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FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Effect of addition of mosambi (*Citrus limetta*) peel powder on textural and sensory properties of papaya jam

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Abstract: This study evaluates the influence of addition of mosambi peel powder on jam prepared from papaya. Mosambi peel powder was first analyzed for its proximate composition and other properties. Mosambi peel had high amount of crude fiber (17.6%), besides water and oil-holding capacity (2.26 and 6.82 mL/g, respectively). Mosambi peel was treated with 5% of salt and/or sodium bicarbonate overnight to remove bitterness. Different levels of treated and untreated mosambi peel powder (2.5, 5, 7.5, 10, and 12.5%) were added to papaya jam and were evaluated for texture and sensory properties. The firmness and chewiness values of the jam added with mosambi peel powder increased significantly as compared to control, whereas adhesiveness and cohesiveness values decreased with increasing levels of mosambi peel powder. Sensory evaluation showed that jam prepared by addition of peel powder was acceptable up to 5% level of incorporation. However, jam made by the addition of untreated peel powder was not acceptable due to bitterness resulted from mosambi peel powder.

Subjects: Carbohydrates; Food Analysis; Fruit & Vegetables; Sensory Science

Keywords: mosambi; papaya; jam; texture; peel

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PUBLIC INTEREST STATEMENT

Most of the mosambi fruits are utilized for juice production, generating a large quantity of peel which is generally thrown as waste. Peel contains various valuable components such as dietary fiber. Effective utilization of the peel can lead to value addition of food products, consequently benefiting both the processors and consumers (for instance, delivering functional properties against various diseases such as diabetes and constipation).

1. Introduction

Citrus fruits and juices are important sources of bioactive compounds including antioxidants such as ascorbic acid, flavonoids, phenolic compounds, and pectin which are important for human nutrition (Ebrahimzadeh, Hosseinimehr, & Gayekhlou, 2004; Fernández-López, Zhi, Aleson-Carbonell, Pérez-Alvarez, & Kuri, 2005; Jayaprakasha & Patil, 2007).

Mosambi (*Citrus limetta*) is a species of citrus that belongs to the family *Rutaceae*. It is extremely valued throughout the world for its exceptional nutritional and medicinal properties (Tanaka, 1994). Mosambi fruits are mostly used by juice processing industries, whereas the peel and seeds are usually thrown as waste. Since the juice yield of citrus is less than half of the fruit weight, very large amounts of byproduct wastes such as peel and seeds are generated every year (Manthey & Grohmann, 2001). The citrus wastes are rich in nutrients and contain many phytochemicals that can be efficiently used as components in pharmaceutical drugs or as food supplements (Middleton, Kandaswami, & Theoharides, 2000).

The main byproducts of citrus processing are the peel, pulp, and seeds, which account for 40–60% of the weight of the raw material (Licandro & Odio, 2002). Although most of the citrus byproducts are used for animal feed (Ting & Rouseff, 1986), many useful byproducts can be obtained from different portions of the citrus fruits, such as pectin, marmalades, candied peel, beverage bases, molasses, peel seasoning, purees, dried pulp, citrus alcohol, bland syrup, citric acid, seed oil, and flavonoids (Braddock, 1995; Braddock & Cadwallader, 1992; Licandro & Odio, 2002). Mosambi peels are rich in pectin which is known to possess blood sugar-lowering and cholesterol-lowering properties (Baker, 1994). Mosambi peel can be incorporated in jam as a source of pectin.

Jam is an intermediate moisture food prepared by boiling fruit pulp with sugar (sucrose), pectin, acid, and other ingredients (preservative, coloring, and flavoring materials) to a reasonably thick consistency, firm enough to hold the fruit tissues in position (Baker, Berry, Hui, & Barrett, 2005; Lal, Siddappaa, & Tandon, 1998). Jam is liked and consumed by a large population throughout the world. However, it is not a welcome food for diabetic individuals due to its high sugar content which is instantly released in blood stream. Fiber-rich foods generally have a low-glycemic index. Low-glycemic index, high-fiber diets have been shown to deliver several beneficial effects including lowering postprandial glucose and insulin responses (Riccardi, Rivellese, & Giacco, 2008). In this study, papaya was selected for the preparation of jam. Papaya is normally consumed fresh and is valued as a health food due to high vitamin C and vitamin A contents (Ahamed & Choudhary, 1995). But being a climacteric fruit, papaya has a short post-harvest life, thus, there is increasing interest in finding other alternatives for their consumption, for example, in juices, nectars, puree, concentrates, and fresh-cut and dehydrated cubes (Diaz Mora, 2003; Gonzalez-Aguilar et al., 2008; Paull & Chen, 1997; Salunkhe & Desai, 1984).

