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A REVIEW

Post harvest processing and value addition of dry chilli (*Capsicum annuum* L.)

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Abstract : Chilli is an important spice crop and India is one of the leading producer and exporter of chilli in the world. Chilli is widely used around the world in food as a spice both in fresh and dried form which adds flavour to the meal by creating spicy pungent taste. The chemical components of the chilli may vary considerably depending on the location of cultivation and postharvest treatments. Chilli contains polyphenol compounds such as capsaisin capsorubin, zeaxanthin and cryptoxanthin are responsible for colour in *Capsicum* species that accounts for its characteristic aroma and therapeutic properties. Post harvest losses in chilli are estimated to be 25-35 per cent. Due to post harvest losses farmers lose both in quality and quantity of the chilli. This compromises farmer's ability to market their produce. The aim of this chapter was to get the best post-harvest handling technology for chilli in the present scenario.

Key Words : Chilli, Post harvest, Drying, Grading, Destalking

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INTRODUCTION

Chilli (*Capsicum annuum* L.) the spice of many wonders is widely used around the world in food in fresh and dried form which adds flavour to the meal by creating spicy pungent and also used as traditional medicine. Orginated from South America and cultivated in all climatic zones expect temperate zones; it forms a major trading commodity across the world accounting 16 per cent of the total spice trading. The chemical components of the chilli may vary considerably depending on the location of cultivation and postharvest treatments. The fruits of chilli contain alkaloid compound called as capsaicinoids which accounts attribute pungency, were as the pigments such as capsanthin, capsorubin, zeaxanthin and cryptoxanthin are responsible for colour in *Capsicum* species these are the two characteristics mainly grade the chilli in commercial value. It also holds health promoting properties due to the presence of vitamins, potassium, magnesium, iron, phenolic acids and flavonoids and diseases preventing properties such as antioxidant, gastroprotective effects, antibacterial and anti-inflammatory activities. Mapping the post harvest management of chilli not only gauges the degree of losses

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but establish links between distinct value chain constraints and respective post harvest losses and their limitations. Post-harvest handling at farm level and shelf-life issues at distribution were identified as vulnerable hot-spots of the processing losses. Improved varieties of chilli and production systems combined with precise post harvest techniques can reduce waste and maximizes the produce, which ultimately can increase the supply of chilli for the fresh market and processing industries. The objective of this chapter is to provide an overview of chilli's production, utilization, quality characteristics, processing and other post harvest management issues.

Chilli production status in India and world's scenario:

World production of green and dry chilli pepper in 2007 was 27 Million tonne and increased to 56.18 Million tonne 2016, the increase may be due changing pattern in consumption and applications of chilli.

Some of the major chilli growing countries are India, Ethiopia, Thailand, China, Pakistan, Bangladesh, Ghana, Myanmar, Nigeria and Mexico etc. India is the world leader in dry chilli production with lion's share of 33 per cent followed by Thailand (9%), Ethopia (7.8%), China (7.2%) and Pakistan (3.16%). The area, production and yield of chilli in major producing countries in the world are mentioned in the Table 1.

Major post harvest problems:

Post harvest damage:

The mechanical damage during harvesting or post harvest handling practices results in injury to the skin

Table 1 : World's status in chilli production

World's top dry chilli producers	Country	Area (,000 ha)		Production-2016 (000, tons)		Yield -2016 (hg/ha)	
		Green	dry	Green	Dry	Green	dry
1	India	8.02	789.00	67.92	1389.00	84592	17605
2	Thailand	1.34	92.12	18.38	379.34	137174	41177
3	Ethiopia	9.8	180.70	61.79	329.80	62850	18251
4	China	753.04	46.40	17458.3	306.98	231838	66152
5	Pakistan	NA	57.56	NA	133.51	NA	23195
6	Bangladesh	NA	101.97	NA	130.26	NA	12774
7	Myanmar	NA	110.05	NA	129.36	NA	11755
8	Ghana	14.40	14.85	122.4	115.55	85000	77768
9	Vietnam	NA	65.68	NA	95.46	NA	14561
10	Benin	27.72	27.72	88.26	88.26	31833	31833
	World	2691.83	1845.25	51955.74	4225.13	31727058	2503663

