

# A Study on Generation of Fruit Waste Among Selected Fruit Juice Outlets in Pune City and Development of Candied Orange Peel

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**Abstract**— Fruit waste like peel, core, seed, pomace and epicarp is considered as a crucial component of our daily food intake as it contains many important nutrients and non-nutrient components, which play an important role in our well-being. The main objective of this dissertation study was to conduct a survey among fruit juice outlets and vendors to assess the fruit waste generated. About 53 fruit juice outlets in Pune Metro City were selected for the study. Mosambi, orange, pineapple, mango, apple, and watermelon were the most popular fruit juices consumed and were available at most of the outlets surveyed. The total fruit peel waste generated was approximately 1300 kg per day. This fruit peel waste was majorly found to be collected by the Pune Municipal Cooperation (85%), some of it was thrown away (11%) and only 4% of it was utilized for animal feed. Out of the total fruit peel waste, 8% of it was orange peels. This part contains natural antioxidants, bio- active compounds, phytochemicals, fibre, polyphenols, flavonoids, and also possesses antimicrobial activity, which can be used for the development of value-added products. Therefore, as a feasible solution to this waste problem, a reasonable technology for value addition of orange peel into sugar impregnated candied orange peels was developed (Osmo-dehydration in a hypertonic solution). The final candied orange peel had 10.27% moisture, 70.4°B TSS, 34.61 mg/100g ascorbic acid (vitamin C), 0.27% acidity (citric acid), 16.24% reducing sugars, 70.4% total sugars, 5.25% fat, 6.10% protein, 6.80% fibre, 74.5% carbohydrates, 4.2% ash (minerals) and energy value 368 Kcal/100 gram. Microbiologically, the candied orange peel did not show any significant growth in terms of total plate count. Likewise, the sensory quality attributes (colour, consistency (texture), flavour, taste, appearance, and overall acceptability), when evaluated by a panel of 20 semi trained members using 5 point hedonic scale, were found to be ranked at the highest rank- I, (means of mean). Even after storing for 40 days the product had exhibited no significant differences ( $p < 0.05$ ) in the quality parameter values as observed on 0th day analysis to that of the 40th day storage sample.

**Index Terms**— Osmo-dehydration, hypertonic solution, candied peels, albedo.

## I. INTRODUCTION

Fruit juice centres produce a significant amount of waste, by-products that include fruit peels, seeds, pomace, stones, etc., which present disposal issues. Since fruit peels are an economic source of antioxidants, bio-active compounds and antimicrobial agents, they can be utilized to develop value added products, which could curb waste disposal issues, and food wastage. Orange peel could be utilized for pectin extraction or animal feed, bio fuels, pectinase, cellulose, essential oil, bio gas, etc., (Gotmare and Gade, 2018). India produces 25 lakh tonnes of orange peels every year, however the peels create environmental problems.

Osmotic dehydration (OD) partially removes natural water from the fruits immersed in a hypertonic solution (Rastogi et al., 1999). Various osmotic agents such as sucrose, glucose, fructose, corn syrup and sodium chloride have been used for fruits and vegetables (Vijayanand et al., 1995). The candying process involves the slow impregnation of syrup, until the sugar concentration in the fruit tissue is sufficiently high to prevent the growth of spoilage microorganisms and the fruit or vegetable does not soften or become tough and leathery (Desrosier and Desrosier, 1977).

The objectives of the study were to conduct a survey among the fruit juice outlets in Pune city to mainly find out the fruit peel waste generated daily and its mode of disposal. Further, as a solution, orange peels were selected for preparation of candied orange peels by using osmo-dehydration technique to develop a value added product, finally conducting its packaging, and storage studies for changes in quality

attributes such as proximate constituents, microbial count (TPC) and sensory quality properties.

## II. MATERIALS AND METHODS

The study was performed in two parts- survey of juice outlets and value-added candied orange peel product development.

