The Pharma Innovation Journal 2023; 12(9): 1663-1671

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(9): 1663-1671

www.thepharmajournal.com
Received: 27-07-2023
Accepted: 01-09-2023

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Response of colour of preharvest fruit bags on yield and quality of *Litchi* cv. Rose Scented

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Abstract
The present study was carried at Horticulture Research Centre, Patharchatta of G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand during the year 2022. The aim of study was to evaluate the effect of different colour non-woven bags (white non-woven bags, pink non-woven bags, yellow non-woven bags and blue non-woven bags) and different bagging dates (45 days before harvest, 35 days before harvest and 25 days before harvest) on physico-chemical properties of *Litchi*. Among different colours of bagging material used, pink non-woven bag tied 25 days before harvesting was most effective in improving the physical as well as the chemical properties of *Litchi* like fruit weight, fruit diameter, fruit length, fruit volume, ascorbic acid, peel colour, pulp weight, TSS, total sugars, reducing sugar, non-reducing sugar and sensory parameters. However, higher fruit retention, minimum fruit cracking and pericarp sun-burn was recorded in fruits bagged in white non-woven bags. The benefit cost ratio calculated for all the treatments showed that bagging of fruits 25 days before harvest showed feasibility in *Litchi* cultivation. Moreover, fruits bagged 25 days prior to harvest gave significant results for all the parameters. On the basis of present study, it is concluded that bagging of *Litchi* fruits 25 days before normal harvest with pink non-woven bags may be recommended to enhance the physical as well as biochemical properties of *Litchi*.

Keywords: *Litchi*, fruit bagging, physico-chemical properties, organoleptic evaluation, yield

Introduction
Litchi (*Litchi chinensis* Sonn.) is one of the most environmentally sensitive fruits among subtropical fruit crops as temperature and humidity highly influence flower bud differentiation, flowering, fruit set, fruit quality, and flavor development. The highly specific climatic requirement consequently limits the spread of the area. A moist atmosphere, occasional rainfall, and cool dry winter, free from frost and hot winds are ideal for its cultivation. Bihar, West Bengal, Jharkhand, Chhattisgarh, and Odisha are the five main *Litchi*-growing states. In Uttarakhand, major *Litchi*-producing districts are Dehradun, Haridwar, Nainital, and Udham Singh Nagar. There is a need to make Indian *Litchi* globally competitive since it is highly export-oriented in nature and has great potential to earn foreign exchange in international markets. The short span of availability of fruits coupled with poor shelf-life limits the duration of the availability of fruits in national and international markets [14]. The major problems associated with *Litchi* production are poor fruit retention, pericarp sunburn and cracking. Fruits are also susceptible to insect pest infestations, bird attacks and various pathogens which reduces the commercial value of fruit and thus causing yield and economic losses. Pre-harvest bagging is one of the practices that is used for the production of quality fruits. In this technique, individual fruit or fruit bunches are covered with bags for a specific time period.

Materials and Methods
The experiment was conducted at Horticulture Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, during the year 2022. Healthy, uniform and vigorously growing *Litchi* trees cv. Rose Scented planted in square system at 10-meter distance were selected. The experiment was laid in factorial randomized block design with 3 replications. The 15 treatment combinations comprised of four different coloured bags i.e., white non-woven bag, pink non-woven bag, yellow non-woven bag, blue non-woven bag and unbagged (used as control) were bagged in four directions on three dates which were 20 April, 30 April and 10 May. Bagged and unbagged fruits were harvested at commercial maturity stage.

Several parameters like fruit retention, fruit cracking, pericarp sunburn, incidence of insect and diseases were recorded as per standard methods, physical parameters like fruit weight, peel weight, pulp weight and seed weight were measured by using electronic balance while fruit diameter and length were measured using vernier calipers. Chemical parameters like TSS was measured using hand refractrometer, whereas ascorbic acid, total sugars, reducing sugar and non reducing sugars were also evaluated as per method given by [15]. Data analysis was carried out with the aid of the programme OPSTAT. The level of significance for different variables was tested at 5% value of significance.

Result and Discussion

The data on initial fruit diameter at the time of bagging is presented in Table 1, shows that fruits were of uniform size with no significant difference in the fruit diameter at the time of bagging.