2. Materials and methods

2.1. Materials

Fresh and fully matured mosambi (*C. limetta*) fruit peel was procured from the juice sellers of local market in Hisar, India. The peel was free of decay, mold growth, and was of good commercial quality. Fully ripe papaya and other ingredients used in jam were also obtained from the local market. Chemicals used in the study were of laboratory grade.

2.2. Methods

2.2.1. Preparation of mosambi peel powder

Mosambi peel was washed several times to remove any extraneous matter using tap water. The cleaned peel was then scalded in water at 95°C for 4 min to reduce the potential pathogenic microorganisms or vegetative cells (Fernández-López et al., 2004). After heat treatment, mosambi peels were grinded in a laboratory-level grinder (Preethi platinum-MG139750). Then, the material was treated overnight with 5% of salt or 5% of sodium bicarbonate to remove bitterness. The traces of

salt and sodium bicarbonate were removed from the grinded mosambi peel by washing in running water in muslin cloth. Washed mosambi peel powder was then dried at 65°C for 24 h (Sendra et al., 2008) and stored at 4°C.

2.2.2. Proximate compositions of mosambi peel powder

Moisture, crude protein, crude lipid, ash, and crude fiber were estimated using the appropriate Association of Official Analytical Chemists (1999) methods.

2.2.3. Oil- and water-holding capacity of mosambi peel powder

Water- and oil-holding capacity of citrus peel was determined as described by Caprez, Arrigoni, Amadò, and Neukom (1986) and Thibault, Lahaye, and Guillon (1992). The water-holding capacity was expressed as the number of grams of water held by 1 g of sample. The oil-holding capacity was expressed as the number of grams of oil held by 1 g of sample.

2.2.4. Determination of total phenol content of mosambi peel powder

The phenolic compounds were extracted according to the procedure described by Kang, Chawla, Jo, Kwon, and Byun (2006). The total polyphenol content of the mosambi peel powder extract was estimated using Folin–Ciocalteu reagent with absorbance monitoring at 765 nm. The spectrophotometric measurement was repeated three times with each extract and the average value was interpolated on the gallic acid calibration curve and expressed as grams of gallic acid per kilogram of the sample (Singleton, Orthofer, & Lamuela-Raventós, 1999).

2.2.5. Antioxidant activity of mosambi peel powder

The effect of extracts on DPPH free radical was estimated according to the procedure described by Yi, Yu, Lianga, and Zeng (2008). With methanol, 0.2 ml of the sample extract was diluted and 1 ml of DPPH solution (0.5 mM) was added. After 30 min, the absorbance was measured at 517 nm. The percentage of the DPPH radical scavenging was calculated by the following equation:

$$\text{Scavenging activity (\%)} = (1 - A1/A0) \times 100$$

where A0 is the absorbance of the blank (methanol replacing the extract), A1 is the absorbance in the presence of the sample extract

2.2.6. Preparation of jam

The jam was prepared according to formula described by Srivastava and Kumar (2002). The control jam formula based on pulp weight was: 1 kg papaya pulp, 0.75 kg sugar, 3 g citric acid, and 100 ml water. All the mixture was heated to remove excessive moisture up to TSS of 68 B. Different percentages of treated mosambi peel powder viz. 2.5, 5, 7.5, 10, and 12.5% were incorporated in papaya jam. Jam was stored at a refrigerated temperature for further analysis.

