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By-product Utilization of Orange Peel and Development of Orange Peel Pickle

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ABSTRACT

This study investigated the utilization of orange peel waste (OPW) by developing a value-added orange peel pickle. The preparation process involved integrating traditional pickling techniques with innovative ingredient combinations to create a flavorful and nutrient-rich product. A storage study was conducted to assess the product's stability and quality over time, focusing on changes in its physicochemical properties and sensory attributes. The findings demonstrated the potential of OPW as a sustainable resource for food innovation, offering both environmental benefits and a versatile food application.

Keywords: Orange peel, Orange peel waste, Orange peel pickle

INTRODUCTION

Pickling is an ancient method used to preserve various types of food like vegetables, fruits, fish, and meat. During the fermentation process, pickles undergo changes in flavor, texture, and color, which contribute to their unique and desirable characteristics (Pederson *et al.*, 1964; Susilowati *et al.,* 2018). The presence of microorganisms, including lactic acid bacteria, Micrococci, Bacilli, yeasts, and filamentous fungi, plays a crucial role in the pickling process. These microorganisms not only affect the quality and safety of the final product but also contribute to its overall taste and preservation. Pickles and other Ready-to-Eat (RTE) food products have become increasingly prevalent in recent years, with India emerging as a major hub for the production of diverse pickled food items. The pickling process involves the formation of lactic acid bacteria, which plays a crucial role in the fermentation process, converting sugars into lactic acid and contributing to the characteristic flavor and texture of pickled foods (Patel, 2019; Behera *et al.,* 2020; Kaur *et al.*, 2018). Despite the lack of definitive evidence regarding its historical and ontogenetic origins, the cultivation and commercial production of citrus fruits (*Citrus rutaceae*) have become a prominent aspect of global horticulture. The growth of the citrus industry, including the rapid development of processing technologies such as frozen concentrated orange juice (FCOJ) following World War II, has been facilitated by international trade and has led to a steady increase in the consumption of citrus fruits and their products over the past several decades. This trend is likely driven by the fruit's widespread availability, nutritional value, and versatility in various culinary applications (Liu *et al.*, 2012; Divya *et al.*, 2016).Orange peel waste (OPW), a discarded portion of the orange fruit, is a rich source of bioactive compounds that can be converted into high-value bioproducts. The global production of OPW is estimated to be in the millions of tonnes, with the majority being disposed of without being fully utilized. This vast volume of annually generated OPW necessitates the development of effective valorization strategies (Oloo *et al.,* 2014; Mohsin *et al.,* 2022). However, there is a dearth of comprehensive data

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on the sustainable fate of OPW, specifically regarding its potential for producing value-added bioproducts. A comprehensive review of the current state of knowledge on this topic is therefore warranted to facilitate the development of innovative solutions for the sustainable valorization of OPW (Mani and Paul, 2020; Sultana *et al.,* 2014).

METHODOLOGY

Orange peels were collected from local market and industrial waste around the Vadodara, Gujarat. The collected peels were washed with hot water and later with cold water. Washed peels were spread and left for drying at room temperature. Dried peels were packed in LDPE pouches and stored in refrigerator *i.e.*, 20 °C for further work.

Preparation of orange peel pickle:

The orange peel was first subjected to size reduction by chopping into small, uniform pieces to ensure consistent thermal treatment. Concurrently, 30 g each of garlic and ginger were prepared by washing thoroughly to remove surface contaminants and then finely chopped to similar dimensions. A pan was preheated, and 50 ml of sunflower oil was introduced as the heating medium. Upon reaching the desired temperature, 1 g each of mustard seeds, cumin seeds, split black lentils, split chickpea lentils, asafetida, and a few curry leaves were added sequentially. The spices were allowed to undergo thermal degradation, releasing volatile aromatic compounds essential for flavor development. Following the tempering process, the chopped orange peel was incorporated into the pan. The mixture was continuously agitated to facilitate uniform heat distribution and to promote the release of essential oils from the orange peel over a 5-min frying period. Subsequently, 50 g of tamarind pulp and 30 g of jaggery were added to the mixture. These components were integrated to introduce acidity and sweetness, respectively. The combined mixture was allowed to undergo a 5-minute thermal treatment, during which the matrix viscosity increased due to the evaporation of moisture and the interaction of the constituents. Once the mixture exhibited a desirable consistency, 1 g of salt and 1 g of chili powder were added to optimize the flavor profile. These additives were homogeneously dispersed within the mixture. Finally, 2 ml of freshly extracted lemon juice was introduced to the mixture to adjust the final pH to 5. The mixture was then removed from the heat source and allowed to cool under ambient conditions before being bottled and stored for subsequent analysis or consumption (Fig. A).