Table 1: Initial fruit diameter at the time of bagging

Bagging material (B)	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	8.59	11.25	18.38	12.74
Pink non-woven bag (B_2)	8.62	11.25	18.27	12.71
Yellow non-woven bag (B_3)	8.61	11.22	18.25	12.69
Blue non-woven bag (B_4)	8.64	11.25	18.28	12.72
Control (B_5)	8.63	11.23	18.27	12.71
Mean	8.61	11.24	18.29	
Factors	SE(m)		C.D at 5%	
Bagging material (B)	0.019		N/S	
Days (D)	0.015		0.043	
Interaction (B X D)	0.033		N/S	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The maximum fruit retention per panicle was observed in panicles bagged with white non-woven bag B_1 (51.81 per cent) and minimum was recorded in unbagged fruits B_5 (42.52 per cent). Among bagging dates, highest fruit retention per panicle (49.87 per cent) was recorded in panicles bagged 25 days before normal harvest D_3 and lowest fruit retention per panicle was observed in panicles bagged 45 days before normal harvest D_1 (44.31 per cent).The interaction effects due to bagging dates and bagging material on fruit retention per panicle was found maximum in fruits bagged 25 days before normal harvest with white non-woven bag B_1D_3 (54.2 per cent) which was at par with fruit bagged in pink non-woven bags on the same date B_2D_3 (53.26 per cent), whereas the minimum fruit retention per panicle was found in fruits bagged 45 days prior to normal harvest with blue non-woven bag B_4D_3(39.71 per cent) which was statistically at par(41.31 per cent) with unbagged fruits tagged on the same date (B_5D_1). [5] reported that fruit retention per panicle was increased significantly when *Litchi* fruits were bagged one week after fruit set.

Table 2: Effect of bagging dates and bag's colour on fruit retention in *Litchi* cv. Rose Scented

Bagging material (B)	Fruit retention (per cent)			
	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	49.83	51.41	54.20	51.81
Pink non-woven bag (B_2)	48.12	49.31	53.26	50.23
Yellow non-woven bag (B_3)	42.60	46.91	48.23	45.91
Blue non-woven bag (B_4)	39.71	42.74	50.19	44.21
Control (B_5)	41.31	42.75	43.50	42.52
Mean	44.31	46.62	49.87	
Factors	SE(m)		C.D at 5%	
Bagging material (B)	0.50		1.48	
Days (D)	0.39		1.14	
Interaction (B X D)	0.88		2.56	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

Maximum fruit cracking (12.82 per cent) was found in unbagged fruits (B_5) while minimum fruit cracking (7.53 per cent) was observed in white non-woven bag (B_1). Among the bagging dates, minimum fruit cracking (8.59 per cent) was observed in fruits bagged 25 days before normal harvest (D_3) and highest fruit cracking (9.48 per cent) was found in fruits bagged 45 days before normal harvest (D_1). Observations on interaction effect showed that fruits bagged with white non-woven bags 25 days before normal harvest (B_1D_3) showed least fruit cracking (7.11 per cent) which was at par with fruits bagged with white non-woven bags 35 days before normal harvest (B_1D_2) i.e.,7.38 per cent. Maximum fruit cracking (13 per cent) was found in unbagged fruits tagged 35 days before normal harvest (B_5D_2). Similar trends have been reported by [9] in *Litchi* and [3,6] in pomegranate.

The least pericarp sun-burn (13.45 per cent) was observed when fruits were bagged in white non-woven bags (B_1) whereas, highest pericarp sun-burn (18.52 per cent) was found in unbagged fruits (B_5). Observations with regard to bagging dates showed that least sun-burn (14.99 per cent) was noticed when fruits were bagged 25 days before normal harvest (D_3) which was at par (15.03 per cent) when fruits were bagged 35 days before harvesting (D_2) and highest pericarp sun-burn (15.75 per cent) was found in fruits bagged 45 days before normal harvest (D_1). Interaction effects due to bagging dates and bagging material revealed that minimum sun-burn (12.61

per cent) was recorded in fruits bagged with white non-woven bags 35 days before normal harvest (B_1D_2). However, sun-burn per cent was found maximum (18.66 per cent) in unbagged fruits tagged 45 days before normal harvest (B_5D_1).

Table 3: Effect of bagging dates and bag's colour on fruit cracking and pericarp sunburn in *Litchi* cv. Rose Scented

