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Short communication

Underutilized citron (*Citrus medica* L.) fruit for development of value-added products and their ambient storage

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ABSTRACT

The fresh fruits of citron were collected, washed, peel separated, juice extracted, filtered and pasteurized. The juice squash was prepared as per the FPO specifications and juice powder with a standardized protocol. Juice was fed in spray dryer @ 2.5 ml/min., atomized under vacuum conditions at - 30 - 40 mm/WC. Free flow powder recovery was of 10% along with the particle size ranging from 0.44 - 0.77 micron of juice with unaltered flavour, colour, aroma, texture, TSS and reduced vitamin'C' content for 12 months under ambient (32 ± 2°C) storage conditions with acceptable limit of limonin. Citron squash had 12 months shelf-life under ambient storage conditions. The TSS, acidity, colour and pH of squash were recorded to be unchanged except vitamin 'C' and carotenoid contents, which reduced slightly during ambient storage conditions. The pectin and oil content in peel were recorded to be of 0.41 and 0.051%, respectively. However, mature stage leaf oil content was founds to be 0.134%. The oil aldehyde content were analyzed and found higher in leaf than the peel oil, indicating the potentialities of citron fruits value-added products for its commercial scale production.

Key words: Citron, value-addition, juice powder, essential oil, shelf-life.

The citron (*C. medica* L.) is a fruit of *Citrus* species belongs to Rutaceae family. The citron fruits are characterized by thick rind impeded with very thick white albedo inner layer, adherent to segments that cannot be separated easily. Internationally, the fruits are used for fragrance or zest of its outer peel but the most important part is albedo, widely employed in the food industry at larger scale. Thus, from ancient through medieval, the citron was used mainly for medical purposes to combat sea sickness, pulmonary troubles, intestinal ailments, and other disorders. The essential oil of the flavedo (the outermost, pigmented layer of rind) was also regarded as an antibiotic. Citron juice with wine was considered an effective antidote to poison.

However, in India, citron cultivation has not been done on commercial scale as its availability is meagre and unorganized. The National Research Centre for Citrus, Nagpur has very large collection of citrus species but its utilization is limited and untapped. But being an important fruits, all molecules / tissue can be utilized for preparation of different value added products. Therefore, an attempt has been made to utilize the whole citron fruits, juice, peel and leaf for developing the value-added products like juice beverage, juice powder and its shelf-life studies under ambient storage conditions. Extraction of peel oil, peel pectin and leaf oil using latest juice processing method as had been applied successfully in other fruits (Jayaraman and Dasgupta, 7), including spray juice drying technique for developing the juice powder.

The citron fruits were collected from the Experimental Orchard of NRCC, Nagpur, were washed twice in tap water followed by distilled water. The peel was separated, juice extracted and strained through the muslin cloth, which were used for the pasteurization at 90°C for 10 sec and cooled at room temperature. Thereafter, maltodextrin as encapsulating agent was mixed and homogenized for development of juice powder adopting spray drying techniques. The juice powder was deposited in cyclone I and II. This was collected and stored in glass bottle tightened with aluminum foil layer below the plastic lid to protect from the moisture. The juice powder was mixed with the cane sugar powder to reduce its hygroscopicity. However, other products like squash was prepared as per the FPO specification followed for juice (%), acidity (%), TSS (%) and SO_2 concentration from the extracted juice. The squash prepared was kept under storage at ambient (32 ± 2°C) temperature. The homogenized juices were fed into dryer for atomization under vacuum at -35 -40 mm/WC, using spray nozzle and collected the developed powder in cyclone-I and II. The vitamin - 'C' and acidity of fresh juice and juice powder were analyzed calorimetrically (AOAC, 1), colour of juice, juice powder as well as peel and leaf oil by color guard, viscosity by Brookfield viscometer and TSS by digital refractometer. The limonin (Wilson and Crutchfield, 14), carotenoids and optical density for NEB were measured at wavelength

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of 503, 450 and 440 nm, respectively using UV spectrophotometer, Japan (Ranganna, 11). The naringin and hesperidin of value-added products were estimated using Hendrickson *et al.* (5&6) procedure. The pectin was estimated as outlined by Ranganna (12) and oil was extracted from separated peel, while the mature leaves were used to extract the essential oil. The peel oil and leaf oil were extracted by hydro-distillation of their tissues in Clevenger apparatus on fresh weight basis, which was expressed in percent oil content. The flavour, texture and aroma of sensorial attributes was judged on 9 point hedonic scale by the panelists. Experiment was designed in CRD replicated thrice having 20 fruits as unit. The data were analyzed statistically using standard statistical.

The data on total soluble solids shown in Table 1 revealed that TSS value of squash was found to be almost constant throughout the ambient storage which ranges from 41.8% (initial) to 46.0% after 360 days under ambient storage indicating the stability of the squash quality. The acidity content reduced slightly after 180 days in storage and thereafter further decreased and stabilized later on at 300 days of storage. Slight reduction in acid content might be attributed chemical reaction between organic constituent of products (Sharma *et al*., 13). However, vitamin 'C' content reduced drastically at 120 days of storage and remain stable up to 360 days of storage. The loss of ascorbic acid in juice product was found possibly due to heat and photo degradation. It was observed that carotenoids content of squash beverage was stable upto 120 days and thereafter, it decreased to non detectable level under storage conditions. While limonin, naringin, hesperidin and non enzymatic browning value were recorded to be unchanged with slight variation. However, no enzymatic browning were recorded after 180 days under ambient storage indicating that squash of citron fruit juice might have 360 days of its shelf-life under ambient storage conditions, with acceptable limit of limonin which is a bitter compound limiting the citrus processing industry. This is possibly due to masking effect of high sugar content in the squash. These results are corroborated with the findings reported by Ram and Singh (9) in *gal gal*.