Source: FAOSTAT, 2018

Table 2: Nutritional and phyto-chemical composition and nutritive value of dry chilli (*Capsicum annuum*) grown in India (Krithika and Radhai 2014, Jalgoankar and Mahawar, 2017)

Proximate composition	Guntur	Sangali Sannam	Reshampatti	Sattur S4	Byadagi
Carbohydrate (mg/100g)	27.10 ± 0.06	27.00±0.24	28.00±0.48	27.00±0.64	28.00±0.44
Protein (mg/100g)	12.8 ± 0.02	20.56±0.07	20.78±0.20	19.68±0.37	20.12±0.30
Fat (mg/100g)	11.8 ± 0.06	13.50±0.32	14.50±0.17	18.00±0.19	14.50±0.42
Fibre (mg/100g)	6.25 ± 0.38	21.30±0.48	22.60±0.72	19.30±0.17	20.60±0.01
Total phenols (mg/100g)	6.77 ±0.10	2.75±0.06	2.35±0.06	2.75±0.05	2.67±0.04
Alkaloids	+	+	+	+	+
Carotenoids	+	+	+	+	+
Saponin	+	+	+	+	+
Steroids	-	–	–	–	–
Tannins	+	+	+	+	+
Flavonoids	+	+	+	+	+
Phenols	+	+	+	+	+
Colour value L^*	44.82±1.87	37.63±0.28	40.94±0.39	40.49±1.29	40.94±1.09
a^*	81.79±4.16	33.30±0.93	36.04±0.17	35.53±0.36	34.77±0.05
b^*	48.31±1.35	34.21±0.26	39.81±1.22	40.28±0.24	38.76±0.08
Capsaisin(%)	0.226	-	-	-	No pungency

and flesh of the fruit. Bruising causes spots on pods, splitting leads to an excessive amount of loose seeds in a consignment causing considerable loss in weight and quality which ultimately leads to price reduction for chilli.

Post harvest diseases:

Holding chilli at a less than optimal temperature and relative humidity (RH) will accelerate post harvest decay. Post harvest losses from diseases are caused by various micro-organisms and fungus like *Alternaria calotopsicums* causes decay in the field and in packing cases during seasonal gult. Another fungal disease anthracnose rot caused by *Colletotrichum capsici* (Syd.) causes heavy loss (12-25%) yield loss to the farmers at farm level due to unscientific method of drying (Mesta *et al*., 2013 and Koppad *et al*., 2017).

Post harvest contamination:

Insect contamination by universal drugstore beetle, *Stegobium paniceum* L. and the cigarette beetle can damage in three-fold, first by the physical loss as frass, second by mould growth and entry of mites due to insect holes in the fruit walls and third by the loss of quality due to broken pods and loose seeds (Muthum and Majumder, 1974).

Psychological changes:

After harvesting the fruits continue to respire, produce ethylene and change colour as they ripen. This process may be quick; if harvesting is not done at proper maturity level or if proper method of storage is not adopted (Ahmad *et al.*, 2013). Thus, the Table 3 shows various losses and their causes during post harvest handling of chilli.

Harvesting and post harvest management:

The level of stress that the crop endures in the field will influence yield, fruit colour, pungency, diseases and ultimately, postharvest quality. Hence, unit operations beginning from the harvesting to packing at field level decides the commercial value of the produce. Combination of various unit operations can be divided into various stages to makeup post harvest technology.

Harvesting:

Harvesting of chilli is done preferably in the morning hours to avoid field heat and storage heat (Krajayklang *et al.,* 2000). Purpose of chilli for which it is grown decides the time and stage of harvesting. After ninty days of its transplantation, chilli will be ready for harvesting. Dark green fruits are plucked for processing chilli pickle, green chilli powder or marketed direct to consumers. Usually, with 8-10 pickings the yield of 30 to 40 q/acre of fresh chilli can obtained depending upon varieties and climatic conditions. whereas, for dry chilli and chilli powder dark red coloured fruits at moisture content of 65-80 per cent are plucked with 5-6 pickings and the yield of 7.5 to 10 q/acre. Chilli of 20 days after fruit setting can be recommended as optimum maturity stage for production of green chilli powder (Panda, 2010) and it is recommended to harvest all the red ripe chillies as soon as they appear on the plant which is processed to achieve best spice colour quality. Pre- or post-harvest treatments may increase the number of red ripe fruit by inducing fruit ripening agent (Tahmidul *et al*., 2015 and Makoka *et al.*, 2010). Usually, chillies are harvested manually either by bare hands or by secateurs, but recently (Akay and Ozcan, 2009) reported that mechanized chilli harvester with four bar mechanism harvested 80 per cent chilli pepper and the result paved way in developing large harvesting machines for chilli.