2.2.7. Textural analysis of jam

The texture analysis was performed directly in the wide-neck bottles at the ambient temperature with a Texture analyzer TA.XT plus, using back extrusion procedure. On the basis of the preliminary work, the instrument working parameters were determined with the test mode compression, pretest speed at 1.0 mm/s, test speed at 1.0 mm/s, post-test speed at 10.0 mm/s, distance 10.0 mm, trigger force at 10.0 g, and data acquisition rate at 200 pp. The data were analyzed using Texture expert Version 1.22 Software to measure the firmness, chewiness, adhesiveness, and cohesiveness of the samples.

2.2.8. Sensory analysis of jam

Sensory analysis of jam was performed by a panel of 10 members. The products were served on white disposable plastic trays and tap water was provided for rinsing. The products were evaluated for color and appearance, texture, taste, and overall acceptability using nine-point hedonic scale (Ranganna, 2008).

2.2.9. Statistical analysis

The results were analyzed statistically using SPSS 16.0 software (IBM). Data were subjected to one-way ANOVA and Duncan’s test to find significant difference in treatments. A value of $p \leq 0.05$ was used to indicate significant difference.

3. Results and discussion

3.1. Proximate composition of mosambi peel powder

Untreated mosambi peel powder had 10.70% moisture, 5.39% protein, 1.58% fat, 3.39% ash. A good quantity (17.58%) of crude fiber was present in mosambi peel powder.

3.2. Total polyphenolic content and antioxidant activity of mosambi peel powder

Total polyphenol content and antioxidant activity of untreated mosambi peel powder was 1.92 and 89.50%, respectively (Table 1). Mosambi peel powder treated with salt and sodium bicarbonate resulted in a significant decrease in their total polyphenol content and antioxidant activity in comparison to control mosambi peel powder. Among the treatments, lowest total polyphenol content and antioxidant activity were found in mosambi peel powder treated with sodium bicarbonate.

This decrease in total polyphenol content and antioxidant activity may be due to solubility of polyphenols in salt or sodium bicarbonate solutions.

3.3. Oil- and water-holding capacity of mosambi peel powder

Effects of salt and sodium bicarbonate on functional properties of mosambi peel powder have been presented in Table 2. Oil-holding capacity (OHC) of control mosambi peel powder was 2.26 ml/g. There was significant improvement in OHC of mosambi peel powder treated with salt and sodium bicarbonate. The OHC of mosambi peel powder treated with salt and sodium bicarbonate was 2.57 ml/g and 2.38 mg/g, respectively. In both types of treated mosambi peel powder, highest OHC was observed in mosambi peel powder treated with salt. Control mosambi peel powder had WHC of 6.82 ml/g. WHC increased in treated samples and significant difference in comparison to control was noticed in both types of treated samples. Highest WHC was observed in mosambi peel powder treated with sodium bicarbonate followed by salt-treated sample.

Table 1. Total polyphenol and antioxidant activity of mosambi peel powder

Treatment	TPP (%)	AOA(%)
MPP	1.92 ± 0.12	89.50 ± 1.11
ST	0.64 ± 0.04	63.41 ± 2.60
SBT	0.59 ± 0.01	30.31 ± 2.64

Notes: Values indicated as Mean ± SD.

MPP: Mosambi peel powder without treatment, ST: Salt-treated mosambi peel powder, SBT: Sodium bicarbonate-treated mosambi peel powder, TPP: Total Polyphenol content of mosambi peel powder, AOA: Antioxidant activity of mosambi peel powder.

Table 2. Oil- and water-holding capacity of mosambi peel powder

Treatment	OHC (ml/g)	WHC (ml/g)
MPP	2.26 ± 4.51	6.82 ± 9.29
ST	2.57 ± 7.02	8.22 ± 9.30
SBT	2.38 ± 5.0	9.30 ± 21.39

Notes: Values indicated as Mean ± SD.

MPP: Mosambi peel powder without the treatment of salt and sodium bicarbonate, ST: Mosambi peel powder with Salt treatment, SBT: Mosambi peel powder with Sodium bicarbonate treatment, OHC: Oil-holding capacity of Mosambi peel powder, WHC: Water-holding capacity of Mosambi peel powder.

