Bangladesh J. Bot. **52**(1): 17-25, 2023 (March) DOI: https://doi.org/10.3329/bjb.v52i1.65228

DEVELOPMENT AND EVALUATION OF OSMO-DRIED PEEL STICKS FROM GALGAL

NEERAJ GUPTA*, MONIKA SOOD AND JULIE D BANDRAL

Division of FST, SKUAST-Jammu, Chatha, J&K UT, India-180009

Keywords: Galgal, Peel, Value addition, Sugar, Jaggery

Abstract

The lab experiment on development and evaluation of osmo-dried peel sticks from galgal was laid out with six treatment combinations *i.e.* dipping concentration of sugar and jaggery solution of 30, 40 and 50^0Brix with three replications. The experiment was conducted by using factorial completely randomized design. The osmo-dried galgal peel sticks were analysed for chemical composition and sensory qualities at an interval of one month till three months of storage period at ambient conditions. However, with an advancement of storage period an increasing trend was observed in reducing sugar, total sugar and hunter colour a*value. However, a decreasing trend was observed in moisture, ash, hunter colour L*and b*value, and pectin content. The galgal peel sticks prepared with treatment T_3(50^0Brix with sugar) showed statistically higher maximum value of colour, flavour, texture and taste during the three months of storage period and was more acceptable than other treatments.

Introduction

Galgal (*Citrus pseudolimon* Tan.), an indigenous variety of lemon, is generally grown well in the lower hills and sub-mountainous regions of northern India. In Jammu and Kashmir UT, citrus fruit is grown on an area of about 2565 million hectares with a production of 7337 million tonnes (Anonymous 2019). It is a good source of vitamin C, mineral and salts. Lemon fruit is utilized for pickle making, culinary purposes and for blending with other fruit juices for squash preparation at small scale. Left over pomace and peel of fruit after juice extraction is discarded as waste. For citrus processing industry, disposal off peel and other residual material is a big problem. Peel of citrus is about 25-35% of fruit weight and is quite nutritious but it do not have commercial importance to the industry or growers (Attri and Maini 1996). Hence, citrus processing industry can easily use candied peel which finds a ready market in confectionery. The candied citrus peel is used in the baking industry in preparation of cakes, cookies and fruit breads. The judicious processing of waste peel in to osmo-dried peel sticks will not only add to the income of processing industry but it will provide remunerative price to the growers as well (Mehta *et al.* 2005, Gupta *et al*. 2020). Thus, the present studies were conducted to utilize the galgal peel for developing osmo-dried nutritious peel sticks.

Materials and Methods

Fresh and healthy galgal fruit was procured from the local market in Jammu and Kashmir UT, India. Juice of galgal was used for making squash and galgal peels were used for making osmo-dried peel sticks. The dried and bruised peel sticks were thoroughly sorted out manually. Peel sticks of almost same size were selected for processing. The graded peel sticks were washed thoroughly under running tap water to remove dust and dirt from the surface. The peel sticks were cut uniformly about 2 to 3 cm length and 0.5 to 0.8cm breadth. Osmo-dried galgal peel sticks was prepared by six treatments *i.e.* T_1: 30°Brix with Sugar, T_2: 40^0Brix with Sugar, T_3: 50^0Brix with Sugar, T_4: 30^0Brix with Jaggery, T_5: 40^0Brix with Jaggery and T_6: 50^0Brix with Jaggery.

*Author for correspondence: <neeruguptapht@gmail.com>.

Galgal peel sticks were then blanched for 2 min followed by steeping in sugar and jaggery syrup for 20 hrs as per the treatment combinations. After completion of steeping time, sugar and jaggery syrup was drained out and osmo-dried galgal peel sticks were spread out on trays. Then osmo-dried galgal peel sticks were kept for drying in a cabinet dryer for 5-6 hrs at 60ºC. The osmo-dried peel sticks were collected and packed in LDPE bags for storage purpose. Galgal peel sticks were stored at room temperature for evaluating changes in chemical constituents and organoleptic quality at monthly interval during three months storage. Products were analysed for reducing, total sugars, moisture and pectin content (Ranganna 2006), ash (AOAC 2007), hunter colour values (Grabowski *et al*. 2006). Total plate count of micro-organisms was determined according to method given by Harrigan and McCance (1976). Organoleptic evaluation was carried out by semi-trained panellists on 9-point hedonic rating scale (Amerine *et al.* 1965). The data were statistically analyzed using CRD factorial for interpretation of results through analysis of variance.