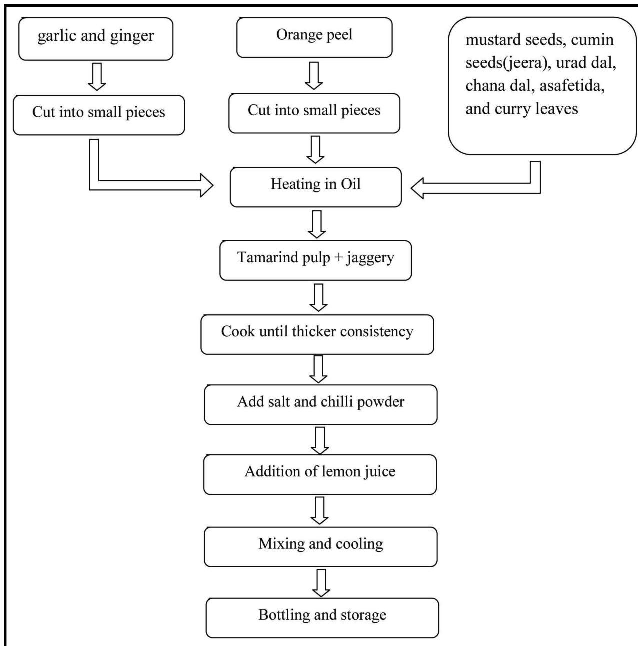

Fig. A : Flow chart for the orange peel pickle development

Physicochemical and sensory analysis:

Physicochemical composition *i.e.,* moisture content, carbohydrates, ash content, salt (as NaCl), fat content, protein content, energy value and titratable acidity (% citric acid) of orange peel pickle was analyzed using methods explained by Ranganna (2007). Sensory analysis carried out as 5-point hedonic scale (Berdos *et al.,* 2021).

Storage study:

Developed orange peel pickle was stored for 60 days. Changes in the physicochemical parameters were analyzed at 10 days interval.

RESULTS AND DISCUSSION

Physicochemical analysis of orange peel pickle:

The physicochemical analysis of the developed orange peel pickle was conducted to evaluate its nutritional composition and other key parameters (Table 1). The analysis revealed that the pickle had an energy value of 272.82 Kcal per 100 grams, indicating its caloric content. The carbohydrate content was measured at 31.57 grams per 100 grams, contributed to the overall energy value.

Protein content was calculated as nitrogen multiplied by a factor of 6.25. It was found to be 3.74 g/100g.The fat content of the orange peel pickle was determined to be 14.62 g/100g. The moisture content was observed to be 42.95 g/100g. Ash content represented the total mineral content, was quantified at 7.12 g/100g. Acidity (expressed as citric acid) was measured at 1.91%, indicating the level of sourness or tartness in the pickle. Additionally, the salt content, expressed as sodium chloride (NaCl), was found to be 5.64%. These findings provided a comprehensive understanding of the nutritional and chemical properties of the orange peel pickle, contributing to the overall assessment of its quality and potential health benefits. The presence of bioactive compounds like flavonoids, carotenoids, and limonoids further enhances its nutritional value and potential health benefits (Maqbool *et al.*, 2023).

