Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 3032-3036
Received: 16-07-2018
Accepted: 18-08-2018

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Value addition and sensory evaluation of products made from underutilized Kachai Lemon (*Citrus jambhiri*) Lush. fruits

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Abstract
Kachai Lemon (*Citrus jambhiri*) Lush. fruits and peel were processed into various value added products like Kachai lemon Squash (KLS), Kachai lemon salt pickle (KLP), Kachai lemon sweet pickle (KLSP), Kachai lemon sweet pickle without oil (KLSPWO), Kachai lemon candied peel (KLCP), Kachai lemon candied peel with chocolate (KLCP-CH), Kachai lemon candied fruit slices (KLCFS), Kachai lemon candied fruit slices with chocolate (KLCFS-CH), Kachai lemon jelly (KLJ) and Kachai lemon and Prunus (*Prunus napaulensis*) jelly (KLPJ). All the products were subjected to sensory evaluation and were well accepted. LP, KLSP and KLPJ received the highest scores for overall acceptability with a score of 8.20 on a 9 point hedonic scale indicating the best way to preserve the highly perishable fruits. Kachai lemon fruits and their by-products (peel) can serve as an alternative source of income to the farmers growing the fruits by appropriate value addition.

Keywords: Kachai lemon; processing; value addition; underutilized; sensory evaluation.

Introduction
Citrus fruits have been cultivated for over 4000 years (Davies and Albrigo, 1994) [3] and are the most produced fruit crops in the world. There are many varieties of citrus fruits in the region of Asia that have distinct flavour characteristics and are only consumed locally. Lemon constitutes an important fresh fruit group even though it is not eaten fresh as mandarins and oranges. They usually have high acid content although acidless cultivars also exist. It is used primarily for drinks and fresh juice or lemonade, cooking and flavouring, especially in the making of lemon pies, lemon cakes, candies, jams and marmalades, and also for medicinal purposes due to its high content of vitamins (Ortiz, 2002) [24].

Kachai lemon is one variety of citrus crop grown widely in Manipur state, especially in Kachai village of Ukhrul district. Citrus is one of the leading crop in North Eastern States which contributes to 55% of total fruit production (Singh, 2004 and Hazarika, 2012) [30, 5]. Every household of Kachai village has no less than 50 to 100 Lemon trees on their private own lands. The village produces more than 600kgs of lemon per year, thus earning an additional income, apart from the other income generated through paddy cultivation (Ray, 2002). However the income is only seasonal as Kachai lemon generally starts bearing fruits from November and continues till April (Malik *et al*., 2013) [15].

With many horticultural interventions, production and area expansion of the Kachai lemon crop have tremendously increased, but because of transport bottleneck coupled with non-availability of credit support, farmers fail to get remunerative price for their lemon as no processing units are established for processing of lemon (Ram *et al*., 2012) [27]. Other citrus crops like sweet lime and mandarin can easily be sold in the local market, whereas fresh lime and lemon are difficult to sell, fetching low prices in the production season when the fruits are abundant (Liu, 2003) [12]. Huge quantities of Kachai lemon are wasted every year (Malik *et al*., 2010) [14]. Local processing of citrus fruits into products that can be kept for a longer time, and for which there is a high demand in rural areas as well as in nearby cities, makes good use of such resources that might otherwise be lost. The processing of Kachai lemon has the additional benefit of generating local employment and raising the income of those community members involved.

Apart from income through value addition, Kachai Lemon is considered to be having highest ascorbic acid, which is 51% while other lemon cultivars have only 20 to 30%. The flavor of this lemon is very refreshing and pleasant with good amount of rich polyphenolic compounds such as flavonoids. These compounds act as functional ingredients in promotion of health and

prevention of degenerative diseases (Ngaorai, 2014) [23]. Hence use of appropriate pre and post-harvest practices is vital for the success of nutritious Kachai lemon processing and to provide good returns to the growers by value addition. Hence an attempt was made to develop, standardize value added products with Kachai lemon, so that the processing techniques developed can be adopted by farmers/women/entrepreneurs to increase their income by producing high quality value added products.

Methodology

Primary processing

Fresh Kachai lemon fruits were procured from ICAR-NEH complex Manipur, Imphal. Freshly harvested Kachai lemon fruits were used for product development. Ingredients required for developing value added products were purchased from local markets to formulate different products.