Results and Discussion

There was a significant increase in per cent reducing sugar of osmo-dried galgal peel sticks during the storage periods (Table 1). Among the different treatments T_3 (50^0Brix with sugar) recorded significantly higher value of reducing sugar (13.41%) however; statistically lower value (11.01%) was observed in T_4 treatment (30^0Brix with Jaggery). Further, the mean reducing sugar content increased to 13.47% from the initial value (11.64%) during the three months of storage. The interaction between the storage and treatment was found significant. The increment in reducing sugar content during the various storage periods might be due to the inversion of non-reducing sugars into reducing sugars. Similar results were observed during standardisation of recipe for the preparation of candy from unripe papaya (Babariya *et al.* 2014) and processing of *kandi* lemon peel waste for candy making (Mehta *et al.* 2005).

Table 1. Effect of treatment and storage period on reducing and total sugar of osmo-dried galgal peels sticks.

Treatments	Reducing sugar					Total sugar				
	Storage period (months)					Storage period (months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: 30^0 Brix with Sugar	10.46	10.78	11.16	12.66	11.27	22.35	22.86	23.12	24.56	23.22
T_2: 40^0 Brix with Sugar	11.98	12.00	12.98	13.72	12.67	31.56	31.98	32.67	32.90	32.28
T_3: 50^0 Brix with Sugar	12.67	12.92	13.43	14.62	13.41	41.67	42.08	43.46	44.68	42.97
T_4: 30^0 Brix with Jaggery	10.32	10.72	11.00	12.00	11.01	22.30	22.70	23.00	24.10	23.03
T_5: 40^0 Brix with Jaggery	11.80	11.98	12.60	13.28	12.42	31.00	31.82	32.06	32.56	31.86
T_6: 50^0 Brix with Jaggery	12.58	12.82	13.26	14.52	13.30	41.05	42.00	43.17	44.25	42.62
Mean	11.64	11.87	12.41	13.47		31.66	32.24	32.91	33.84	
CD (5%)										
Treatments	0.17					0.37				
Storage	0.14					0.31				
Treatments x storage	0.35					0.74				

On a critical analysis of data among different treatments significantly higher and lower values for total sugars in osmo-dried galgal peel sticks was 42.97 and 23.03% recorded in treatments $T_3$and T_4, respectively. At 0 month of storage; significantly higher (41.67%) total sugar content was observed in treatment T_3 and lower (22.30%) was found in treatment T_4 and the values of total sugar increased to 44.68 and 24.10% after three months of storage, respectively (Table 1). It was also found that the storage mean value increased from 31.66 to 33.84% after three months of storage. The increase in total sugars content during the different storage periods could be due to hydrolysis of polysaccharides and inversion of non-reducing sugars. Similar results were reported

in studies on effect of sugar concentration and time intervals on quality and storability of ber chuhara (Gupta and Kaul 2013).

A significant decrease in moisture content was observed in different treatments during storage of osmo-dried galgal peel sticks (Table 2). During storage period, mean values of moisture content decreased from 15.17 to 14.58%. After three months of storage, treatment T_4 had the maximum moisture content (14.70%), whereas T_3 had the minimum moisture content (14.40%).The effect of interaction between treatment and storage period was also found significant at 5% significance. A gradual decrease in the moisture content was observed with a respective increase in osmotic concentration. This might be due to the increase in osmotic syrup concentration and the osmotic pressure exerted on the fruit cell structure resulting in greater moisture reduction in more concentrated solutions. The similar results were reported in banana (Jalali *et al*. 2006) and pumpkin candy (Muzzaffar *et al.* 2016).

Table 2. Effect of treatment and storage period on moisture and ash of osmo-dried galgal peel sticks.