The free flow powder recovery in citron juice was of 10% along with the particle size ranged from 0.44 micron (fine) to 0.77 micron (coarse) , respectively in cyclone-I and II. The moisture of the juice powder was observed to be recorded as 2.5 initially at the time of product development, while it was recorded as 3.0% during the ambient storage. The juice powder being highly hygroscopic it was protected from coming in to contact of moisture. The Table 2 revealed that TSS, ascorbic acid, carotenoids, limonin and colour of spray dried juice powder remain unchanged up to 12 months under ambient storage condition which ranges as 9.0% (TSS), 1.08-1.76% (acidity), 8-10 mg/ 100 ml (vitamin-C), 3.41-4.02 ppm (limonin), 0.05-0.04 mg/ ml juice (carotenoids) from the day developed (initial) to 12 months during storage, respectively, indicating the stability in quality of biochemical aspects of the juice powder with unchanged limonin, which ranged between acceptable limits, possibly due to non-thermal process involved in spray drying techniques (Chegini and Ghobadian, 3) . However, the aroma flavour, and texture of juice powder had scored the value between 7-8 during the ambient storage upto 12 months, showing the high acceptability of sensorial attributes by the panelist, which further strengthened stability of the product. Similar findingss on Nagpur mandarin fruit juice powder was also reported by Ram and Singh (9).

The oil content was recorded higher as 0.05 and 0.14% in flavedo and mature leaf of citron fruits,

Table 1. Physico-chemical changes in citron fruit juice and its squashes during storage at ambient conditions.

Parameter	Fresh juice	Squash (Initial)	Storage under ambient conditions (30 ± 2°C)						
			60 day	120 day	180 day	240 day	300 day	360 day	LSD (p = 0.5)
TSS (%)	6.00	41.8	44.0	44.0	45.0	45.0	46.0	46.0	NS
pH	2.54	2.55	2.60	2.81	3.15	3.08	3.11	3.12	0.05
Acidity (%)	4.80	2.05	1.86	1.08	1.98	1.32	1.58	1.44	NS
Vit - 'C' (mg/100ml)	26.00	16.00	14.0	4.00	3.00	4.65	2.50	2.50	2.05
Limonin (ppm)	6.25	5.96	6.39	5.59	3.65	3.50	3.85	4.01	0.03
Naringin (%)	0.98	0.41	0.54	1.19	0.51	2.05	2.05	2.09	NS
Hesperidin (%)	1.52	0.14	0.58	0.59	0.54	1.85	1.76	1.66	NS
Carotenoids (mg/ml)	0.00	0.011	0.01	0.00	0.00	0.00	0.00	0.00	NS
NEB (OD_{440} nm)	0.28	1.813	1.23	0.76	0.61	0.00	0.00	0.00	0.05

Table 2. Changes in chemical composition of citron juice powder under ambient storage conditions.

Parameter	Fresh juice	Juice powder in ambient storage (30 ± 2°C)		
		Initial*	6 month**	12 month
TSS (%)	9.0	9.0	9.00	9.00
Acidity (%)	6.14	1.08	1.76	1.34
Vit 'C' (mg/ 100ml)	32.0	10.0	8.00	9.00
Limonin (ppm)	5.57	3.41	3.61	4.02
Carotenoid (mg/ml)	-	0.05	0.05	0.04
Colour L*	1.27	1.00	0.79	3.47
a*	-0.10	-0.12	0.11	0.17
b*	0.35	0.04	-0.50	-0.72
a/b*	-0.28	-3.00	-0.22	-0.23
Flavour	7.5	7.0	7.0	7.0
Aroma	8.1	7.4	7.5	7.5
Texture	8.0	7.2	7.1	7.0

*L = lightness/darkness, a = greenness, b = yellowness, a/b = orange

Table 3. Physico-chemical quality of peel and leaf oil in citron fruits.

Parameter	Peel	Leaf
Oil (%)	0.052	0.14
Aldehyde (%)	2.18	1.87
Optical rotation (+ degree)	60.20	49.15
Refractive index (+ degree)	1.36	1.28
pH	6.0	6.0
Temperature (°C)	27.2	27.0
Colour L*	2.11	4.99
a*	-0.09	-0.39
b*	0.04	0.73
a/b*	-2.25	-0.53
Visual colour	Yellow - wish	Whitish - yellow

L* = lightness/darkness, a = greenness, b = yellowness, a/b = orange

respectively However, reverse trend of aldehyde content of these oil were observed in flavedo and leaf tissues. Which was found to be higher in flavedo oil (2.18%) than that of leaf oil (1.187%), indicating the higher potential of its entrepreneurship programme. The variation in oil yield of two different tissues might be due to their site of synthesis as leaf is considered to be more active site having more oil glands than that of fruit peel (Crescimanno *et al.*, 2). The similar pattern in optical rotation and refractive index quality of leaf and peel oil were also recorded. However, peel oil had higher optical rotation value (60.20°) and refractive index (1.36°) than that of leaf with yellowish and whitish-yellow oil colour, respectively, showing the quality of peel oil was better than that of the leaf oil (Lallan Ram, 8).

The juice powder and squash of citrus fruit is the value-added products which can be developed from the juice of citron fruit that could tap up the market for longer duration at least up to 12 months. The peel and leaf tissue can be utilized for extraction of pectin and essential oil for entrepreneurship.

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