Bagging material (B)	Fruit cracking (per cent)				Pericarp sunburn (per cent)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	8.11	7.38	7.11	7.53	14.27	12.61	13.48	13.45
Pink non-woven bag (B_2)	8.78	8.20	7.66	8.21	14.66	13.83	14.11	14.20
Yellow non-woven bag (B_3)	8.28	7.85	7.54	7.89	15.20	14.85	14.21	14.75
Blue non-woven bag (B_4)	9.38	8.45	8.03	8.62	15.95	15.28	14.83	15.35
Control (B_5)	12.85	13.00	12.61	12.82	18.66	18.58	18.33	18.52
Mean	9.48	8.97	8.59		15.75	15.03	14.99	
Factors	SE(m)		CD at 5%		SE(m)		C.D at 5%	
Bagging material (B)	0.05		0.15		0.08		0.25	
Days (D)	0.04		0.12		0.06		0.19	
Interaction (B X D)	0.09		0.27		0.14		0.43	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The data regarding the effect of various bagging treatments on incidence of pest and diseases are presented in the Table 4 revealed that minimum incidence of diseases and pest (3.23 per cent) was found in pink non- woven bag (B_2) which was at par (3.49 per cent) with yellow non-woven bag (B_3) and blue non-woven bag (4.2 per cent) (B_4), however it was highest (15.94 per cent) in unbagged fruits (B_5). Among the bagging dates, minimum incidence of pest and diseases (6.01 per cent) was observed when fruits were bagged 25 days before normal harvest (D_3). However, no significant interaction was found between bagging material and bagging dates. Minimum incidence of insect and diseases (2.89 per cent) was found fruits bagged in pink non-woven bags 35 days before normal harvest (B_2D_2) and maximum incidence of pest and diseases (17.33 per cent) was reported in unbagged fruits tagged 35 days before normal harvest (B_5D_2). The present results are in conformity with the findings of [6]. They observed that bagging significantly reduced the incidence of insect like fruit borer and melay bug and diseases like oily spot in pomegranate

Table 4: Effect of bagging dates and bag's colour on incidence of insects and diseases in *Litchi* cv. Rose Scented

Bagging material (B)	Incidence of insects and diseases (per cent)			
	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	7.30	7.20	5.58	6.69
Pink non-woven bag (B_2)	3.67	2.89	3.12	3.23
Yellow non-woven bag (B_3)	4.03	3.18	3.26	3.49
Blue non-woven bag (B_4)	3.68	4.22	4.71	4.20
Control (B_5)	17.10	17.33	13.40	15.94
Mean	7.15	6.96	6.01	
Factors	SE(m)			C.D at 5 %
Bagging material (B)	0.77			2.24
Days (D)	0.59			N/S
Interaction (B X D)	1.33			N/S

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The highest fruit weight (23.08g) was observed when fruits were bagged in pink non-woven bags (B_2) and minimum fruit weight (20.33 g) was recorded in unbagged fruits. Among bagging dates, highest fruit weight (22.35 g) was observed when fruits were bagged 25 days before normal harvest (D_3). Data regarding the interaction between bagging material and bagging dates revealed that fruits bagged 25 days before normal harvest in pink non-woven bag (B_2D_3) had maximum fruit weight (23.42g) which was at par with yellow non-woven bags (23.26g) on the same date. Minimum fruit weight (20.01g) was observed in unbagged fruits tagged 45 days before normal harvest (B_5D_1). Almost similar findings were observed by [9,5] in *Litchi*, [2,19] in mango.

Similar trends were observed in fruit volume where highest fruit volume (22.64 cm^3) was recorded in pink non-woven bag (B_2) while, lowest fruit volume (20.02 cm^3) was reported in unbagged fruits (B_5). Maximum fruit volume (21.91 cm^3) was observed in fruits bagged 25 days before normal harvest (D_3) and minimum (21.21 cm^3) was recorded in fruits bagged 45 days before normal harvest (D_1). Observations regarding interaction effects show that maximum fruit volume (22.86 cm^3) was recorded in fruits bagged 25 days before normal harvest in pink non-woven bag (B_2D_3) which was at par with fruits bagged in yellow non-woven bag on same date (22.80 cm^3) and fruits bagged 35 days before normal harvest in pink non- woven bag (22.71 cm^3). The present findings are in conformity with the earlier observations made by [4] who reported that higher fruit volume in banana fruits might be due to higher humidity and appropriate microclimate inside the bags which results in proper growth and development of the fruits.

Table 5: Effect of bagging dates and bagging materials on fruit weight and fruit volume of *Litchi* cv. Rose Scented

Bagging material (B)	Fruit weight (g)				Fruit volume (cm^3)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	21.93	22.52	22.96	22.47	21.87	22.23	22.51	22.20
Pink non-woven bag (B_2)	22.72	23.09	23.42	23.08	22.35	22.71	22.86	22.64
Yellow non-woven bag (B_3)	21.98	22.73	23.26	22.66	21.55	22.43	22.80	22.26
Blue non-woven bag (B_4)	20.61	20.86	21.59	21.02	20.40	20.65	21.16	20.74
Control (B_5)	20.01	20.46	20.51	20.33	19.87	19.97	20.23	20.02
Mean	21.45	21.93	22.35		21.21	21.60	21.91	
Factors	SE(m)		C.D at 5%		SE(m)		C.D at 5%	
Bagging Material (B)	0.06		0.19		0.057		0.166	
Days (D)	0.05		0.14		0.044		0.129	
Interaction (B X D)	0.11		0.33		0.099		0.287	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The lowest yield (172.93 g) was observed when fruits were left unbagged (B_5) whereas, highest yield (233.01 g) was found in fruits bagged in white non-woven bag (B_1) which was at par with fruits bagged in pink non-woven bag (231.98 g). Observations with regard to bagging dates showed that minimum yield (190.75g) was noticed when fruits were bagged 45 days before normal harvest (D_1) and highest yield per bag (223.61 g) was noticed in fruits bagged 25 days before normal harvest (D_3). Data on interaction effect revealed that minimum yield (165.35 g) was recorded in unbagged fruits tagged 45 days before normal harvest (B_5D_1). However, maximum yield (249.46 g) was found in fruits in fruits bagged 25 days before normal harvest with pink non-woven bag (B_2D_3) which was statistically at par (248.90 g) with bagged fruits with white non-woven bag on same date (B_1D_3). The results are in close agreement with [1] in pomegranate who reported that higher yield/tree was observed when fruits were bagged.