Post harvest management:

Chillies, contains high moisture content is highly perishable in nature and hence, processing and storage are considerably important to farmer, processor, exporter and consumer. Since initial moisture content of freshly harvested red chilli contains 65-80 per cent it is difficult to process or to store. It is estimated that the shelf-life of the fruit is 2-3 days at this moisture content

Table 3 : Estimated post-harvest losses of chilli at producer's level

Sr. No.	Causes	Losses (Percentage of total production)
1.	Moisture	15-25%
2.	Spoilage in field	1-10%
3.	Farm to assembling	05-10%
4.	Assembling to distribution	2-5%

Source: Marketing of chillies in India, post harvest profile of chilli

(Anonymous, 1983). In order to increase shelf-life of chillies and to avoid development of micro flora and subsequent quality loss due to spoilage, it is essential to reduce the moisture content and to accommodate better aeration to the chillies after harvesting (Harpal, 1985).

Drying:

Open sun drying:

Traditionally, red chillies are dried directly under the sun in most of the chilli producing countries; this may be due to various reasons *viz*., natural and sustainable source of drying, cost effectiveness and field level drying. With retaining the fruit quality, any drying method which exhibits all these advantages may pave way for the farmer to practice comfortably and effectively.Sun drying has also got various disadvantages like it depends on the availability of sunshine and is susceptible to insect and fungal infestations due to moist atmospheric conditions and contamination with foreign materials, unpredicted rain, bruising rendering the red chili unusable. Drying operation does not start on the same day; the harvested fruits are heaped indoors for 3-4 days so that the partially ripe fruits if any, are ripen fully and develop uniform red colour (Prutlil, 1998). During sun drying the fresh red chilli pods are spread out in sun on hard dry ground (field) or on concrete floors or even on the flat roofs of houses in thin layer. Regular stirrings are done for uniform drying and to avoid discoloration or mould growth.

Solar drying:

Concept of drying remains same, were heat from the sun is used to dry the chillies but solar dryer is a

Table 4 : According to UNECE standard DDP-24, provisions concerning sizing and moisture content is given in the following table (UNECE, 2013)

Commercial type	Class and length (cm)			Maximum content (%)
	Extra	Class I	Class II	
Pasilla	> 20	> 14	< 14	13.5
Guajillo	> 14	> 10	< 10	12.5
Puya	> 10	> 8	< 8	10.0

Table 5: Grading of chilli (Weiss, 2002)

Level of pungency	Total capsaicinoids (µg/g dry weight)	Pungency intensity (Scoville units)	Content determined
Non-pungent	67 – 100	0-700	Capsaicin and Dihydrocapsaicin
Mildly pungent	201 – 335	700-300	
Moderately pungent	335 – 2010	3000-25000	
High pungent	2010 – 6670	25 000 – 70 000	
Very highly pungent	> 6670	> 80000	

Table 6: Some of the quality tolerance set by United Nations for Europe developed to harmonize and facilitate national and international trade for whole dried chilli peppers

Defects allowed	Tolerances allowed, percentage of defective produce, by number or weight		
	Extra	Class I	Class II
Tolerances for produce not satisfying the minimum requirements of which no more than	5	10	15
Blemishes, stains, discolorations, burns, scratches, scars, deformations	2	5	10
Decayed and mouldy produce	0.5	1	2
Damaged by pests	0.5	0.5	1
Living pests	0	0	0
Missing stems and broken produce	5	7	10
Size tolerances, if sized			
For produce not conforming to the size indicated, in total	10	10	10
Tolerances for other defects			
Foreign matter (by weight)	1	1	1
Whole dried chilli of commercial types other than that indicated	5	10	10

structured cover comes in different size and design and it owns various advantages like protected from dust, rain, insects, animals etc. Using this method, the drying time reduces to half compared to conventional drying system and imparts superior in quality (Garg and Krishnan, 1985). During harvesting season chilli flushes with heavily output hence small structured solar (cabinet) dryers are not preferred. The most popularly used solar dryers for drying red chilli are either solar tunnel dryer or green house solar dryer. The economic feasibility of solar tunnel dryer of one tonne of chilli in comparison with the conventional sun drying method was saving in cost of 40 per cent.