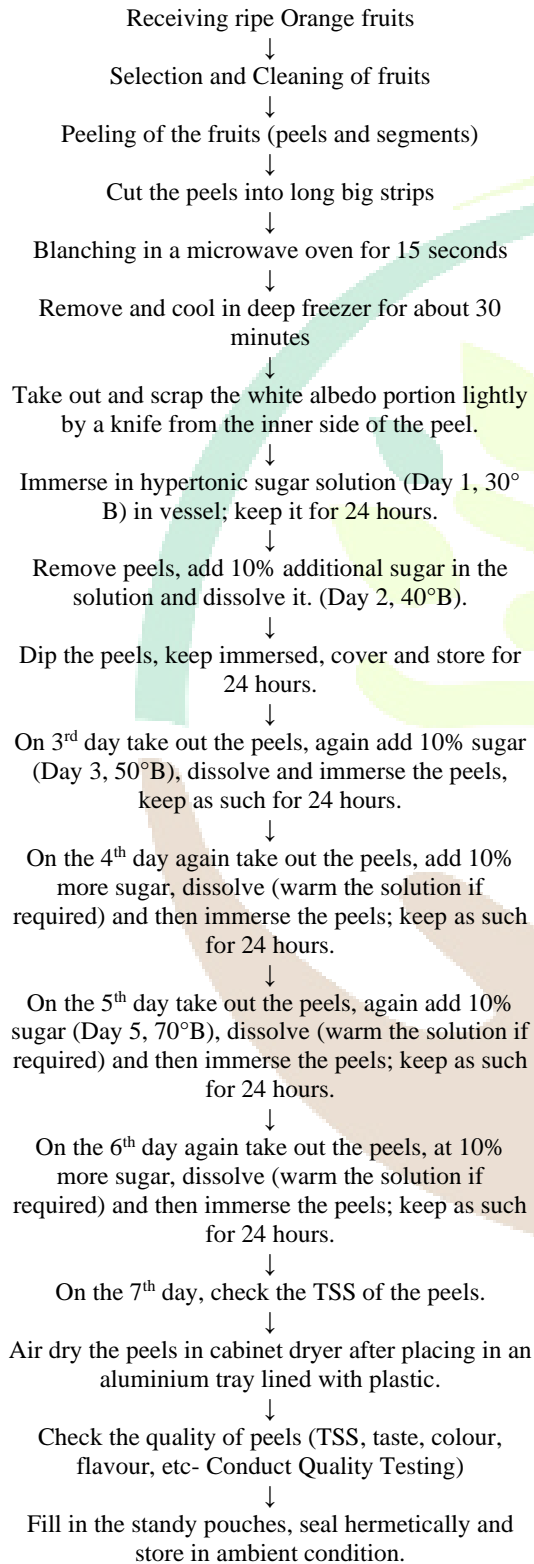
Part A- Survey of Juice Outlets:

- The survey was conducted in January and February 2020 in Pune city
- Target population: Fruit Juice Vendors, both mobile and fixed stall vendors
- Sample selection: 'Convenience Sampling' Technique
- Sample size: 53 participants responses were recorded (visiting and interviewing the stall vendors)
- Tool for Data Collection: Questionnaire prepared in English and collected information by personal interview from each stall vendor
- Survey Questionnaire: Included questions on fruits purchased, purchasing frequency, location of purchase, quantity of fruits purchased, quantity of juice obtained, quantity of juice served per glass, number of juice glasses sold per day, peak period of rush, types of equipment used, types of customers, amount of fruit waste generated/day and storage, method and waste disposal ways.

Part B- Food Product Development: Orange Peel Candy

- **Raw Materials:** The raw materials selected were Orange fruit, sugar, and water.
- **Preparation of orange peel candy:** The orange peels were obtained from the freshly procured fruits, further processed as per the flow chart and converted into orange peel candy. The candied peels after drying were packed into standby pouches, and stored under ambient conditions.

#### Process Flow Chart



- **Packaging and storage:** The air dried Orange Peel Candy was filled into standby pouches, on bulk scale, sealed

hermetically, and further, stored under ambient conditions-  $25 \pm 2^\circ\text{C}$  for about 40 days.

- **Sampling Protocol:** The sample packet on every 10th day interval was withdrawn and subjected to analysis of various quality attributes like changes in proximate constituents, microbial changes and sensory quality attributes for 40 days storage.