Table 6: Effect of bagging dates and bagging materials on yield per bag in *Litchi* cv. Rose Scented

Bagging material (B)	Yield (g/bag)			
	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	218.60	231.55	248.90	233.01
Pink non-woven bag (B_2)	218.75	227.74	249.46	231.98
Yellow non-woven bag (B_3)	187.31	213.17	224.39	208.29
Blue non-woven bag (B_4)	163.75	178.36	216.82	186.31
Control (B_5)	165.35	174.93	178.50	172.93
Mean	190.75	205.15	223.61	
Factors	SE(m)		C.D at 5%	
Bagging material (B)	2.31		6.72	
Days (D)	1.79		5.21	
Interaction (B X D)	4.00		11.65	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The maximum fruit diameter (3.24 cm) was recorded in fruits bagged in pink non-woven bag (B_2) closely followed by 3.18 cm in fruits bagged with yellow non-woven bag (B_3) while lowest 2.96 cm in unbagged fruits (B_5). Higher fruit diameter (3.18 cm) was observed in fruits bagged 25 days before normal harvest (D_3). Among interaction effects, fruits bagged 25 days before normal harvest with pink non-woven bag (B_2D_3) had highest fruit diameter (3.32 cm). Similar trend in diameter have been reported by [2] in mango and [8] in dateplam.

The lowest fruit length (3.61 cm) was observed in unbagged fruits (B_5) whereas, highest fruit length (3.98 cm) was recorded in pink non-woven bag (B_5). Data with regards to date of bagging showed that fruits bagged 25 days prior to normal harvest (D_3) resulted in maximum fruit length (3.93 cm). Interaction effects showed maximum fruit length (4.2 cm) was recorded in fruits bagged 25 days prior to harvesting with pink non-woven bag (B_2D_3). Similar trends were observed by [17, 9] in *Litchi*, [8] in mango.

Table 7: Effect of bagging dates and bagging materials on fruit diameter and fruit length of *Litchi* cv. Rose Scented

Bagging material (B)	Fruit diameter (cm)				Fruit length (cm)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	3.04	3.12	3.18	3.11	3.61	3.77	3.90	3.76
Pink non-woven bag (B_2)	3.17	3.22	3.32	3.24	3.82	3.93	4.20	3.98
Yellow non-woven bag (B_3)	3.11	3.18	3.25	3.18	3.69	3.76	4.11	3.85
Blue non-woven bag (B_4)	2.90	3.05	3.15	3.03	3.55	3.67	3.76	3.66
Control (B_5)	2.90	2.95	3.03	2.96	3.53	3.62	3.67	3.61
Mean	3.02	3.10	3.18		3.64	3.75	3.93	
Factors	SE(m)		C.D at 5%		SE(m)		C.D at 5%	
Bagging material (B)	0.010		0.030		0.011		0.031	
Days (D)	0.008		0.023		0.008		0.024	
Interaction (B X D)	0.018		0.052		0.018		0.054	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

Data presented in Table 8 showed that maximum peel weight (2.41 g) was noticed in pink non-woven bag (B_2) and minimum peel weight (2.14g) was recorded in unbagged fruits. Among bagging dates, highest peel weight (2.34g) recorded when fruits were bagged 45 days before normal harvest (D_1) and minimum peel weight (2.23g) was found in fruits bagged 25 days before normal harvest (D_3). The interaction effects showed that highest peel weight (2.48 g) was observed in fruits bagged 45 days before normal harvest with pink non-woven bags (B_2D_1).

The maximum seed weight (3.51 g) was observed in white non-woven bag (B_1) and minimum seed weight (3.16 g) was noticed in unbagged fruits which was at par with fruits bagged in fruits bagged in blue non-woven bag (3.18 g) and pink non-woven bag (3.25 g). Among bagging dates, maximum seed weight (3.35 g) was observed in fruits bagged 45 days before normal harvest (D_1) and minimum seed weight (3.18 g) was noticed in fruits bagged 25 days before normal harvest (D_3). Among interaction, seed weight was maximum (3.73 g) in fruits bagged 45 days prior to harvest in white non-woven bag (B_1D_1) which was at par with fruits bagged 35 days prior to harvest in white non-woven bag (3.60 g). The similar results were found by [8] in datepalm.