The primary processing of Kachai lemon included cleaning, cutting, juice extraction and blanching. Kachai lemons were sorted out, separated from bruised and damaged fruits, then washed thoroughly in fresh tap water to remove the dust and extraneous material. The adhering moisture was removed by using muslin cloth. One set of cleaned Kachai lemon were cut into two halves to remove the seeds and the juice was extracted from them. The extracted juice was stored in sterilized bottles for secondary processing. The peel of kachai lemon, a byproduct was blanched in 5% salt solution for 20 minutes. Blanching was repeated again after 20 minutes to ensure that the bitterness in the peel is completely removed. The blanched peel was dried on a muslin cloth to remove the excess moisture (Lal, 1967) [10]. Another set of whole Kachai lemon were used to make value added products like pickles, Jelli and candied peel products.

Secondary processing

The primary processed Kachai lemon juice and peels were used to develop different products. Whole Kachai lemon was used for making pickles (sweet pickle and salt pickle); extracted juice was used in making squash, fruit extract was used for making jelly; peel of Kachai lemon and whole fruit with peel was used to make candied peel and candied fruit slices (with and without chocolate coating).

Kachai lemon Squash (KLS)**:** Squash is a type of fruit beverage containing 25–33% fruit juice or pulp, 40–50% total soluble solids (TSS), 1.0% acid, and 350ppm sulfur dioxide. Kachai lemon squash was prepared with Kachai lemon juice (22.3%), sugar and water; and its brix was adjusted to 45% (Srivastava and Sanjeev, 2006) [31]. Sodium benzoate (600ppm) was added and filtered and stored in sterilized pet bottles. KLS was diluted with chilled water before serving in 1:3 ratio of squash and water (Jood and Ketarpaul, 2002) [9] to serve as RTS beverage.

Kachai lemon pickle: Three variants of pickles were made with Kachai lemon; Kachai lemon salt pickle (KLP), Kachai lemon sweet pickle (KLSP) and Kachai lemon sweet pickle without oil (KLSPWO). Regular traditional method (Srivastava and Sanjeevkumar 2006) [31], was followed to make Kachai lemon salt pickle (KLP), with 64% Kachai lemon and other ingredients ie., salt, oil and chilli powder. The pickle can be stored upto one year under ambient temperature (30 °C±5 °C). The Kachai lemon sweet pickle (KLSP) was formulated by adding Kachai lemon (60.6%), and other ingredients ie. jaggery and spices (king chilli, fenugreek, cumin seed powders, salt, turmeric, chilli and oil). The unique flavored sweet pickle without oil (KLSPWO) is a combination of sweet, spicy and tangy taste. KLSPWO was prepared using sliced Kachai lemon (37.1%) boiled in sugar syrup, added with salt and spices (green chilli, salt, cumin, fenugreek and turmeric powders). After mixing all ingredients, the product was stored in sterilized glass container for 15 days at 30 °C±5 °C temperature with occasional sun drying. After 15 days KLSPWO was seasoned for used for sensory evaluation.

Candied peel products: Four variants of Kachai lemon peel products were developed - Kachai lemon candied peel (KLCP), Kachai lemon candied peel with chocolate (KLCP-CH), Kachai lemon candied fruit slices (KLCFS) and Kachai lemon candied fruit slices with chocolate (KLCFS-CH). To develop KLCP, the primary processed kachai lemon peel (52%) was further cooked by adding kachai lemon (10%) juice, water and sugar syrup till 55% brix and left in the syrup for 24 hours. The boiling process was repeated after 24 hours and 55% brix was maintained. Later the candied peel was dried in cabinet drier at 60˚C for 8 hours and coated with powdered sugar and cinnamon powder after cooling. The candied peel were packed in LDPE bags and stored in cool dry place (Tulsi, 2017) [37]. These peels can be used as snack or topping to cakes, muffins, breads etc.