Functional properties of fiber are related to the structure of constituent polysaccharides and may be influenced by porosity, particle size, ionic form, pH, ionic strength, and type (Fleury & Lahaye, 1991; Robertson, 1987). So, it is clear that the ionic form and ionic strength of mosambi peel increased due to salt or sodium bicarbonate treatment. Due to this reason, oil-holding capacity and water-holding capacity of mosambi peel were improved.

3.4. Effect of addition of mosambi peel powder on texture of papaya jam

The results presented in Table 3 show the textural properties of papaya jam containing different levels of treated and untreated mosambi peel powder. Texture profile analysis depicted an increase in firmness and chewiness of all types of jam in comparison to control. As the level of mosambi peel powder was increased higher values of firmness were observed in all types of jams. A significant decrease in cohesiveness with respect to control was observed in all types of jam. No significant difference was observed in chewiness between control and untreated mosambi peel powder jam and salt-treated mosambi peel powder jam up to 2.5% level. Significantly higher values of adhesiveness were experienced in all types of jam compared to control.

It is well known that mosambi peel is good source of pectin. It is due to pectin, the jam sets, gives it a desired shape and firmness. Mosambi peel, like other fruit dietary fiber, contains pectin and shows a high WHC, which aids in the gel formation and texture stability of the product by avoiding syneresis. Syneresis or weeping occurs in many food products with a gel structure, including jams and yoghurt, when water is no longer physically bound to the food system. Because of the water affinity of fruit dietary fiber, it can prevent syneresis by binding the released water (Kuntz, 1994). Therefore, as the concentration of mosambi peel powder was increased in papaya jam, firmness increased because pectin content also increased.

Table 3. Effect of addition of mosambi peel powder on textural properties of jam

Treatment	Firmness	Chewiness	Adhesiveness	Cohesiveness
Control	6.82 ± 0.035 ^a	5.65 ± 0.12 ^a	-13.88 ± 0.1 ^a	0.83 ± 0.02 ^a
UTJ				
2.5%	8.32 ± 0.11 ^b	6.07 ± 0.15 ^a	-14.77 ± 0.71 ^a	0.76 ± 0.15 ^a
5%	13.41 ± 0.91 ^c	8.72 ± 0.12 ^b	-22.82 ± 0.15 ^b	0.66 ± 0.22 ^a
7.5%	20.33 ± 0.72 ^d	12.92 ± 0.46 ^c	-26.65 ± 0.30 ^c	0.65 ± 0.23 ^a
10%	29.33 ± 0.71 ^e	30.45 ± 1.01 ^d	-26.70 ± 0.95 ^c	0.57 ± 0.20 ^a
12.5%	40.64 ± 1.02 ^f	45.62 ± 0.40 ^e	-29.42 ± 0.95 ^d	0.47 ± 0.22 ^a
STJ				
2.5%	9.54 ± 0.34 ^b	6.35 ± 0.36 ^a	-17.31 ± 1.0 ^b	0.67 ± 0.26 ^{ab}
5%	15.59 ± 0.4 ^c	11.74 ± 1.0 ^b	-18.34 ± 0.21 ^b	0.65 ± 0.18 ^{ab}
7.5%	38.59 ± 0.43 ^d	14.56 ± 1.0 ^c	-24.64 ± 0.58 ^c	0.49 ± 0.17 ^{bc}
10%	82.68 ± 1.0 ^e	36.95 ± 0.87 ^d	-26.79 ± 2.08 ^d	0.43 ± 0.05 ^{bc}
12.5%	92.97 ± 1.0 ^f	42.31 ± 0.90 ^e	-27.90 ± 0.64 ^d	0.30 ± 0.22 ^c
SBTJ				
2.5%	30.39 ± 1.32 ^b	16.46 ± 0.76 ^b	-35.65 ± 0.50 ^b	0.65 ± 0.12 ^{ab}
5%	39.36 ± 0.69 ^c	22.81 ± 0.21 ^c	-43.58 ± 1.0 ^c	0.59 ± 0.21 ^{ab}
7.5%	44.54 ± 1.0 ^d	23.31 ± 1.53 ^{cd}	-54.06 ± 1.52 ^d	0.53 ± 0.2 ^{ab}
10%	48.43 ± 0.33 ^e	24.42 ± 1.0 ^{cd}	-55.49 ± 1.0 ^d	0.44 ± 0.01 ^b
12.5%	60.63 ± 1.37 ^f	25.23 ± 1.8 ^d	-71.89 ± 1.73 ^e	0.41 ± 0.01 ^b

Notes: Mean ± SD with different superscripts in a column for a particular parameter differ significantly ($p \leq 0.05$).