The minimum pulp weight (14.75 g) was found in unbagged fruits and maximum pulp weight (17.40 g) was observed in pink non-woven bag (B_2) which was closely followed by yellow non-woven bag (17.00 g). Fruits bagged 25 days prior to normal harvest (D_3) exhibited highest pulp weight (16.86 g). However, lowest pulp weight (15.73 g) was recorded in fruits bagged 45 days before normal harvest. Interaction effect between bagging dates and bagging material showed highest pulp weight (17.86 g) in fruit bagged 25 days prior to normal harvest in pink non-woven bag (B_2D_3) which was at par with fruits bagged in yellow non-woven bag (17.79 g) on the same date (B_3D_3). This may be due to more moisture level and temperature inside the bags which promotes better fruit development. Similar trends were found by [17] in *Litchi*, [19,3] in mango.

Table 8: Effect of bagging dates and bagging materials on peel weight, seed weight and pulp weight in *Litchi* cv. Rose Scented

Bagging material (B)	Peel weight (g)				Seed weight (g)				Pulp weight (g)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	2.36	2.30	2.23	2.29	3.73	3.60	3.18	3.51	15.83	16.61	17.53	16.60
Pink non-woven bag (B_2)	2.48	2.40	2.34	2.41	3.34	3.26	3.15	3.25	16.91	17.44	17.86	17.40
Yellow non-woven bag (B_3)	2.43	2.32	2.27	2.34	3.33	3.36	3.17	3.28	16.21	17.16	17.79	17.00
Blue non-woven bag (B_4)	2.31	2.21	2.20	2.24	3.22	3.16	3.15	3.18	15.00	15.48	16.23	15.57
Control (B_5)	2.13	2.14	2.14	2.14	3.16	3.06	3.27	3.16	14.69	14.67	14.88	14.75
Mean	2.34	2.27	2.23		3.35	3.29	3.18		15.73	16.27	16.86	
Factors	SE(m)		C.D at 5%		SE(m)		C.D at 5%		SE(m)		C.D at 5 %	
Bagging material (B)	0.008		0.023		0.047		0.136		0.039		0.114	
Days (D)	0.006		0.018		0.036		0.105		0.030		0.088	
Interaction (B X D)	0.014		0.040		0.081		0.236		0.068		0.198	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The data displayed in Table 11 showed that highest pulp peel ratio (7.30) was found in yellow non-woven bag (B_3), with respect to bagging dates, fruits bagged 25 days before normal harvest (D_3) had highest pulp peel ratio (7.53). Among interaction, it was recorded maximum in treatment B_1D_3 i.e., bagged 25 days before normal harvest with white non-woven bag (7.86). The results are in conformity with findings of [8] in datepalm. The higher pulp peel ratio in bagged fruits may be due to high pulp weight of the bagged fruits.

The highest pulp seed ratio (5.34) was found in pink non-woven bag (B_3) which was at par with fruits bagged in yellow non-woven bag (5.26). Among bagging dates, fruits bagged 25 days before normal harvest (D_3) had highest pulp seed ratio (5.29). The interaction effect showed that maximum (5.61) pulp seed ratio was found in fruits bagged 25 days before normal harvest in yellow non woven bag which was at par with fruits bagged in white non woven bag and pink non woven bag on the same date and fruits bagged 35 days before normal harvest. Similar results were found by [8] in Date palm.

Table 9: Effect of bagging dates and bagging materials on pulp peel ratio and pulp seed ratio in *Litchi* cv. Rose Scented

Bagging material (B)	Pulp peel ratio				Pulp seed ratio			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	6.69	7.22	7.86	7.25	4.24	4.62	5.57	4.81
Pink non-woven bag (B_2)	6.89	7.23	7.60	7.24	5.05	5.36	5.60	5.34
Yellow non-woven bag (B_3)	6.65	7.39	7.85	7.30	5.04	5.12	5.61	5.26
Blue non-woven bag (B_4)	6.48	6.97	7.34	6.93	4.63	4.93	5.16	4.91
Control (B_5)	6.87	6.83	7.02	6.91	4.93	4.95	4.54	4.81
Mean	6.71	7.13	7.53		4.78	4.99	5.29	
Factors	SE(m)		C.D at 5 %		SE(m)		C.D at 5 %	
Bagging material (B)	0.034		0.098		0.119		0.346	
Days (D)	0.026		0.076		0.092		0.268	
Interaction (B X D)	0.058		0.170		0.206		0.600	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The maximum TSS (20.23 °B) was observed in pink non-woven bag (B_2) while, lowest TSS (19.05 °B) was found in unbagged fruits (B_5). Among bagging dates, highest TSS (19.84 °B) was found in fruits bagged 25 days prior to normal harvest (D_3) and lowest (19.38 °B) was observed in fruits bagged 45 days prior to harvest (D_1). The data pertaining to