Mechanical dryers:

Mechanical drying of chillies has advantage over sun drying in obtaining a better and consistent chilli in quality along with minimizing time consumption and crop losses. In India tobacco barns were used for this purpose. In the United States, the chilli fruits are dried in heated buildings or in tunnel dryers or usually in stainless steel continuous-belt or belt-trough dryers, exposing fruits to a forced current of air at temperatures of 50-60°C, thereby reducing moisture content to 7-8 per cent (Prutlil, 1998).

Cleaning and grading :

Destemming/cleaining:

Destalking is still done manually in many chilli producing countries which causes revenue loss of 20 per cent. According to an estimate, In India it requires 106 lakh labour days to handle the country's total chilli production of 16 lakh metric tonnes. Thus, to improve upon the existing manual destalking practices, mechanical means of removing stalk can be thought off. This will not only enhance the quality of destalked chilli but will also improve the efficiency of the overall process. No much literature are reported on mechanized stalk remover (Jalgoankar and Mahawar, 2017). In most processing applications the calyx and stem are considered foreign matter and will either reduce the worth of processed chilli or make it unmarketable. The absence of destemming technology has limited acceptance of harvest mechanization because it has merely moved hand labour from the field to the processing plant (Herbon *et al.*, 2009). Attempts to mechanically destem medium sized chilli in 1977 were unsatisfactory (Dilon, 1981).

Grading:

Grading of dry chilli is considered one of the main tools for the marketing of commodity in the local and has become a prerequisite for international markets due to its worldwide commercialization. Grading done at the producer level, is mainly sorting out of spoiled, discolored and white chillies. Deep red and light red coloured dry chillies, chillies containing less seed usually fetch premium price. Good fruit length, high pungency, shining red colour and strong attachment of the calyx are the important factors for higher price. Commercially there are various grades such as the first sort, the second sort, mixture etc. In Table 4 the graded chilies are classified into Extra, Class I and Class II which defines superior quality, good quality and acceptable quality, respectively and whole dried chilli peppers are characterized commercially by their length and pungency in accordance with the following Table 3 and 4.

The US food defect action levels (DAL) specifies an action level at an insect filth, mammalian excreta when it is detected at an average of more than 1 mg per pound of chilli and mold level of an average of 3 per cent of pods by weight. The ASTA (American Spice Trade Association) also stipulates some sets limits for extraneous matter in chilli *viz*., mold (% by wt.), whole insect dead by count, mammalian excreta (mg/lb), other excreta (mg/lb), extraneous foreign matter (% by wt.) and infested / insect defiled (% by wt.) Jacob, 1998.

Packaging:

The most common method of packaging of chillies in gunny or barlap bags are used for both export as well as for internal trade. In dry whole chillies, increased density poses a problem which needs to be decreased. In bailing process chillies are compressed with a pressure of 2.5 kg/cm^2 and at moisture content of 10 per cent, which reduces the volume upto to 78 per cent of its original volume without causing any damage to the product. Whereas, compressing the chillies at moisture content below 8 per cent can cause breakage loss due to brittleness. Bulk compressed packaging bags of 10 to 23 kg capacity made up of of 75µm polyethene materials are generally used. Such type of packaging to provides protection against moisture, insects and contamination from external sources.

Experiments were carried out to study the influence of vacuum packaging and long term storage on quality in red chilli. Where chilli fruits stored in vacuum packed and jute bags at two moisture levels (10 % and 12 %) in room and cold conditions (25 ± 2 and 4 ± 1 °C) under

both light and dark environment for a period of 24 months and revealed that the vacuum packed chillies under cold storage were found to have the least per cent changes in various quality parameters *viz.,* Changes of moisture, capsaicin, oleoresin and total extractable colour. Vacuum packed chillies stored at 12 per cent moisture content recorded better quality parameters over 10 per cent moisture. CFTRI, of Mysore in India had undertook the studies to see the effect on the quality with respect to colour and capsaicin in dried whole chillies packed in 75µ HDPE and 12µ metallised polyester / 37µ LDPE pouches of 250 grams capacity and reported that the chillies (250g each) packed in HDPE and metallised polyester / LDPE pouches had better colour even after 180 days at 4-5°C than at ambient conditions.