Treatments	Moisture(%)					Ash(%)				
	Storage period (months)					Storage period (months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: 30^0 Brix with Sugar	15.00	14.86	14.76	14.66	14.82	6.81	6.70	6.58	6.40	6.62
T_2: 40^0 Brix with Sugar	15.03	14.84	14.63	14.50	14.75	6.50	6.42	6.34	6.22	6.37
T_3: 50^0 Brix with Sugar	15.00	14.75	14.50	14.40	14.66	6.38	6.30	6.25	6.20	6.28
T_4: 30^0 Brix with Jaggery	15.12	14.96	14.80	14.70	14.89	6.75	6.68	6.57	6.38	6.60
T_5: 40^0 Brix with Jaggery	15.30	14.88	14.65	14.66	14.87	6.47	6.40	6.32	6.17	6.34
T_6: 50^0 Brix with Jaggery	15.56	14.70	14.58	14.56	14.85	6.35	6.28	6.22	6.12	6.24
Mean	15.17	14.83	14.65	14.58		6.54	6.46	6.38	6.25	
CD (5%)										
Treatments			0.03					0.09		
Storage			0.02					NS		
Treatments x storage			0.05					0.20		

The ash content of osmo-dried peel sticks revealed that the storage mean values decreased from the initial level of 6.54 to 6.25% during three months of storage (Table 2). Initially among different treatments, maximum value to the tune of 6.81% recorded in treatment T_1 whereas, significantly lower value (6.35%) recorded in T_6 which decreased to 6.40 and 6.12%, respectively after three months of storage. Statistically higher ash content of 6.62% recorded in T_1 (30^0Brix sugar syrup), whereas the lowest value of 6.24% noted in treatment T_6. Moreover, interaction between treatment and storage period was also found significant at 5% level of significance. The decrease in ash content might be due to the microbial activities which utilize the minerals for growth. These results are in accordance with the study on development and evaluation of flavoured *ladoo* from different cultivars of aonla (Pandita and Gupta 2019).

A decrease in pectin content of osmo-dried peel sticks during storage period was observed and the mean value decreased from 1.61 to 1.37 per cent (Table 3). After preparation of osmo-dried peel sticks, treatment T_3 showed maximum pectin content (1.75% calpectate), while as treatment T_1 showed minimum pectin content (1.50% calpectate). After 3 months, T_3 exhibited the significantly higher pectin content (1.52% calpectate), whereas, T_4 recorded statistically lower pectin content (1.20% calpectate). The interaction between treatment and storage period was found

non-significant. This could be due to degradation of pectin into pectic acids during storage. Similar findings were reported by sweet orange peel candy (Bisht 2017).

Table 3. Effect of treatment and storage period on pectin and microbial count of osmo-dried galgal peel sticks.

Treatments	Pectin(% calpectate)					Microbial Count(cfux10^6)			
	Storage period (months)					Storage period (months)			
	0	1	2	3	Mean	0	1	2	3
T_1: 30^0 Brix with Sugar	1.50	1.42	1.39	1.33	1.41	ND	ND	ND	0.20
T_2: 40^0 Brix with Sugar	1.63	1.50	1.48	1.37	1.50	ND	ND	ND	0.18
T_3: 50^0 Brix with Sugar	1.75	1.64	1.56	1.52	1.62	ND	ND	ND	0.15
T_4: 30^0 Brix with Jaggery	1.51	1.42	1.35	1.20	1.37	ND	ND	ND	0.26
T_5: 40^0 Brix with Jaggery	1.59	1.47	1.40	1.32	1.44	ND	ND	ND	0.24
T_6: 50^0 Brix with Jaggery	1.66	1.63	1.48	1.46	1.56	ND	ND	ND	0.21
Mean	1.61	1.51	1.44	1.37					
CD (5%)									
Treatments			0.38						
Storage			0.31						
Treatments x storage			NS						

All the samples found to be free from microbial count up to two months of storage (Table 3). However, after three months of storage, the highest microbial count of 0.26 x 10^6 cfu/g was recorded in T_4 (30^0Brix with Jaggery) whereas the lowest value to the tune of 0.15 x 10^6 cfu/g was observed in treatment T_3 (50^0Brix sugar syrup). This might be due to low water activity which is not favourable to the microbial growth. Similar findings have been reported in intermediate moisture beet root cubes (Chibber *et al*. 2019).

