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Scope of Entrepreneurial Developments in Cocoa Processing

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Introduction

Cocoa, *Theobroma cacao* L. popularly known as 'Food of Gods', the original source of chocolate, is indigenous to tropical humid forests on the lower eastern equatorial slopes of the Andes in South America. Cocoa spread to all over the tropical regions of the world from 18th century onwards and is now grown in 58 countries covering 6.9 million ha worldwide, producing 4 million tons of cocoa. Cocoa is an important agricultural commodity and the key raw material in chocolate manufacture. Unlike large, industrialized crops, 80 to 90% of cocoa comes from small, family-run farms, with approximately five to six million cocoa farmers worldwide. Total production has increased by 13% from 4.3 million metric tons in 2008 to 4.8 million metric tons in 2012. This represents an average year-over-year production increase of 3.1%. This rate of increase may slow in the coming years, as cocoa trees are sensitive to changing weather patterns. Periods of drought and of excessive rain or wind can negatively impact the yield, and will continue to fluctuate as climate change intensifies. Most of the world's cocoa is produced in West Africa (70%) followed by Asia and Oceania (15.6%) and Latin America (14.1%). World leaders in cocoa bean production are Ivory Coast, Ghana, Indonesia, Nigeria, Cameroon, Brazil, Ecuador, The Dominican Republic, and Malaysia, supplying 90% of the world production.

Though, cocoa was introduced in India in the early 20th century; its exploitation as a crop of significant economic value is just five decades old and confined as an inter crop in Kerala, Karnataka, Tamil Nadu and Andhra Pradesh in small/ middle holder sector. As a cash crop, a cocoa plantation can last between 15 and 40 years. Cocoa constitutes a significant source of income for the small scale operators who are responsible for majority of worldwide production. Cocoa flavour is unique, complex, and fascinating. Cocoa and cocoa based products such as chocolates are one of the major natural sources of flavonoids because

of its high content of polyphenols, epicatechin, catechin and their oligomers, and the procyanidins. Both non-volatile and volatile chemical components contribute to the cocoa aroma. When fermented and dried, it contains 50 - 57% lipids, 10% proteins, 12% fibre, 8% carbohydrates and 5% minerals.

History of chocolate

Cocoa was domesticated by the natives of Central America and the produce was used for consumption for the first time by Mayas and Aztecs. Spanish were the first Europeans to drink cocoa when they invaded and conquered the empire of Mexico in 16th century. The Spanish learnt from the Aztecs the art of making 'xocoatl', a drink made from roasted beans after roasting and grinding. The word 'chocolate was originated from 'xocoatl'. The recipe of xocoatl was later modified by a Spanish explorer, Herman Cortz in 1517. Spanish people kept this as a trade secret for more than 100 years. In 1580, world's first chocolate factory was established in Spain. The mesmerizing taste of cocoa spread throughout the European countries and first cocoa product in solid form was made by Joseph Fry and Sons in 1847. Within two years, Cadbury entered the field and it was William Peter in 1876, who made world's first milk chocolate.

Post harvest handling of cocoa

Quality of finished product depends upon a number of factors like the variety, agro techniques adopted, environmental conditions during the development of pod and processing technology adopted. Hence, it is necessary to maintain the quality standards throughout the processing period. Cocoa processing is mainly divided in to two; primary and secondary processing.

Primary processing

Primary processing is actually curing of cocoa. Curing is a process by which cocoa beans are prepared for the market. It involves fermentation and drying and final quality of the product is solely dependent on these two processes. Any defect occurring during this process will ultimately affect the quality of the end product irrespective of the superiority of the genotype selected for processing.

Harvesting

Harvesting is the process by which ripe pods are removed from the tree. Stage of maturity of pods is best judged by change of colour of pods. Pods, which are green when immature, turn yellow when, mature (forastero) and the reddish pods (criollo) turn yellow or orange (Prasannakumari *et al.*, 2009). Only healthy ripe pods should be harvested. Use of unripe and over ripe pods may be avoided which may affect fermentation process. Time taken for ripening varies with

agro climatic conditions. There is considerable correlation of maturation with temperature, ie during high temperature, time required to attain maturity is less (Minimol *et al.*, 2015). Harvested pods when heaped under shade condition for one or two days enhance fermentation process (Anon, 1981). Pods are opened by hitting with each other or on a hard surface. Iron knife is not recommended because, the iron cause blanching effect on seeds. Seeds are extracted from broken pods and collected for fermentation without placenta.