UTJ: Untreated mosambi peel powder jam, SBTJ: Sodium bicarbonate-treated mosambi peel powder jam, STJ: Salt-treated mosambi peel powder jam.

Table 4. Effect of addition mosambi peel powder on sensory quality jam

Percentage levels	Color and appearance	Texture	Taste	Overall acceptability
Control				
0%	8.7 ± 0.26 ^a	8.56 ± 0.16 ^a	7.81 ± 0.26 ^a	8.36 ± 0.14 ^a
UTJ				
2.5%	7.8 ± 0.26 ^b	7.76 ± 0.14 ^b	4.61 ± 0.15 ^b	6.72 ± 0.10 ^b
5%	7.56 ± 0.36 ^{bc}	7.01 ± 0.12 ^c	4.23 ± 0.20 ^c	6.27 ± 0.20 ^c
7.5%	7.44 ± 0.15 ^{bc}	6.55 ± 0.13 ^d	2.21 ± 0.20 ^d	5.4 ± 0.26 ^d
10%	7.26 ± 0.18 ^c	6.23 ± 0.12 ^e	1.33 ± 0.11 ^e	4.94 ± 0.07 ^e
12.5%	7.13 ± 0.22 ^c	5.9 ± 0.10 ^f	1.43 ± 0.26 ^e	4.82 ± 0.14 ^e
STJ				
2.5%	8.32 ± 0.20 ^b	7.27 ± 0.20 ^b	7.34 ± 0.20 ^b	7.64 ± 0.15 ^b
5%	8.44 ± 0.02 ^{ab}	7.08 ± 0.11 ^b	6.76 ± 0.15 ^c	7.43 ± 0.20 ^{bc}
7.5%	8.13 ± 0.04 ^b	7.16 ± 0.15 ^b	6.47 ± 0.19 ^c	7.25 ± 0.15 ^c
10%	7.36 ± 0.23 ^c	7.03 ± 0.11 ^b	5.61 ± 0.09 ^d	6.67 ± 0.19 ^d
12.5%	7.03 ± 0.19 ^d	5.8 ± 0.10 ^c	5.03 ± 0.04 ^e	5.95 ± 0.18 ^e
SBTJ				
2.5%	8.47 ± 0.20 ^{ab}	7.43 ± 0.17 ^b	8.19 ± 0.16 ^a	8.03 ± 0.16 ^b
5%	8.33 ± 0.11 ^b	7.29 ± 0.36 ^b	7.61 ± 0.14 ^b	7.81 ± 0.14 ^b
7.5%	7.83 ± 0.13 ^c	7.22 ± 0.19 ^{bc}	7.19 ± 0.26 ^c	7.38 ± 0.18 ^c
10%	7.15 ± 0.10 ^d	6.83 ± 0.13 ^c	6.56 ± 0.17 ^d	6.85 ± 0.10 ^d
12.5%	6.93 ± 0.08 ^d	6.26 ± 0.12 ^d	5.84 ± 0.83 ^e	6.35 ± 0.13 ^e

Notes: Means ± SD with different superscripts in a column for a particular parameter differ significantly ($p \leq 0.05$).

UTJ = Untreated mosambi peel powder jam, SBTJ = Sodium bicarbonate-treated mosambi peel powder jam, STJ = Salt-treated mosambi peel powder jam.

3.5. Sensory evaluation of jam incorporated with different levels of mosambi peel powder

Sensory scores of papaya jam containing different levels of mosambi peel powder are presented in Table 4. The addition of treated mosambi peel powder was found to be acceptable up to 5% level of addition. However, as the level of mosambi peel powder was increased sensory scores decreased significantly as compared to the control. Lower scores were noticed in untreated mosambi peel powder incorporated jam as compared to the other types of jam due to bitterness resulted from untreated mosambi peel powder.