The data pertaining to the hunter colour values; the L*values decreased significantly while values of a* increased. With the advancement of storage period up to three months, mean value of L* showed a decreasing trend from the initial levels of 26.21 to 24.53 (Fig. 1) while a* value increased significantly from 3.70 to 4.18 at 5% level of significance (Fig. 2). The b* value showed a decreasing trend from the initial value of 11.81 to 11.57 (Fig. 3). This might be due to the increased rate of Maillard reaction because of the availability of more sugar. Similar findings were reported during storage of eureka lemon peel flakes and observed similar changes in L*, a* and b* values. These changes may be attributed to the occurrence of non-enzymatic browning that results in darkening of the product, resulting in a decrease in L* and b* value and increased a* values (Kour 2019).

A significant decrease in mean score of colour in osmo-dried galgal peel sticks was recorded during three months of storage period (Fig. 4). Osmo-dried peel sticks showed significant decrease in colour during storage period and the mean value decreased from 7.63 to 7.24. Among the various treatment combinations, maximum score (8.83) of colour was observed in T_3 with minimum score (6.52) in T_4 after preparation of osmo-dried galgal peel sticks. At the end of storage period of candy, maximum score (8.17) of colour was observed in T_3 and minimum score (6.25) in T_4.This could be due to occurrence of non-enzymatic browning in candy during storage. Similar results were reported in development and quality evaluation of honey based carrot candy (Durrani *et al.* 2011) and in the preparation and evaluation of candies from citron peel (Shamrez *et al.* 2013).

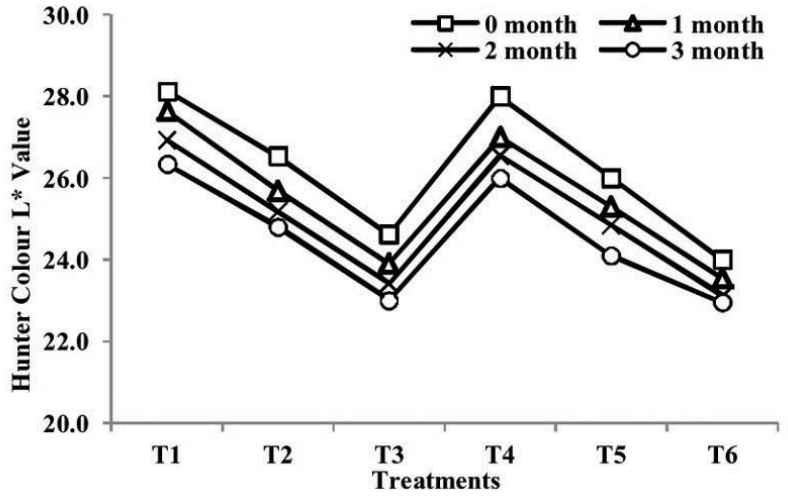

Fig 1. Effect of treatments and storage periods on L* (lightness)value of osmo-dried galgal peel sticks

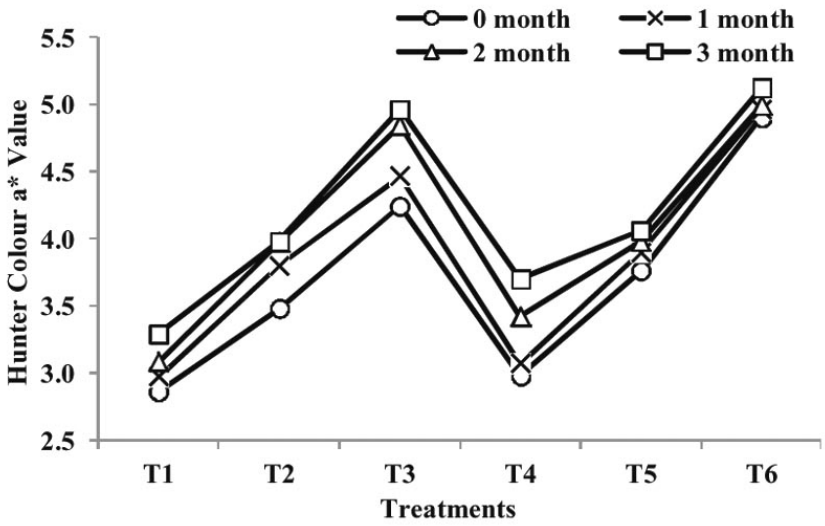

Fig 2. Effect of treatments and storage periods on a*(redness)value of osmo-dried galgal peel sticks.

