ 30 S**	$M_{3:}$ 60 S	**Mean (P_1, S)**	**$M_{1:}$control**	**$M_{2:}$ 30 S**	**$M_{3:}$ 60 S**	**Mean (P_2, S)**		
S_1: Initial	**T_1**: Shredding	175.95	177.43	178.04	177.14	139.18	133.52	120.67	131.12	154.13	**118.63**
	T_2: Crushing	177.28	178.45	180.13	178.62	111.13	104.81	114.90	110.28	144.45	**105.91**
	T_3: Slicing	171.87	170.44	178.40	173.57	171.11	171.11	176.82	173.01	173.29	**124.72**
	Mean (MP of S_1)	**175.03**	**175.44**	**178.86**	**176.44**	**140.47**	**136.48**	**137.46**	**138.14**	**157.29**	
S_2:2 Months	**T_1**: Shredding	154.33	155.86	156.47	155.55	114.09	117.25	110.03	113.79	134.67	
	T_2: Crushing	155.70	156.88	158.56	157.05	80.61	92.11	101.13	91.28	124.17	
	T_3: Slicing	150.30	148.87	156.77	151.98	149.48	148.41	155.24	151.04	151.51	
	Mean (MP of S_2)	**153.44**	**153.87**	**157.27**	**154.86**	**114.73**	**119.26**	**122.13**	**118.71**	**136.78**	
S_3:4 months	**T_1**: Shredding	116.48	117.96	118.63	117.69	88.16	89.74	95.38	91.09	104.39	
	T_2: Crushing	117.81	118.98	120.72	119.17	70.85	72.87	77.01	73.58	96.37	
	T_3: Slicing	112.40	110.98	118.93	114.10	111.64	110.52	117.40	113.19	113.65	
	Mean (MP of S_3)	**115.56**	**115.97**	**119.43**	**116.99**	**90.22**	**91.04**	**96.60**	**92.62**	**104.80**	
S_4:6 months	**T_1**: Shredding	67.58	69.05	69.72	68.78	42.45	52.97	55.23	50.22	59.50	
	T_2: Crushing	68.90	70.07	71.81	70.26	44.20	42.16	54.80	47.05	58.66	
	T_3: Slicing	50.55	62.12	70.02	60.90	53.73	61.61	64.49	59.94	60.42	
	Mean (MP of S_4)	**62.34**	**67.08**	**70.52**	**66.65**	**46.79**	**52.25**	**58.17**	**52.40**	**59.53**	
Grand Mean (P)		**126.60**	**128.09**	**131.52**	**128.73**	**98.05**	**99.76**	**103.59**	**100.47**		
Grand Mean (M)		**112.32**	**113.92**	**117.55**							

	S.Em. ±	**$CD_{0.05}$**		**S.Em. ±**	**$CD_{0.05}$**		**S.Em. ±**	**$CD_{0.05}$**		**S.Em. ±**	**$CD_{0.05}$**
T	0.405	1.161	**T_XP**	0.572	1.641	**S**	0.512	1.436	**TxMxS**	1.537	4.309
M	0.405	1.161	**MxP**	0.572	1.641	**TxS**	0.887	2.488	**TxPxS**	1.255	3.518
P	0.330	0.947	**TxMxP**	0.991	2.842	**MxS**	0.887	2.488	**MxPxS**	1.255	3.518
T_XM	0.171	0.490				**PxS**	0.725	2.031	**TxMxPxS**	2.174	6.094
CV %	3.02					**CV %**	3.31				

Table 7: Effect of preparation, microwave, and pressingon the sensory overall acceptability (9-point Hedonic scale) of carrot powder during storage

Storage Intervals(S)	Preparation techniques (T)	Pressing (P)									
		P_1: Without pressing - (Control)				P_2: Pressing				Grand Mean (S, TS)	Grand Mean (T)
		Microwave pre-treatment (M)				Microwave pre-treatment (M)					
		M_1: control	M_2: 30 S	M_3: 60 S	Mean (P_1, S)	M_1: control	M_2: 30 S	M_3: 60 S	Mean (P_2, S)		
S_1: Initial	**T_1**: Shredding	6.20	6.75	6.85	6.60	6.88	6.75	7.00	6.88	6.74	**6.25**
	T_2: Crushing	7.30	7.95	7.95	7.73	8.15	8.35	8.65	8.38	8.06	**7.56**
	T_3: Slicing	6.95	7.00	7.18	7.04	7.10	7.10	7.40	7.20	7.12	**6.59**
	Mean (MP of S_1)	**6.82**	**7.23**	**7.33**	**7.13**	**7.38**	**7.40**	**7.68**	**7.49**	**7.31**	
S_2:2 Months	**T_1**: Shredding	5.85	6.40	6.75	6.33	6.70	6.40	6.65	6.58	6.46	
	T_2: Crushing	6.95	7.60	7.70	7.42	7.80	8.00	8.25	8.02	7.72	
	T_3: Slicing	6.70	6.85	6.90	6.82	6.60	6.75	7.20	6.85	6.83	
	Mean (MP of S_2)	**6.50**	**6.95**	**7.12**	**6.86**	**7.03**	**7.05**	**7.37**	**7.15**	**7.00**	
S_3:4 months	**T_1**: Shredding	5.58	6.13	6.48	6.06	6.93	6.13	6.38	6.48	6.27	
	T_2: Crushing	6.68	7.33	7.58	7.19	7.53	7.73	8.03	7.76	7.48	
	T_3: Slicing	6.43	6.58	6.63	6.54	6.83	6.48	6.93	6.74	6.64	
	Mean (MP of S_3)	**6.23**	**6.68**	**6.89**	**6.60**	**7.09**	**6.78**	**7.11**	**6.99**	**6.79**	
S_4:6 months	**T_1**: Shredding	4.81	5.40	5.58	5.26	5.63	5.70	6.03	5.78	5.52	
	T_2: Crushing	6.01	6.72	6.87	6.53	7.07	7.39	7.78	7.41	6.97	
	T_3: Slicing	5.15	5.63	5.92	5.57	5.70	5.87	6.33	5.96	5.76	
	Mean (MP of S_4)	**5.32**	**5.92**	**6.12**	**5.79**	**6.13**	**6.32**	**6.71**	**6.39**	**6.09**	
Grand Mean (P)		**6.22**	**6.69**	**6.86**	**6.59**	**6.91**	**6.89**	**7.22**	**7.00**		
Grand Mean (M)		**6.56**	**6.79**	**7.04**							

	S.Em. ±	$CD_{0.05}$		S.Em. ±	$CD_{0.05}$		S.Em. ±	$CD_{0.05}$		S.Em. ±	$CD_{0.05}$
T	0.021	0.059	**T_XP**	0.029	0.084	**S**	0.026	0.073	**TxMxS**	0.079	0.220
M	0.021	0.059	**MxP**	0.029	0.084	**TxS**	0.045	0.127	**TxPxS**	0.064	0.180
P	0.017	0.049	**TxMxP**	0.051	0.145	**MxS**	0.045	0.127	**MxPxS**	0.064	0.180
T_XM	0.036	0.103				**PxS**	0.037	0.104	**TxMxPxS**	0.111	0.312
CV %	2.59					**CV %**	2.84				