4. Conclusion

This study demonstrated the feasibility of using some byproduct from food industry as food ingredients. The results showed that the mosambi peel powder had significant effects on the functional and technological properties. Furthermore, mosambi peel powder had high WHC and OHC values, which can be exploited for food applications. Moreover, it is a good source of total polyphenols and has good antioxidant properties which will make it a useful ingredient in the preparation of various food products. Overall, the results suggested that mosambi waste could be used as a raw material for many products. From industrial point of view, mosambi peel which is the residues from processing industry could be further processed for value addition of various food products.

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References

- Ahamed, J., & Choudhary, D. R. (1995). Osmotic dehydration of papaya. *Indian Food Packer*, 49, 5–9.
- Association of Official Analytical Chemists. (1999). *Official method of analysis* (15th ed.). Washington, DC: Author.
- Baker, R. A. (1994). Potential dietary benefits of citrus pectin and fiber. *Food Technology*, 48, 133–138.
- Baker, R. A., Berry, N., Hui, Y. H., & Barrett, D. M. (2005). Food preserves and jams. In D. M. Barrett, L. Somogyi, & H. S. Ramaswamy (Eds.), *Processing fruits: Science and technology* (2nd ed., 113–125). Boca Raton, FL: CRC Press.
- Braddock, R. J. (1995). By-products of citrus fruit. *Food Technology*, 49, 74–77.
- Braddock, R. J., & Cadwallader, K. R. (1992). Citrus by-products manufacture for food use. *Food Technology*, 46, 105–110.
- Caprez, A., Arrigoni, E., Amadó, R., & Neukom, H. (1986). Influence of different types of thermal treatment on the chemical composition and physical properties of wheat bran. *Journal of Cereal Science*, 4, 233–239.
[http://dx.doi.org/10.1016/S0733-5210\(86\)80025-X](http://dx.doi.org/10.1016/S0733-5210(86)80025-X)
- Diaz Mora, M. M. (2003). *Evaluación preliminar de la vida de anaquel de papaya deshidratada osmóticamente con película de quitosano* [Preliminary evaluation of the shelf life of papaya osmotically treated with chitosan films] (Bachelor thesis). Food Engineering. Department of Chemical and Food Engineering, School of Engineering, Universidad de las Américas Puebla, Cholula.
- Ebrahimzadeh, M. A., Hosseinimehr, S. J., & Gayekhlou, M. R. (2004). Measuring and comparison of vitamin C content in citrus fruits: Introduction of native variety. *Chemistry: An Indian Journal*, 1, 650–652.
- Fernández-López, J., Fernández-Ginés, J. M., Aleson-Carbonell, L., Sendra, E., Sayas-Barberá, E., & Pérez-Alvarez, J. A. (2004). Application of functional citrus by-products to meat products. *Trends in Food Science & Technology*, 15, 176–185.
<http://dx.doi.org/10.1016/j.tifs.2003.08.007>
- Fernández-López, J., Zhi, N., Aleson-Carbonell, L., Pérez-Alvarez, J. A., & Kuri, V. (2005). Antioxidant and antibacterial activities of natural extracts: Application in beef meatballs. *Meat Science*, 69, 371–380.
<http://dx.doi.org/10.1016/j.meatsci.2004.08.004>
- Fleury, N., & Lahaye, M. (1991). Chemical and physicochemical characterization of fibers from *Laminaria digitata* (Kombu Breton): A physiological approach. *Journal of Science of Food & Agriculture*, 55, 389–400.
- Gonzalez-Aguilar, G. A., Valenzuela-Soto, E., Lizardi-Mendoza, J., Goycoolea, F., Mart Anez Tllez, M. A., Villegas-Ochoa, M. A., Monroy-García, I. N., & Ayala-Zavala, J. F. (2008). Effect of chitosan coating in preventing deterioration and preserving the quality of fresh-cut papaya 'Maradol'. *Journal of Science of Food & Agriculture*, 89, 15–23.