Data revealed that the sensory score for flavour of osmo-dried galgal peel sticks decreased significantly during storage period (Fig. 5). The mean value decreased from 7.56 to 7.20. Treatment T_3 showed maximum score (8.89), while treatment T_4 showed minimum score (6.49) and decreased to 8.57 and 6.20, respectively. Treatment $T_3$is highly acceptable for flavour and this is due to the high sugar concentration. Decrease in flavour may be due to oxidative and physico-chemical changes during storage and also it is a sensory attribute which depends on human perception. Similar results were also found during development and shelf-life prediction of pineapple preserve and candy (Jothi *et al.* 2014).

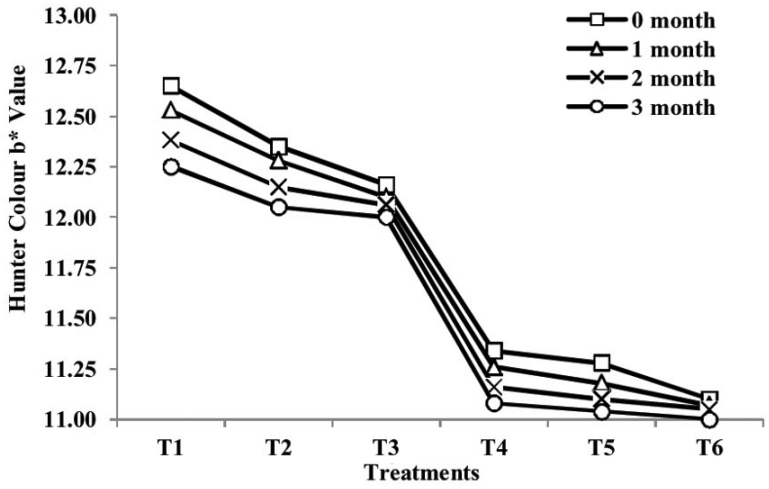

Fig 3. Effect of treatments and storage periods on b*(yellowness)value of osmo-dried galgal peel sticks

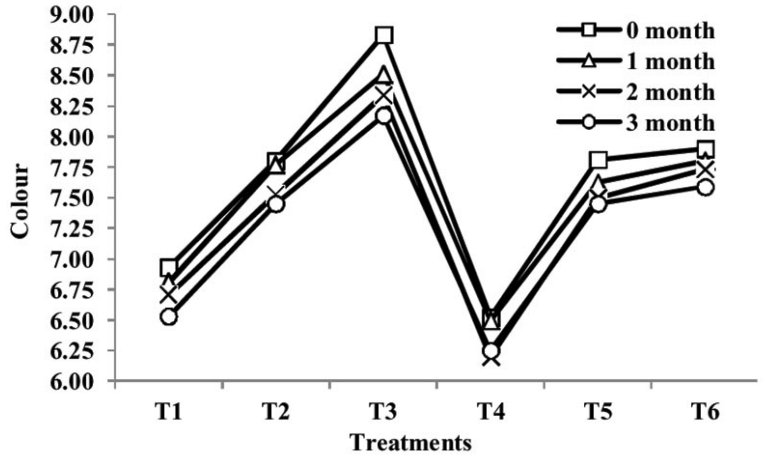

Fig 4. Effect of treatment and storage period on colour of osmo-dried galgal peel sticks

Data regarding effect of treatment and storage period on taste of osmo-dried peel sticks presented in Fig. 6 showed that the maximum score (8.80) for taste of galgal peel sticks was recorded in T_3, whereas, minimum in T_1 (6.76) at 0 day of storage of the product. After 3 months of storage, maximum and minimum scores of 8.20 and 6.24were recorded in treatments T_3 and T_1, respectively. On average basis, maximum and minimum scores were recorded for T_3(8.47) and T_1(6.48). The scores for taste parameter of galgal peel sticks were found to decrease from 7.52 to 7.15 during storage. Interaction of treatment and storage period indicated a significant effect. The decrease in taste scores with increase in storage time might be due to reduction of volatile flavouring components during storage which might ultimately be responsible for decreased taste scores. Similar findings have been recorded in kinnow peel candy (Bhatlu *et al.* 2014).