interaction between bagging material and bagging dates showed that fruits bagged 25 days prior to harvest in pink non-woven bags (B_2D_3) had maximum TSS (20.72 °B). However, minimum TSS (18.87°B) was observed in unbagged fruits tagged 45 days before normal harvest (B_5D_3). This increment in TSS might be due to higher temperature in covered panicles which favoured the conversion of starch to sugar. Thus, resulting in higher accumulation of amino acids and sugars. The increase in total soluble solids by bagging had been reported by several other investigators *viz*., [5] in *Litchi*, [2,23] in mango.

Table 10: Effect of bagging dates and bagging materials on TSS in *Litchi* cv. Rose Scented

Bagging material (B)	Total soluble solids (TSS) (°B)			
	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	19.43	19.55	19.76	19.58
Pink non-woven bag (B_2)	19.84	20.14	20.72	20.23
Yellow non-woven bag (B_3)	19.68	19.86	19.44	19.83
Blue non-woven bag (B_4)	19.09	19.25	19.51	19.28
Control (B_5)	18.87	19.04	19.26	19.05
Mean	19.38	19.57	19.84	
Factors	SE(m)		C.D at 5%	
Bagging material (B)	0.031		0.089	
Days (D)	0.024		0.069	
Interaction (B X D)	0.053		0.155	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

Among different colour bags, highest acidity (0.56 per cent) was found in unbagged fruits (B_5) and lowest acidity (0.50 per cent) was found pink non-woven bag (B_2). With regards to bagging dates, highest acidity (0.54 per cent) was recorded in fruits bagged 45 days before normal harvest (D_1) and lowest (0.50 per cent) was observed in fruits bagged 25 days prior to normal harvest (D_3). The interaction between bagging dates and bagging material showed that highest acidity (0.57 per cent) was observed in unbagged fruit tagged 35 days before normal harvest. A significant decrease in acidity was recorded in bagged fruits compared to unbagged fruits which can be explained as harvesting of bagged and unbagged fruits was taken on the same date and bagging resulted in early maturation of fruits due to favourable micro-climate. The findings are in accordance with [21] in guava and [12] in loquat.

The maximum ascorbic acid content (22.25 mg $100g^{-1}$) was recorded in fruits bagged with pink non-woven bag (B_2) and minimum ascorbic acid (20.79 mg $100g^{-1}$) was observed in unbagged fruits (B_5). Among bagging dates, highest ascorbic acid (21.99 mg $100g^{-1}$) was observed when fruits were bagged 25 days before normal harvest (D_3) and lowest ascorbic acid (21.52 mg $100g^{-1}$) was observed in fruits bagged 45 days before normal harvest (D_1). An interaction of bagging dates and bagging materials showed that maximum ascorbic acid content (22.52 mg $100g^{-1}$) was found in fruits bagged in pink non-woven bags 25 days prior to harvesting (B_2D_3). It may be due to higher temperature inside the bag which resulted in activation of phytochemicals and their synergistic effect which resulted in higher ascorbic acid content in the bagged fruits. Similar findings have been reported by [18] in apple.

Table 11: Effect of bagging dates and bagging materials on acidity and ascorbic acid content in *Litchi* cv. Rose Scented

Bagging material (B)	Acidity (per cent)				Ascorbic acid (mg/100g)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	0.55	0.52	0.50	0.52	21.66	21.96	22.28	21.97
Pink non-woven bag (B_2)	0.53	0.52	0.47	0.50	21.93	22.29	22.52	22.25
Yellow non-woven bag (B_3)	0.53	0.52	0.48	0.51	21.75	22.14	22.33	22.08
Blue non-woven bag (B_4)	0.56	0.54	0.52	0.54	21.48	21.81	22.12	21.80
Control (B_5)	0.56	0.57	0.56	0.56	20.79	20.89	20.71	20.79
Mean	0.54	0.53	0.50		21.52	21.82	21.99	
Factors	SE(m)	C.D at 5%			SE(m)		C.D at 5%	
Bagging material (B)	0.004	0.012			0.027		0.080	
Days (D)	0.003	0.009			0.021		0.062	
Interaction (B X D)	0.007	0.021			0.047		0.138	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest'

The maximum TSS Acidity ratio (39.89) was recorded in pink non-woven bags (B_2) whereas, minimum TSS Acidity ratio (33.62) was observed in unbagged fruits (B_5). Among bagging dates, highest TSS Acidity ratio (39.10) was found in fruits bagged 25 days prior to normal harvest and lowest (35.24) was found in fruits bagged 45 days prior to normal harvest (D_1). Interaction effects due to bagging dates and bagging material showed that minimum TSS Acidity ratio (32.93) was observed in unbagged fruits tagged 35 days before normal harvest. The higher TSS Acidity ratio may be due to higher total soluble solids and lower acidity in bagged fruits. Similar trends were found by [11] in guava and [13] in *Litchi*.