Storage:

Storage has an apparent influence on the colour of dried whole chillies though it has little effect on pungency. Since colour is one of the main arresting factor for the price, which a producer receives. Hence, conserving the colour is a final determinant in whole chilli processing before it reaches to the consumers, which can be necessarily achieved during the storage period. The effect of packaging and the storing of chilli are more prominent to that of the temperature at which the chillies were dried.

During summer, the cold storage is recommended which will impart in colour retention and guard against infestation. Storage of chilies in cold store is extensively followed in India as it fetches premium price due to excellent colour retention. The use of commercial cold store for chilli storage has now become almost a general practice among farmers in the country. Temperature in the cold store is maintained in the range of 5-8^{0}C and relative humidity is about 55-60 per cent. The present practice by farmers is to store in cold storage when most of the crop is harvested. The usual cold storage period lasts for about 9 months beyond this period is not generally preferred unless the market prices are very low.

Processing and value addition:

The value addition can be classified into two first in manufacturing process involves cleaning, drying, grading, sieving and packing of chili and in second process involves processing into various products *viz.*, Chilli grinding, pickles, paste, oil brined chilli, oleoresin, sauces etc. Overall, value addition builds up profit to farmers and easies to transport, catches more attraction of consumers and it adds flavour to product.

Chilli grinding :

Dry chilli powder or ground pepper is produced by grinding dried, cleaned chilli with the moisture content less than 10 per cent in a hammer mill having copper tipped hammers. The desired fineness is being achieved by the type of hammer, speed of the rotor, size of screen opening according to market requirements. The final output product is then collected from the cyclone separator then sieved in sieves of required mesh size and packed in airtight containers. The following points are to be considered in the production of ground pepper (Ravindran *et al.*, 2000).

– Loss in volatile oil content must be least during the grinding process.

– Particle size should be optimum so as to ensure free flow for the duration of its shelf-life.

– Air tight packaging should be ensured.

– Microbiological cleanliness like free from moulds and bacteria should be ensured.

– Heat generation should be minimum during pulverizing.

Recently development of cryogrinding, a new technique were grinding is done at low temperature to reduce the volatile oil loss. This is done by injecting liquid nitrogen into the grinding zone and the temperature is adjusted suitably through the control of LN_2 flow rate. The advantage in cryogrind is it dispense more uniformly in spice formulations and the volatile oil and minimized flavour loss.

Chilli oleoresin:

According to FAO, chilli oleoresin or paprika extract obtained by solvent extraction of paprika, which consists of the ground fruit pods, without or with the seeds, of *Capsicum annuum* L. containing the major colouring and flavouring principles of this spice; the major colouring principles are capsanthin and capsorubin and the major flavouring principle is capsaicin (JECFA, 2013). The organic solvent is recovered completely from the oleoresin and the ISO as well as the importing countries have fixed maximum permissible limits for the approved solvents. The paprika oleoresin is used as additive colorant. The oleoresin and its components (carotenoids, capsaicinoids, and tocopherols), extracted are used in formulating nutraceutical, colorants and pharmaceuticals (Fernandez-

Trujillo, 2007).

Chilli sauce:

The process starts with cleaning up of dried chillies (5 kilograms for each batch) and is separated from impurities subsequently boiled over medium heat until tender. Boiled and drained dried chillies are then ground to smooth using a grind machine. The next process is cooking by placing the chilli in a pot together with ingredients like sugar, salt, water, starch, starch and food preservatives and gently brings to a simmer. Once cooked, chili sauce is poured into the processing tank for bottling process. Then the next process is labeling and packaging.

Conclusion:

Chilli is a spice which is used as condiment, culinary supplement or as vegetable. It is valued because of its colour and pungency and has been used through ages in almost all systems of food and medicines against many maladies due to its medicinal properties. Role played by chilli in national and international trade has got direct influence on economic growth of chilli growing countries. But, most of the chilli growing countries are being still under developing nations has got many hinges in implementing post harvest technologies. The unit operations such as harvesting, drying, destalking, packing, storage and product development for chilli has got many challenges and scope for efficient chain in value addition for chilli. Consolidation of post-harvest technologies which has been developed for chillies in different countries and executing them in chilli growing countries may bring down post harvest losses drastically and can meet international standards for exporting.

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