KLCP (60%) was coated with dark chocolate to get KLCP-CH. KLCPs were dipped into melted (60 °C±5 °C) dark chocolate and refrigerated for 1 hour. The product was stored in sterilized container. KLCFS-CH (52%) was developed in similar process, where lemon fruit slices along with coated other ingredients (sugar, cinnamon powder) were vacuum dried at 60˚C for 8 hours and further coated with powdered sugar and cinnamon powder. Later chocolate coating was given as for KLCP-CH. KLCFSL-CH can be used as a juicy and healthy relishing snack with chocolaty lemon flavor, and these can also be used as topping on cakes and muffins

Kachai lemon Jellies: Two variants of jellies were developed using methods described by Reddy *et al*. (2014) [28] and Srivastava & Kumar, (2007) [35] with Kachai lemon extract. One variant of Kachai lemon jelly (KLJ) was made using exclusively Kachai lemon extract (25%), sugar, pectin (2%), citric acid (1%). Second variant of Kachai lemon and Prunus (*Prunus nephalensis*) Jelli (KLPJ) was developed using combination of *Prunus nepalensis* extract (27.5%) and Kachai lemon extract (27.5%) and sugar, pectin (2%), citric acid (1%). The mixes were boiled till TSS reached 65% and poured in jelly moulds. KLPJ had very attractive color due to addition of *Prunus* extract and had a sweet and tangy taste.

The sensory assessment of all the products developed was conducted in a purpose-built, ten-booth sensory evaluation laboratory. A panel of 30 members consisted of staff and graduate students of Department of Foods and Nutrition, Professor Jayashankar Telangana State Agricultural University and MFPI - Quality Control laboratory, Hyderabad. All the products prepared were coded using random three-digit numbers and served in transparent glass bowls on three different days with various products for sensory evaluation. Panelists were provided with a glass of water and instructed to sip in between samples. All the panelists were given written instructions and asked to evaluate the products for acceptability based on its colour, flavor, texture, taste and overall acceptability using nine-point

hedonic (0=Dislike extremely to 9=Like extremely) scale (Meilgaard *et al*., 1999) [16, 19].

The data obtained from sensory evaluation was subjected to analysis of variance (ANOVA) to test the difference between means (within in the samples) and were analyzed by the Tukey test at 95% (p<0.05) level of significance using statistical software (SPSS).

Results and Discussion

Oranges, lemons, grapefruits and mandarins represent approximately 98% of the entire industrialized crop. Citrus fruits are processed, mainly to obtain juice, but also, in the canning industry, to produce marmalades and by the chemical industry to extract flavonoids and essential oils (Izquierdo & Sendra, 2003) [8]. Juice is the primary product obtained from citrus fruits (Braddock, 1999) [1] and it is also one of the most important commodities. The citrus juices contain vitamins, minerals, carotenoids, sugars, organic acids, amino acids, phenolics, nucleotides, enzymes, limonoids, lipids, proteins, pectins and other soluble and insoluble solids. Citrus fruits are commonly extracted for their juices and they are widely consumed for their health benefits due to the content of nutrients and other bioactive compounds (McGill *et al*., 2004) [20]. Kachai lemon also known for its rich nutrients is one among the citrus family which is underutilized and hence various value added products were formulated. The products developed with Kachai lemon were subjected to sensory acceptability and the results are presented in table.1.

Table 1: Organoleptic characteristics of Kachai lemon products

S. No	Name of the Products	Colour	Flavour	Texture	Taste	Overall Acceptability
1	KLP	8.13±0.21^{d}	8.13± 0.19 ^{d}	7.73±0.24^{cd}	8.13±0.16^{b}	8.20±0.17^{c}
2	KLSP	7.86±0.19^{cd}	7.93±0.22^{d}	7.86±0.25^{d}	8.00±0.23^{b}	8.20±0.17^{c}
3	KLSPWO	7.53±0.21^{abc}	6.93±0.26 ^{ab}	7.40±0.23^{abcd}	7.13±0.19^{a}	7.40±0.19^{ab}
4	KLS	7.53±0.19^{abc}	7.80±0.29^{cd}	7.53±0.16^{bcd}	8.26±0.22^{b}	8.00±0.21^{bc}
5	KLCP	7.26±0.15^{ab}	6.60±0.25^{a}	7.06±0.28^{abc}	6.60±0.23^{a}	7.06±0.18^{a}
6	KLCP-CH	7.00±0.32^{a}	7.06±0.38^{abc}	6.80 ±0.32^{a}	6.93±0.34^{a}	7.00±0.30^{a}
7	KLCFS	7.20±0.17^{a}	6.86±0.35^{ab}	7.00±0.30^{ab}	7.06± 0.20^{a}	7.13±0.23^{a}
8	KLCFS-CH	7.80±0.22^{bcd}	7.26±0.18^{abc}	7.00±0.19^{ab}	7.93±0.18^{b}	7.86± 0.16 ^{bc}
9	KLJ	7.86±0.16^{cd}	7.46±0.37^{bcd}	7.66±0.25^{bcd}	7.93±0.22^{b}	7.86± 0.25 ^{bc}
10	KLPJ	8.33±0.23^{d}	7.33±0.36^{abcd}	7.86±0.25^{d}	7.80±0.27^{b}	8.20±0.29^{c}
	CD value	0.59698	0.83271	0.71779	0.65751	0.63093