- Jayaprakasha, G. K., & Patil, B. S. (2007). In vitro evaluation of the antioxidant activities in fruit extracts from citron and blood orange. *Food Chemistry*, 101, 410–418.
<http://dx.doi.org/10.1016/j.foodchem.2005.12.038>
- Kang, H. J., Chawla, S. P., Jo, C., Kwon, J. H., & Byun, M. W. (2006). Studies on the development of functional powder from citrus peel. *Bioresource Technology*, 97, 614–620.
<http://dx.doi.org/10.1016/j.biortech.2005.03.037>
- Kuntz, L. A. (1994). Fiber: From frustration to functionality. *Food Product Design*, 2, 91–108.
- Lal, G., Siddappa, G. S., & Tandon, G. L. (1998). *Preservation of Fruits and Vegetables*. New Delhi: ICAR Publication.
- Licandro, G., & Odio, C. E. (2002). Citrus by-products. In G. Dugo & A. Di Giacomo (Eds.), *Citrus: The genus citrus* (pp. 159–178). London: Taylor and Francis.
- Manthey, A., & Grohmann, K. (2001). Phenols in citrus peel byproducts: Concentrations of hydroxycinnamates and polymethoxylated flavones in citrus peel molasses. *Journal of Agriculture & Food Chemistry*, 49, 3268–3272.
- Middleton, E., Kandaswami, C., & Theoharides, T. C. (2000). The effects of plant flavonoids on mammalian cells: Implications for inflammation, heart disease, and cancer. *Pharmacological Reviews*, 52, 673–751.
- Paull, R. E., & Chen, W. (1997). Minimal processing of papaya (*Carica papaya* L.) and the physiology of halved fruit. *Postharvest Biology & Technology*, 12, 93–99.
- Ranganna, S. (2008). *Sensory evaluation in analysis and quality control for fruit and vegetable products* (pp. 623–624). New Delhi: McGraw-Hill.
- Riccardi, G., Rivellese, A. A., & Giacco, R. (2008). Role of glycemic index and glycemic load in the healthy state, in prediabetes, and in diabetes. *American Journal of Clinical Nutrition*, 87, 269–274.
- Robertson, J. A. (1987). Physicochemical characteristics of food and digestion of starch and dietary fibre during gut transit. *Proceedings of the Nutrition Society*, 47, 143–152.
- Salunkhe, D. K., & Desai, B. B. (1984). *Postharvest biotechnology of fruits* (Vol. 2, p. 147). Boca Raton, FL: CRC Press.
- Sendra, E., Lario, Y., Sayas-Barbera, E., Perez-Alvarez, J. A., Aleson-Carbonell, L., Fernandez-Gines, J. M., & Fernandez-Loez, J. (2008). Obtention of lemon fibre from lemon juice by-products. *Agro Food Industries*, 19, 22–24.
- Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods in Enzymology*, 299, 152–178.
[http://dx.doi.org/10.1016/S0076-6879\(99\)99017-1](http://dx.doi.org/10.1016/S0076-6879(99)99017-1)
- Srivastava, R. P., & Kumar, S. (2002). *Jam, jelly and marmalade in fruit and vegetable preservation principles and practices* (pp. 215–216). Lucknow: International book distributing company.
- Tanaka, T. (1994). Species problem in Citrus: A critical study of wild and cultivated units of Citrus, based upon field studies in their native homes. *Revisio Aurantiacearum*, 9, 115–117.
- Thibault, J. F., Lahaye, M., & Guillon, F. (1992). Physico-chemical properties of food plant cell walls. In T. F. Schweizer & C. A. Edwards (Eds.), *Dietary fibre—A component of food: Nutritional function in health and disease* (pp. 21–39). London: Springer Verlag.
- Ting, S. V., & Rouseff, R. L. (1986). *Citrus fruits and their products: Analysis and technology* (p. 293). New York, NY: Marcel Dekker.
- Yi, Z., Yu, Y., Lianga, Y., & Zeng, B. (2008). In vitro antioxidant and antimicrobial activities of the extract of Pericarpium Citri Reticulatae of a new citrus cultivar and its main flavonoids. *Food Science and Technology*, 41, 597–603.



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