Table 12: Effect of bagging dates and bagging materials on TSS Acidity ratio in *Litchi* cv. Rose Scented

Bagging material (B)	TSS acidity ratio			
	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	35.06	36.91	39.18	37.05
Pink non-woven bag (B_2)	37.28	38.40	43.99	39.89
Yellow non-woven bag (B_3)	36.60	37.70	41.10	38.47
Blue non-woven bag (B_4)	33.64	35.24	36.91	35.26
Control (B_5)	33.61	32.93	34.32	33.62
Mean	35.24	36.24	39.10	
Factors	SE(m)		C.D at 5%	
Bagging material (B)	0.306		0.892	
Days (D)	0.237		0.691	
Bagging material (B X D)	0.531		1.545	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvest D_3= bagging 25 days before harvest

The total sugar was found to be increased with the pre-harvest fruit bagging and thus, B_2 i.e., fruits bagged with pink non-woven bags recorded the highest value (13.28 per cent), while unbagged (B_5) observed the least value (11.98 per cent). Among bagging dates, maximum total sugar (12.99 per cent) was noticed when the fruits were bagged 25 days before normal harvest D_3 while minimum total sugar (12.52 per cent) was observed in fruits bagged 45 days before normal harvest (D_1).The interaction effect showed that maximum total sugar (13.66 per cent) was observed in fruits bagged 25 days before normal harvest in pink non-woven bag (B_2) and minimum total sugar (11.81) was observed in unbagged fruit tagged 35 days before normal harvest (B_5D_2) followed by fruits tagged 25 days before normal harvest (B_5D_3). The increase in sugar content could be due to enzymatic activity of sucrose synthase (SS) and sucrose-phosphate synthase (SPS), SS plays an important role in sucrose decomposition. These results are in accordance with the findings of [9,13] in *Litchi*, [23] in mango.

The maximum reducing sugar (11.42 per cent) was found in fruits bagged in pink non-woven bag (B_2) and lowest (10.22) was recorded in unbagged fruits (B_5). With respect to the bagging dates, maximum reducing sugar (11.14 per cent) was recorded in fruits bagged 25 days prior to normal harvesting (D_3) while lowest (10.76 per cent) was recorded in D_1 treatment, i.e., 45 days before normal harvest. The interaction effect between bagging dates and bagging materials showed that maximum reducing sugar sugar (11.73 per cent) was found in fruits bagged 25 days prior to normal harvest in pink non-woven bags (B_2D_3). The higher reducing sugar in bagged fruits may be due to breakdown of sucrose into glucose due to more activity of sucrose synthase and sucrose-phosphate synthase inside the bags. The results are in conformity with findings of [8] in datepalm.

Among bagging dates, highest non-reducing sugar (1.85 per cent) was found in fruits bagged 25 days before normal harvest (D_3) and lowest (1.76 per cent) was found in fruits bagged 45 days prior to normal harvest (D_1). With respect to bagging materials, highest non-reducing sugar (1.852 per cent) was found in fruits bagged in pink non-woven bag (B_2) and lowest non-reducing sugar (1.761 per cent) was found in unbagged fruits (B_5). The interaction effect of both the factors showed that non-reducing sugar was found maximum (1.92 per cent) in fruits bagged 25 days before normal harvest in pink non-woven bag (B_2D_3) and minimum amount of non-reducing sugar (1.72 per cent) was recorded in fruits bagged 45 days before normal harvest in blue non-woven bag. Similar beneficial effect of bagging dates and bagging materials on non-reducing sugar content of the fruits was found by [23] in mango.