All the values are expressed as Mean ± SD. Comparisons at P<0.05% level

The colour component of all the products received scores between 7.00 ± 0.32 to 8.33 ± 0.23, with KLPJ receiving the highest score. Addition of Prunus extract to lemon improved the colour of the jelly, indicating combined usage of Kachai lemon and Prunus for better sensory acceptability of the products. Results of sensory evaluation of flavor component indicate lowest score of 6.60±0.25 by KLCP and highest score of 8.13± 0.19 by KLP. Pickles made with citrus fruits were always well acceptable by consumers and the results of our study reinforce that Kachai lemon can be effectively used for developing various kinds of pickles. The highest score for flavor in pickle indicate that, lesser the processing conditions, higher is the retention of flavor in Kachai lemon products.

Candied Peel (KLCP) was formulated by blanching the Kachai lemon peel for 20 min (twice) indicating that the flavor components were completely lost due to the process parameters. The delicate flavour of citrus juices is easily changed by heat treatment during processing or storage due to the degradation of some volatile compounds (Pérez-López and Carbonell-Barrachina, 2006) [25, 26]. The compounds found to be responsible for the quality loss of the citrus juices after 24 excessive heat treatment are 1-ethyl-2-formylpirrole, 2-hydroxy-3-methyl-2- cyclopenten-1-one, 5-methyl-2-furaldehyde, 2,5-dimethyl-4-hydroxy-3(2H)-furanone, 2-methyl-4-ethylphenol and alpha-terpineol (Pérez-López *et al*., 2006) [25]. As pickle preparation requires less processing, retention of flavor will also be very high compared to other products.

The flavour quality of citrus fruits can also be affected by various factors, namely agricultural practice, which includes fertilization, climate, rootstock and maturity; the ratio of total sugar and acid present in the juice; the presence of pectin, high molecular weight carbohydrates, bitter compounds like limonin and naringin; as well as presence of volatile compounds (Nagy and Shaw, 1990) [22]. Yet, it is well known that the fresh and uniquely delicate flavour of citrus fruits is mainly contributed by the complex combinations of many volatile compounds blended in the proper proportions (Shaw, 1991; Moshonas and Shaw, 1995) [32, 21]. Kachai lemon can be extensively popularized for development of various kinds of pickles with unique flavor and aroma.

The taste scores obtained for various Kachai lemon products ranged between 7.06 ± 0.20 in KLCFS to 8.26±0.22 in KLS. Beverages such as squashes based on lemon continues to receive a considerable amount of attention reflecting a growing awareness of the potential of this production in the market place. These beverages have high nutritional quality and increased energy value. These could be particularly useful in place where there is lack of food and proper nutrition leading to deficiency of certain nutrients. Kachai Lemon juice and other beverages developed from the juice can be aimed to improve taste, aroma, palatability and also nutritive value.

Among all the products, KLPJ obtained highest overall acceptability (Fig.1) score of 8.20±0.29, which could be due to the attractive colour and the sweet and tang taste. Wang and Stoner., (2008) [38] reported that Prunus fruits rich in anthocyanin's and their health benefits, along with attractive color and taste have generated a great deal of interest among the food processors. Kachai lemon and Prunus fruits can be further explored for formulating various other products. KLPR and KLSP received similar scores (8.20±0.17), followed by KLS (8.00±0.21), indicating that they were well accepted in terms of colour, flavor, texture, taste and overall acceptability. Lime is commonly used in limeade and carbonated beverages, and as a constituent of alcoholic drinks. They can also be used for pickling; for culinary purposes, such as flavouring for jellies, jams and marmalades; as a garnish; for medicinal purposes, especially in the treatment and prevention of scurvy; as well as a source of lime oil (Devi *et al*., 2015, Ziena, 2000, Marina *et al*., 2018, Ting and Rouseff, 1986) [4, 39, 18, 36].