### III. QUALITY EVALUATION

- **Changes in Physical Quality Parameters-** Condition of pouches and product, colour of the candy
- **Proximate or Chemical Analysis-** Determination of moisture, protein, fat, total carbohydrate, fibre, ash (minerals), pH, acidity (citric acid), TSS ( $^\circ\text{B}$ ), reducing sugar, total sugars, vitamin C, and energy value (Kcal) per 100 gram sample, etc., were analysed as per the sampling protocol using standard methods of analysis (Ranganna, 2014)
  - **Changes in Microbial Count-** TPC as per the schedule using standard method as CFU/mg (Ranganna, 2014)
  - **Changes in Sensory Quality Attributes-** The sensory quality analysis was carried out on every 10th day of storage (0th, 10th, 20th, 30th, and 40th day) and was evaluated on 5 point hedonic scale using 20 semi trained panel members for various quality attributes (colour, flavour, taste, texture, appearance, overall acceptability). The means of mean for each attribute was determined and ranking was decided according to the score. (Ranganna, 2014).

### IV. RESULTS AND DISCUSSION

#### Part A- Survey of Juice Outlets

The data was collected through questionnaire and personal interview method. After analysing the data for various statistical parameters it was found that 41% of the participants reported that they did not pass 10th standard. Almost 87% of the participants were mobile vendors and also 87% participants had reported that they had worked for all 365 days of the year, 49% population worked for around 10 to 12 hours a day.

Results on the fruits purchased across the fruit juice centres indicated that pineapple was the highest purchased fruit (98%) followed by orange (96%) and least being amla, tomato, and mulberry (2% each).

The purchasing frequency of the fruits indicated that 58% juice vendors purchased fruits twice a week from the main APMC Market Yard, Pune. The highest number of glasses of juice sold per day was reported to be orange (11.26%) followed by pineapple (10.14%). About the equipment used, 89% vendors reported using food mixers, whereas the rest reported using food processors or juicers.

The fruit waste generated per day as reported by 41% participants was to the tune of 5 to 10 kg waste, followed by 28% vendors 10 to 20 kg, and 8% reported 20kg waste per day.

About the method of disposal 85% of the population responded that their fruit peel waste was collected by the Pune Municipal Corporation daily and 4% reported that the peel waste was given for animal feed.

## Part B- Food Product Development: Candied Orange Peel

After purchasing the ripe orange fruit (Malta Cv), they were processed in the NFP lab. The peels obtained was subjected to the proximate constituent analysis and the data obtained is presented below.

Table 1- Proximate constituent of fresh orange peel/100gm \*

Sr. No	Parameters (%)	Values
1	Moisture	64.80
2	Protein	6.10
3	Fat	5.25
4	Carbohydrate	19.61
5	Fibre	6.80
6	Ash	4.25
7	Energy Value (Kcal per 100 gram)	150
8	TSS (°B)	8.5
9	pH	3.88
10	Titrateable Acidity (Citric Acid)	0.27
11	Ascorbic Acid (Vitamin C) mg/100g	35.6
12	Reducing Sugars	3.50
13	Total Sugars	5.00

\*Means of 3 determinations

From the data given above it is observed that the fresh orange peel had estimated moisture of 64.80%, protein 6.10%, fat 5.25%, carbohydrate 19.61%, fibre 6.80%, ash (minerals) 4.25%, 150 Kcal energy value (per 100 gram sample). The other parameters analysed for were: total soluble solids 8.5° B, pH 3.88, titrateable acidity (citric acid) 0.27%, Vit. C (ascorbic acid)

From the data given above it is observed that the fresh orange peel had estimated moisture of 64.80%, protein 6.10%, fat 5.25%, carbohydrate 19.61%, fibre 6.80%, ash (minerals) 4.25%, 150 Kcal energy value (per 100 gram sample). The other parameters analysed for were: total soluble solids 8.5° B, pH 3.88, titrateable acidity (citric acid) 0.27%, Vit. C (ascorbic acid) 35.6 mg, reducing sugars 3.5% and total sugars 5.0 % per 100 gram sample.

These observed values of protein, fat, carbohydrate, fibre, and ash content was found to be on par with that of the values reported earlier. (Gotmare and Gade, 2018; Rodriguez and Rodriguez, 2013; Pandharipande and Gaikar, 2015)

Apart from the data presented in the above table, the peels were shelled by hand, and further blanched in a microwave oven for inhibiting the browning enzyme activity. The bitterness of orange peel present in the white albedo portion of the peel is due to the presence of flavonoids- Pyridine and Naringin (Rodriguez and Rodriguez, 2013). The percentage weight of peel was 28%, seed 3%, pomace 32% and juice 37%. These peels were further subjected to osmotic dehydration process using hypertonic solution of sucrose.