Table 1 : Physicochemical analysis of developed orange peel pickle

Sr. No.	Test parameter	Value	Unit
1.	Energy value	272.82	Kcal/100gm
2.	Carbohydrates	31.57	g/100gm
3.	Protein (N x 6.25)	3.74	g/100gm
4.	Fat	14.62	g/100gm
5.	Moisture	42.95	g/100gm
6.	Ash	7.12	g/100gm
7.	Acidity (as citric acid)	1.91	%
8.	Salt (as NaCl)	5.64	%

Storage study of the orange peel pickle:

Changes in carbohydrates in orange peel pickle:

Carbohydrates has been gradually decreased 31.50 to 29.00% has been decreased in 60 days. Orange peel contain high percentage of carbohydrates. The enzymes present in the orange peel could break down the carbohydrates into simpler sugars. This enzymatic activity could be more pronounced during the initial stages of the pickling process, leading to a decrease in carbohydrate content (Kim *et al.*, 2016). As the orange peel pickle undergoes storage, enzymatic activity continues. Initially, enzymes are more active, leading to the breakdown of carbohydrates. This enzymatic hydrolysis results in a gradual decrease in carbohydrate content over time, as shown in Fig. 1.

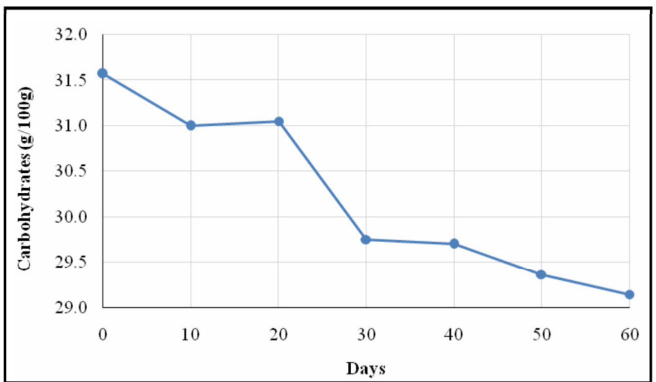

Fig. 1 : Changes in carbohydrates during storage of orange peel pickle

Changes in fat in orange peel pickle:

The data showed the fat content in orange peel pickle over a 60-day period as shown in Fig. 2. Initially, the fat content was 14.62%, which gradually decreased to 14.00% by the end of the study. The non-significant reduction in fat content over time was attributed to the oxidative degradation of fatty acids and producing peroxides and other oxidative compounds that lowered the overall fat content. Oxidation can cause the breakdown of fat molecules, while hydrolysis can lead to the splitting of fat into glycerol and fatty acids. These reactions can cause the fat content to decrease (Pike, 2024).

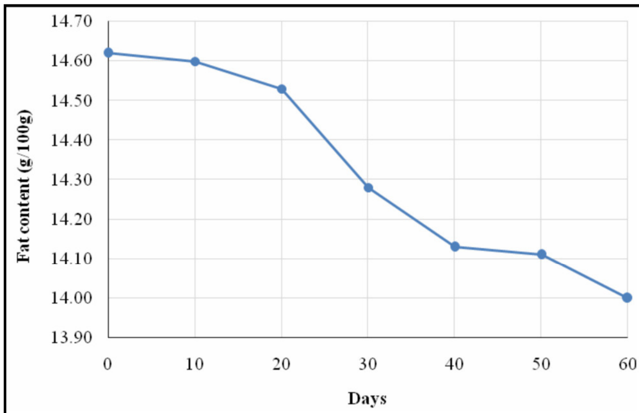

Fig. 2 : Changes in fat content during storage of orange peel pickle

Changes in acidity in orange peel pickle:

The data shows the acidity levels (% citric acid) in orange peel pickle over a 60-day period (Fig. 3). The acidity was found to be stable at 1.91% up to the 20th day. From the 30th day onwards, there was a gradual increase in acidity, reaching 2.05% by the 60th day. This rise in acidity could be due to the fermentation process, where the natural sugars present in the orange peel might have been metabolized by lactic acid bacteria, producing organic acids like citric acid. The breakdown of pectin and other complex carbohydrates in the peel could have contributed to the increase in acidity over time. This also enhanced the preservation of the pickle.