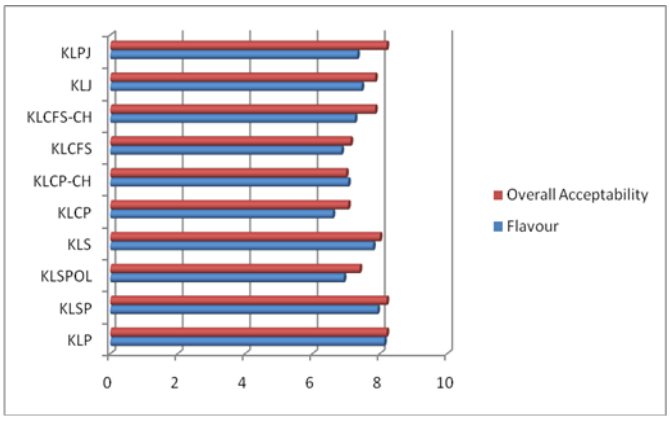

Fig 1: Flavour and Overall acceptability of Kachai Lemon Products.

All the candied peel products received lower scores compared to other products. However, the formulas can be altered to ensure better acceptability and usage of peel of Kachai lemon. Worldwide industrial citrus wastes are estimated at more than 15 million tons (Laufenberg *et al*. 2003, Cohn & Cohn, 1997) [11, 2]. The main by-products of citrus processing are the peel, pulp and seeds, which account for 40-60% of the weight of the raw material (Licandro and Odio, 2002) [13]. These residues can be processed into marketable products and value added food products. Although most of the citrus by-products are used for animal feed (Ting and Rouseff, 1986) [36], there are many useful by-products made from different portions of the citrus fruits, such as pectin, dried pulp, molasses, marmalades, candied peel, peel seasoning, purees, beverage bases, citrus alcohol, bland syrup, citric acid, seed oil, flavonoids peel oil, oil and water-phase essences, pulp sacs, Limonene and other products (Martin 1998, Laufenberg *et al*. 2003, Hendrix, Jr. and Hendrix, 1996; Braddock, 1999; Licandro and Odio, 2002) [17, 11, 6, 1].

In the past, by-products became the source of additional revenue for many citrus processors with low juice values (Braddock, 1999) [1]. Hence, the utilization of citrus by-products to produce more valuable products is getting increasingly important as future world citrus production increases and then surpasses the demand for citrus juices and beverage products. Furthermore, the future uses of citrus byproducts will also need to expand beyond the current major uses as low-value animal feed. Kachai lemon peel processing also can be optimized to make better use of the by-product obtained from Kachai lemon.

Citrus fruits and their by-products are of high economic and medicinal value because of their multipurpose uses, such as in food industry for the preparation of squash, cordial, syrup, marmalade, pickle, salted lime, dried peel etc and also in cosmetics and folk medicine (Silalahi, 2002; Saidani *et al*., 2004) [34, 33]. There is also an increasing demand of "high quality fresh citrus" driven by World Health Organization recommendations. Citrus contain the largest amount of carotenoids found in any fruit and an extensive array of secondary compounds with pivotal nutritional properties such as vitamin E, provitamin A, flavonoids, limonoids, polysaccharides, lignin, fiber, phenolic compounds, essential oils etc (Iglesias *et al*., 2007) [7].

Conclusion

The current rapid growth of the citrus industry is largely due to population increase and improved economic conditions in the consuming nations of the world, together with the rapid advance of agricultural sciences and technology for the production of by-products. The fact that Kachai lemon fruits are a rich source of essential minerals, vitamins and dietary fibres with its distinctive natural flavour and that the consumers are nowadays more nutrition-conscious, can contribute to the increased demand for Kachai lemon products and and their by-products. Although there were differences in sensory characters in prepared value added products, all are well acceptable and formulated products range does not exist in the market. The value-addition initiative allows Kachai lemon farmer producers to gain double income and promote better utilization of underutilized Kachai lemon. Hence Kachai lemon should be extensively promoted for development of various value added products like squashes, pickels, jellies, candied peels etc for income generation as well as to reduce post-harvest losses.

Acknowledgments

The authors acknowledge the financial support received from Department of Biotechnology (DBT), Govt. of India (BT/336/ NE/TBP/2012), Government of India for sponsoring this study under DBT twining project to MFPI - Quality Control Laboratory, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, Telangana and ICAR-NEH Complex, Manipur, Imphal.

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