The white albedo portion of the peel was scraped out by using a sharp knife. The data on osmotic dehydration of orange peel dipped in hypertonic solution is given in the following Table 3.

Sr. No.	Particulars	Values (kg)
1	Weight of the fruit lot taken	5 kg
2	Stage of the fruit.	fully matured, ripe
3	Colour of the fruit	deep orange red
4	Size of the fruit.	medium
5	Average weight of the fruit	200gm
6	Number of fruits	25
7	Average weight of peel	1.400
8	Weight of seed	150gm
9	Weight of juice obtained	1.850ltrs
10	Weight of pomace	1.600
11	Percentage of peel obtained	28%
12	Percentage of seed obtained	3%
13	Percentage of pomace obtained	32%
14	Percentage juice obtained	37%
15	Consistency of juice	watery
16	Colour of juice	light orange

Table 2- Processing characteristics of orange fruit \*

Day	TSS of sugar solution (°B)		TSS of peel (°B)	pH	Moisture (%)	Acidity (%)
	Start	End				
1st	0	30	25	3.22	68.16	0.68
2nd	25	40	35	3.51	55.48	0.60
3rd	35	50	42	3.64	48.20	0.53
4th	42	60	58	3.72	32.30	0.46
5th	58	70	63	3.85	27.25	0.41
6th	63	80	66	3.98	24.60	0.36

Table 3: Osmotic dehydration of orange peels and changes in the chemical constituents per 100 gm \*

From the data on osmotic dehydration of orange peel, it is observed that the sugar solution prepared on the 1st day had TSS of 30°B. The blanched peels were dipped in the above solution in a stainless steel vessel by keeping a weight over it, so as to ensure complete immersion of the peels. On the

second day the peels were drained out and sugar was added and dissolved to make the TSS 40°B. The peels were then added to the solution, immersed completely, until the next day (24 hours). It was repeated upto the sixth day as shown in the table. Finally the peels were drained off and kept for drying after gently wiping of the syrup layer on the surface of the peels by a muslin cloth. Then the ready candied orange peels were filled in standy pouches (100 gram size), sealed hermetically and stored under ambient conditions (25± 2°C).

Storage Studies- The changes in quality attributes were studied for the changes in chemical constituents using the standard analytical methods. The sampling was done on 0th, 10th, 20th, 30th, and 40th day of storage. The results obtained are presented in the following table no. 4.

Sr. No	Storage days	Moisture (%)	TSS (°B)	Acidity (Citric Acid %)	pH	Reducing sugars (%)	Total sugar s (%)	Ascorbic acid (mg/100 gram)
1	0 <sup>th</sup>	16.60	72.4	0.27	3.97	16.24	66.3	34.61
2	10 <sup>th</sup>	16.50	73.2	0.29	3.96	16.45	66.4	32.39
3	20 <sup>th</sup>	16.46	73.6	0.30	3.95	16.62	66.6	31.72
4	30 <sup>th</sup>	16.40	73.9	0.30	3.95	16.63	66.8	30.19
5	40 <sup>th</sup>	16.35	74.0	0.30	3.95	16.65	66.9	29.80
	Mean	16.46	73.42	0.29	3.96	16.52	66.6	31.74
	SE ±	0.12	0.19	0.11	0.30	0.11	0.09	0.80
	CD at 5%	0.36	0.57	0.33	0.90	0.33	0.27	2.4

Table 4: Changes in chemical constituents in the orange peel candy during storage per 100 gm\*

\*Mean of 3 determinations

From the data regarding changes in chemical constituent during the storage of orange peel candy, it is seen that the percent values of the moisture, TSS, acidity, pH, reducing sugars, total sugars and ascorbic acid (mg per 100 gram) analysed on 0th day storage and that of the values observed on the 40th day storage did not show any statistical significant differences. Hence this indicates that the candy was found to be in a good condition as far as the quality parameters are concerned, throughout the storage period.

Likewise the changes in proximate constituents in orange peel candy during storage are given below.