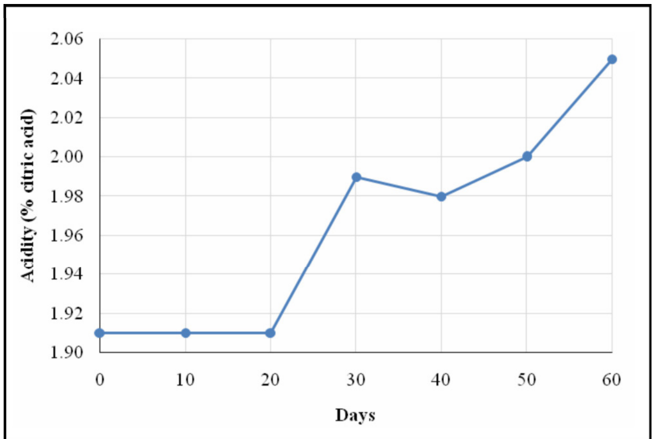

Fig. 3 : Changes in acidity content during storage of orange peel pickle

Changes in protein in orange peel pickle:

The graph (Fig, 4) shows the protein content in orange peel pickle over a 60-day period. Initially, the protein content was 3.74%, which gradually decreased to 2.84% by the 60th day. This decline in protein content could be attributed to the hydrolysis of proteins during storage, where enzymes or microbial activity break down the protein molecules into smaller peptides and amino acids. Additionally, the acidic environment, as indicated by the increase in acidity over time, might have contributed to protein denaturation and degradation. The gradual reduction in protein content reflects these biochemical changes occurring during the storage of the pickle.

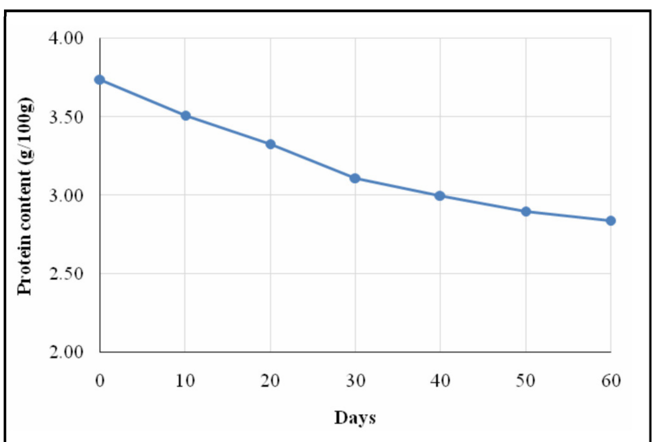

Fig. 4 : Changes in protein content during storage of orange peel pickle

Changes in salt in orange peel pickle:

The data shows the salt content (as NaCl) in orange peel pickle over a 60-day period (Fig. 5). Initially, the salt content was 7.00%, which steadily increased to 8.00% by the 60th day. This rise in salt concentration could be due to the water loss from the pickle through evaporation or osmotic dehydration, concentrating the salt. Additionally, as the pickle matures, the diffusion of salt into the orange peel tissues might stabilize, leading to higher measurable salt levels in the liquid phase. The increase in salt content helps in preserving the pickle by inhibiting microbial growth and enhancing its shelf life.

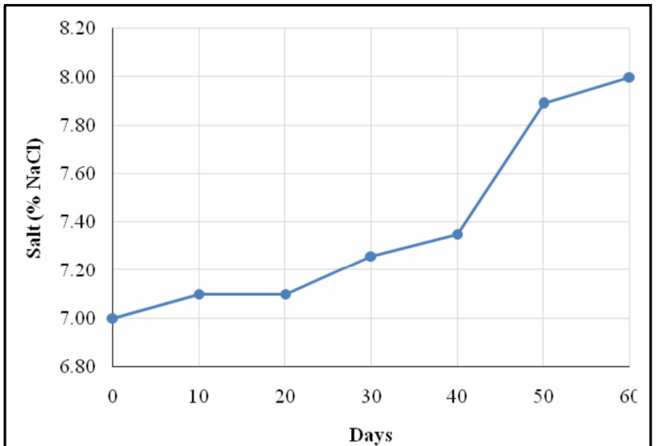

Fig. 5 : Changes in salt content during storage of orange peel pickle

Changes in moisture content in orange peel pickle:

The data shows the moisture content in orange peel pickle over a 60-day period (Fig. 6). Initially, the moisture content was 42.95%, remaining relatively stable until the 30th day, after which it gradually increased, reaching

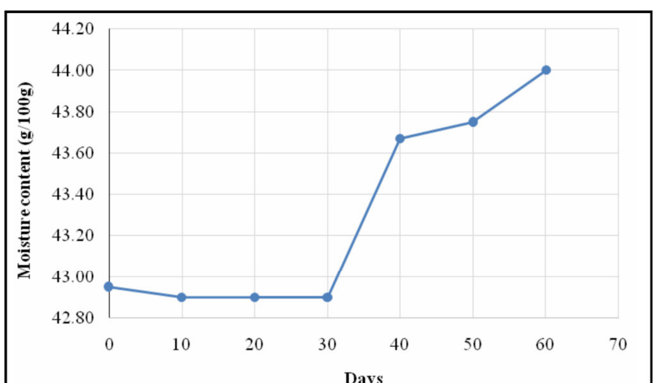

Fig. 6 : Changes in moisture content during storage of orange peel pickle

44.00% by the 60th day. The increase in moisture content could be attributed to osmotic interactions between the ingredients, where water is drawn into the pickle matrix from surrounding solutions. Additionally, the breakdown of pectin and other polysaccharides in the orange peel during fermentation or preservation may have contributed to increased water retention. This rise in moisture could also affect the texture and shelf stability of the pickle over time.

Changes in ash content in orange peel pickle:

The data shows the ash content in orange peel pickle over a 60-day period (Fig. 7). Initially, the ash content was 7.12%, which gradually decreased to 7.02% by the 60th day. Ash content reflects the total mineral composition in the pickle, and the slight reduction over time could be due to the leaching of minerals into the brine or liquid phase of the pickle. This could occur due to osmotic interactions or the breakdown of cell walls in the orange peel, allowing minerals to dissolve and be distributed unevenly. The stability of the ash content indicates that the mineral loss was minimal during the storage period.

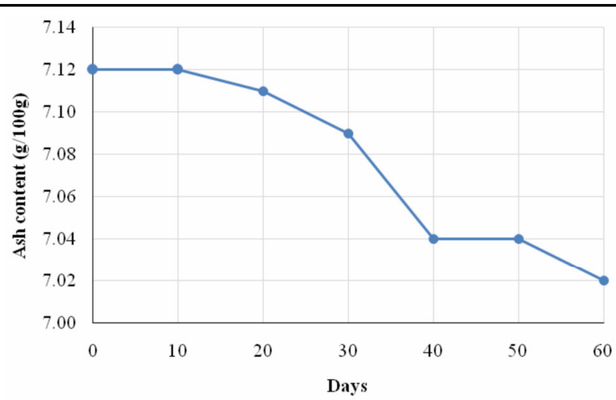

Fig. 7 : Changes in ash content during storage of orange peel pickle

Conclusion:

The process of making orange peel pickle involves several steps, including peeling, cleaning, and slicing oranges, preparing a pickling mixture of spices and salt, and then combining the two to create a flavorful and preserved dish. The preparation requires attention to detail, patience, and a keen sense of taste to balance the flavors. To make an orange peel pickle, one needs fresh oranges, a variety of spices such as mustard seeds, red chili, turmeric, and fenugreek, salt, and optional ingredients like oil or vinegar for added flavor and preservation. The materials used in this pickling process are easily accessible and affordable, making it a cost-effective and versatile dish. The outcome of the orange peel pickle is a tangy, spicy, and flavorful condiment that can be enjoyed with various meals. The pickled orange peels have a unique texture, combining the softness of the fruit's flesh with the crunchiness of the peel. The pickling process not only enhances the taste of the oranges but also extends their shelf life, allowing people to enjoy this fruit even during off-seasons. In conclusion, orange peel pickle is a delightful and flavorful condiment that results from a carefully executed pickling process. The preparation involves a combination of fresh oranges, spices, and optional ingredients, which together create a unique and enjoyable taste experience. This pickle not only adds a burst of flavor to various dishes but also offers a practical way to preserve oranges for future consumption.

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