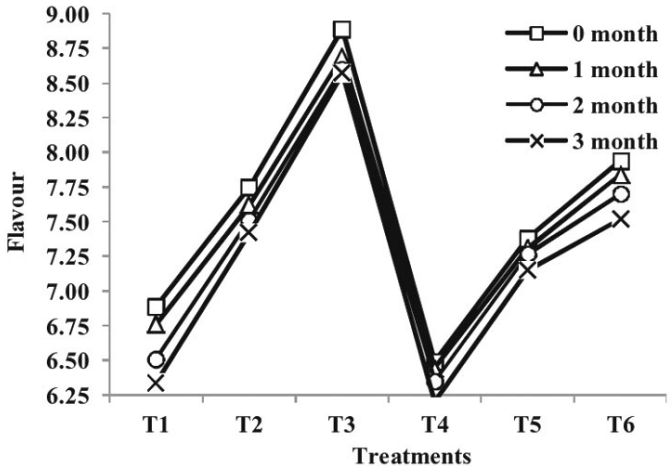

Fig. 5. Effect of treatment and storage period on flavour of osmo-dried galgal peel sticks

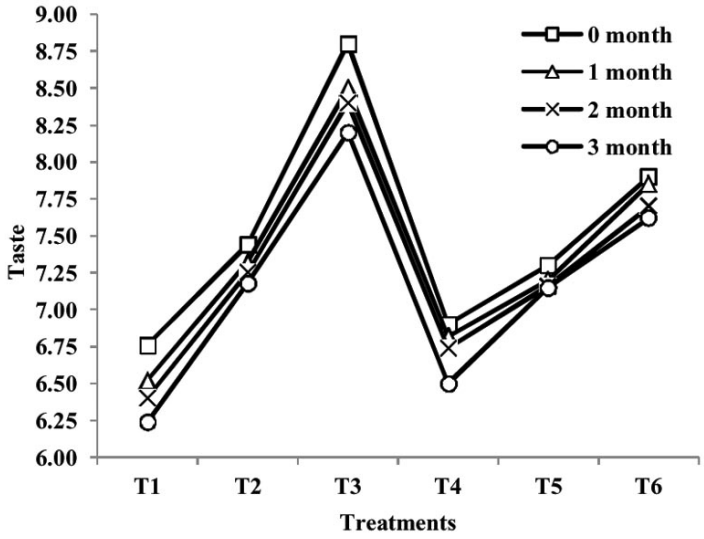

Fig. 6. Effect of treatment and storage period on taste of osmo-dried galgal peel sticks

The mean score for texture in osmo-dried peel sticks decreased significantly during three months of storage period (Fig. 7). The mean value decreased from 7.60 to 7.11. Treatment T_3 showed the maximum score (8.32), while treatment T_1 showed the minimum score (6.11) at the end of storage period. The data revealed that treatment T_3showed the maximum score (8.56), while T_1gave the minimum score (6.37) in treatment mean values. This might be due to the high concentration of sugar solution, dipping time of candy and loss of moisture by the candy during storage period. Similar results were also recorded in papaya candy (Chauhan *et al*. 2014) and citrus peel candies (Shamrez *et al*. 2013).

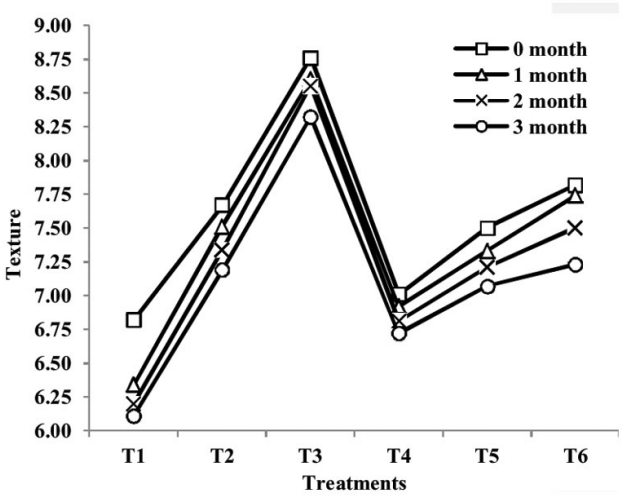

Fig 7. Effect of treatment and storage period on texture of osmo-dried galgal peel sticks

Osmo-dried galgal peel sticks prepared from 50^0 Brix with sugar (T_3) was the best with regard to various organoleptic characteristics like colour, flavour, taste and texture. The product could be also used for commercialization purpose.