Proxi mate Cons titu ents	Storage days					M ea n	S E ±	C D at 5 %
	0 <sup>th</sup> Day	1 <sup>st</sup> Day	2 <sup>nd</sup> Day	3 <sup>rd</sup> Day	4 <sup>th</sup> Day			
Mois ture	10.27	10.10	10.22	10.17	10.09	10.20	0.09	0.09
Prote in	10.51	10.05	10.55	10.48	10.84	10.49	0.06	0.06
Fat	7.15	7.14	7.73	7.73	7.12	7.13	0.02	0.06
Carb ohyd rate	68.77	68.88	68.88	68.99	68.55	68.87	0.02	0.11
Fibre	5.99	5.91	5.99	5.99	5.88	5.90	0.03	0.09
Ash	3.30	3.28	3.22	3.25	3.25	3.25	0.02	0.06
Ener gy (Kcal /100g )	34.6	35.4	38.3	38.2	38.2	38.2	1.4	4.2

Table 5: Changes in proximate constituents in orange peel candy during storage per 100 gm\*

\*Means of 3 determinations

From the data given in the table above, it is revealed that all the quality parameters of orange peel candy in terms of proximate constituents (moisture, protein, fat, carbohydrate, fibre, ash and energy) as the percent values analysed on 0th day storage was found to be statistically insignificantly different from each other with that of the percent values observed on the 40th day of storage. Hence it can be concluded that the orange peel candy was found to remain in good shape without showing any signs of change in these quality parameters.

V. MICROBIAL EVALUATION

Storage days	Dilution		
	10 <sup>-3</sup>	10 <sup>-4</sup>	10 <sup>-5</sup>
0 <sup>th</sup> Day	Nil	Nil	Nil
10 <sup>th</sup> Day	Nil	Nil	Nil
20 <sup>th</sup> Day	Nil	Nil	Nil
30 <sup>th</sup> Day	TFTC	TFTC	TFTC
40 <sup>th</sup> Day	TFTC	TFTC	TFTC

Table 6: Changes in microbial count (TPC) CFU/g of orange peel candy during storage \*

\*Means of 3 determinations, \*\*TFTC- Too few to count

The microbial evaluation of the sample performed on 0th day storage and that of on the 40th day storage show that there were no significant growth observed on the 0th day storage samples. Likewise on the 40th day, storage sample of the Orange Peel Candy, there were no significant TPC growth observed. In earlier studies the microbial spoilage did not occur in dried or high sugar fruits which contained moisture less than 18 to 25% (Somogi and Luh, 1986; Wellington and Badrie N, 2003). Hence, the product Orange Peel Candy was found to be microbiologically safe.

VI. SENSORY QUALITY EVALUATION

Storage Days	Sensory Quality Attributes						
	Colour	Consistenc y/Texture	Flavou r	Taste	Appearanc e	Overall Acceptabilit y	Mean s of mean
	(5)	(5)	(5)	(5)	(5)	(5)	(5)
0 <sup>th</sup> Day	4.80	4.10	4.30	4.10	4.15	4.10	4.14
10 <sup>th</sup> Day	4.66	4.10	4.28	4.10	4.12	4.10	4.23
20 <sup>th</sup> Day	4.58	4.05	4.25	4.05	4.12	4.10	4.19
30 <sup>th</sup> Day	4.52	4.05	4.20	4.0	4.10	4.05	4.15
40 <sup>th</sup> Day	4.50	4.0	4.18	4.0	4.10	4.0	4.13

Table 7: Changes in sensory quality attributes of the orange peel candy during storage \*

\*Key Score, 5 Point = Excellent, 1 Point = Very Poor, RANK = Point > 4.0 = I; Point < 4.0 = II

From the data given above on sensory evaluation, there were no significant differences observed in the 0th day storage sample and that of the values observed on 40th day storage. These samples secured rank I on 0th day and on 40th day storage also. From the sensory quality point of view, the sample was found to remain in most acceptable excellent (means of mean score) condition up to 40 days storage period under ambient conditions.

It may be concluded that the fruit waste generated at the juice centres could be disposed of everyday to avoid health sanitation and pollution problems by the juice centres. The orange peel candy developed by osmo-dehydration process, as a solution to food waste problem, was found to be in an excellent condition up to 40 days of storage under ambient conditions as far as the quality aspects, chemical changes in proximate constituents, microbial count and sensory quality attributes are concerned.

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