Table 13: Effect of bagging dates and bag's colour on total sugar, reducing and non-reducing sugar in *Litchi* cv. Rose Scented

Bagging material (B)	Total sugar (per cent)				Reducing sugar (per cent)				Non-reducing sugar (per cent)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	12.67	13.11	13.34	13.04	10.92	11.29	11.48	11.23	1.75	1.81	1.86	1.82
Pink non-woven bag (B_2)	12.93	13.25	13.66	13.28	11.13	11.41	11.73	11.42	1.79	1.84	1.92	1.85
Yellow non-woven bag (B_3)	12.45	12.69	13.30	12.81	10.64	10.86	11.44	10.98	1.80	1.82	1.86	1.82
Blue non-woven bag (B_4)	12.36	12.53	12.73	12.54	10.63	10.76	10.89	10.76	1.72	1.77	1.83	1.79
Control (B_5)	12.21	11.81	11.93	11.98	10.46	10.03	10.17	10.22	1.74	1.77	1.76	1.76
Mean	12.52	12.68	12.99		10.76	10.87	11.14		1.76	1.80	1.85	
Factors	SE(m)	C.D at 5%			SE(m)	C.D at 5%			SE(m)		C.D at 5%	
Bagging material (B)	0.013	0.038			0.013	0.038			0.009		0.027	
Days (D)	0.010	0.030			0.010	0.030			0.007		0.021	
Interaction (B X D)	0.023	0.066			0.023	0.066			0.016		0.046	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvestD_3= bagging 25 days before harvest

According to Table 16, maximum hedoic score (8.13) was obtained by fruits bagged in pink non-woven bag, while lowest score (6.64) was found in unbagged fruits (B_5). Data regarding effect of bagging dates showed that fruits bagged 25 days before normal harvest (D_3) had maximum score of 7.70 and minimum score of 7.21 was found in fruits bagged 45 days prior to normal harvest (D_1). Among interaction effect, maximum score (8.53) was found in fruits bagged 25 days before normal harvest in pink non-woven bag (B_2D_3). However, lowest score (6.51) was found in unbagged fruits tagged 35 days before normal harvest. The higher score of bagged fruits may be due to improved quality parameters like colour, length, TSS, total sugars and reduced incidence of insect and diseases. The similar results were found by [10,19] and [22] in mango.

Table 14: Effect of bagging dates and bag's colour on sensory parameters in *Litchi* cv. Rose Scented

Bagging material (B)	Sensory evaluation			
	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	7.09	7.40	7.51	7.33
Pink non-woven bag (B_2)	7.73	8.13	8.53	8.13
Yellow non-woven bag (B_3)	7.51	7.85	8.00	7.78
Blue non-woven bag (B_4)	7.10	7.35	7.66	7.37
Control (B_5)	6.61	6.51	6.80	6.64
Mean	7.21	7.45	7.70	
Factors	SE(m)		C.D at 5%	
Bagging material (B)	0.035		0.101	
Days (D)	0.027		0.078	
Interaction (B X D)	0.060		0.175	

D_1= bagging 45 days before harvest D_2= bagging 35 days before harvestD_3= bagging 25 days before harvest

The data presented in Table 15 showed that bagging 100 kg of fruit was found feasible with benefit cost ratio of 1.37, when bagged fruits were bagged 25 days before normal harvest. With regard to bagging material, highest benefit cost ratio (1.37) was recorded in fruit bagged with white non-woven bags (B_1) which was at par with fruits bagged in pink non-woven bags (B_2) and yellow non-woven bag (B_3). The data on interaction effects of both the factors showed that the highest benefit cost ratio (1.44) was noticed in the fruits bagged in white non-woven bags 25 days prior to harvest (B_1D_3) which was equal to fruits bagged with pink non-woven bag 25 days before normal harvest (B_2D_3). However, lowest benefit cost ratio was found in fruits bagged with blue non-woven bags 45 days before normal harvest due to low fruit retention in the bagged fruits, high sunburn percent and cracking percent that reduced the yield and affected other quality parameters of the fruits. Similarly, [20] reported bagging of *Litchi* fruits with pink polypropylene bags resulted in higher benefit cost ratio compared to unbagged fruits.

Table 15: Economic feasibility of bagging in *Litchi* cv. Rose Scented fruit for 100 kg produce

Bagging material (B)	Benefit cost ratio			
	D_1	D_2	D_3	Mean
White non-woven bag (B_1)	1.30	1.36	1.44	1.37
Pink non-woven bag (B_2)	1.31	1.34	1.44	1.36
Yellow non-woven bag (B_3)	1.15	1.42	1.33	1.30
Blue non-woven bag (B_4)	1.04	1.11	1.29	1.15
Mean	1.20	1.31	1.37	
Factors	SE (m)		CD at 5%	
Factor (A)	0.027		0.081	
Factor (B)	0.024		0.070	
Factor (A X B)	0.480		N/S	

Conclusion

It can be concluded that pre-harvest bagging was effective in improving the physico-chemical attributes of *Litchi*. Therefore, bagging of *Litchi* fruits 25 days before the normal harvest with pink non-woven bags may be recommended to enhance the physico-chemical characters of *Litchi* to obtain good quality fruit for profitable *Litchi* cultivation.

Acknowledgement

We cordially acknowledge the assistance extended by Department of Horticulture, G.B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

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