References

Amerine MA, Pangborn RM and Roessler EB 1965. Principle of sensory evaluation of food.Academic Press, New York and London.

Anonymous 2019. Directorate of Horticulture, Rajbagh Srinagar, Kashmir, 190 008. Website http://Hort. Kashmir.gov.in assessed on 01-10-2019.

AOAC 2007. Official Methods of Analysis. 19th Edition, Association of Official Analytical Chemists, Arlington.

Attri BL and Maini SB 1996. Extraction of pectin from galgal (*Citrus pseudalemon* Tan) peel. Ind. Food Packer **50**: 5.

Babariya VJ, Makwana AN, Hadwani M and Panjair N 2014. Standardization of a recipe for the preparation of candy (tutifruiti) from un-ripe papaya. The Asian J. Hort. **9** (1): 94-99.

Bhatlu LD, Yadav AK and Singh SV 2014. Preparation of candy from Kinnow (citrus) peel. *Global Sustainability Transitions: Impacts and Innovation*, ISBN: 978-93-83083-77-0: 151-154.

Bisht T 2017.Studies on standardisation of sweet orange peel candy. M.Sc. (Fruit Science) Department of Horticulture COA, PVNMKV, Parbhani-431 402 (M.S.), India.

Chauhan N, Singh S, Singh P, Singh BR and Sweta 2014. Effect of different citric acids levels on quality papaya candy prepared by various methods. Ind. J. Res. **3** (9): 1-4.

Chibber AK, Singh J and Gupta N 2019. Effect of humectants on mineral composition and microbial count of intermediate moisture beetroot (*Beta vulgaris* L.) cubes. *Ann. Plant Soil Res.***21** (2): 167-171.

Durrani AM, Srivastava PK and Verma S 2011. Development and quality evaluation of honey based carrot candy. J. Food Sci. Technol. **48** (4): 502-505.

Grabowski J K, Trung P and Daubert R 2006. Spray drying of amylase hydrolysed sweet potato puree and physico-chemical properties of powder. J. Food Eng.**71**: 209-17.

Gupta N and Kaul RK 2013. Effect of sugar concentration and time intervals on quality and storability of berchuhara. Ind. J. Hort. **70** (4): 566-570.

Gupta N, Bandral JD, Sood M and Bhat A 2020. Preparation of osmo-dried peel sticks from galgal. Ind. J. Ecol. **47** (1): 68-71

Harrigan W F and Mccane M E 1976. Laboratory Techniques in Food and Dairy Microbiology. Academic Press, London.

Jalali VRR, Narain N and Silva GF 2006. Effect on osmotic pre-dehydration on drying characteristics of banana fruits. Sci. Tech. Alimentary **28** (2): 269-273.

Jothi JS, Islam M, Islam MS, Rahman MRD and Akther S 2014. Development and shelf-life prediction of pineapple (*Anana scomosus*) preserve and candy. *Int. J. Inno. Scientific Res*. **10** (1): 77-82.

Kour P 2019**.**Waste utilization of eureka lemon for development of value added product. M.Sc Thesis, Division of FST, SKUAST-Jammu.

Mehta A, Ranote PS and Bawa AS 2005. Processing of kandi lemon (Galgal) peel waste for candy making. Indian Food Packer 54: 67-74

Muzzaffar S, Waqas NB, Nazir N, Masoodi FA, Bhat MM and Bazaz R 2016. Effect of storage on physicochemical, microbial and antioxidant properties of pumpkin (*Cucurbita moschata*) candy. Cogent Food and Agri. **2**: 1-13.

Pandita N and Gupta N 2019. Development and evaluation of flavoured ladoo from different cultivars of aonla. Bangladesh J. Bot. **48** (4): 957-965.

Ranganna S 2006. Handbook of analysis and quality control of fruit and vegetable products, 2nd ed. Tata McGraw-Hill, New Delhi, India.

Shamrez B, Aftab S, Junaid M, Ahmed N and Ahmed S 2013. Preparation and evaluation of candies from citron peel. IOSR J. Environ. Sci. Toxico. Food Tech.**7**: 21-24.

(Manuscript received on 22 July 2020 , revised on 17 November 2022)