Fermentation

Fermentation is the most important step in processing cocoa. The process involves keeping together a mass of wet beans. Numerous microorganisms act on sugary pulp covering the beans and result in temperature build up with in the mass. Most of the pulp will drain out within 24 hours. During fermentation, a series of biochemical reactions occur in the beans. Most important one is oxidation reaction which will continue even during drying (Wood and Lass, 1985).

Types and duration of fermentation

Types of fermentation vary from country to country or even from farmer to farmer. Duration of fermentation depends upon variety and season. Criollo cocoa will ferment within 2 – 3 days, while forestero will take 3 – 7 days and sometimes even more (Wood & Lass, 1985). Recovery per cent is highly influenced by the environmental conditions. Recovery percentage during dry season is about 38% compared to 34 % in wet season (Prasannakumari *et al.*, 2002).

Methods for large scale fermentation

Among various methods adopted for fermentation in different cocoa producing countries, heap, tray and box methods are considered as the standard methods.

i) *Heap method*: Cocoa beans of 50-500 kg are heaped over a layer of banana leaves in a slopy floor. The sweating will flow off within 24 hours. Then, it is covered with gunny bags keeping weight above the beans. Dismantle the heaps and mix the beans on the third and fifth days. Fermentation will be usually completed by sixth day and beans are taken out for drying on seventh day. This method is practised in West Africa and large fermentaries of India.

ii) *Tray method*: Wooden trays of size 90x60x10 cm are made by fixing reapers at the bottom, with gaps in between, such that beans do not fall through; at the same time allow free flow of sweating. Each tray can hold 45 kg of wet beans. Stack the trays one over the other and minimum

six trays are required. An empty tray will be kept at the bottom to allow drain of the sweating. After stacking, the top most tray is covered with banana leaves and after 24 hours it is covered with gunny bags. Beans up to a depth of 10 cm will ferment in trays stacked one above the other. Normally, fermentation will be completed by four days and on fifth day the beans can be taken out for drying.

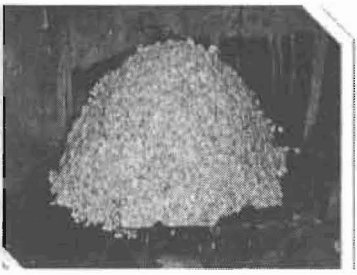
iii) *Box method*: This method is commonly used in cocoa estates of Malaysia. Boxes made of wood of standard dimension of 1.2x0.95x0.75 m which can hold one ton of beans are used. Holes are provided at the bottom and sides to allow free flow of sweating and to facilitate aeration. This will necessitate having a minimum of three boxes. Beans are mixed by transferring from one box to another. Though, box method of fermentation is convenient to handle large number of beans, the quality of beans is often rated as inferior.

Methods for small scale fermentation

All the standard methods of fermentation need relatively minimum quantities of wet beans. In heap method, the smallest batch size is 50 kg. Hence, in areas where cocoa is grown in small holdings, alternate method of fermentation involving small quantities of beans is necessary. It is not easy to develop small scale fermentation methods since small quantity of beans will make it difficult to develop adequate temperature of fermenting mass. Attempts were made to find out suitable small scale methods of fermentation using bean lots substantially smaller than those required for standard methods. Some of these methods are identified as heap, basket and plastic bag methods, as judged from temperature development of the ferment, pH of the beans and cut test.

i) *Heap method*: It is same as that of large scale fermentation process but the quantity of beans kept for fermentation is not less than 50 kg.

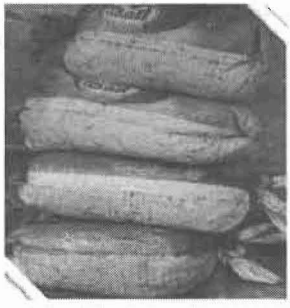
ii) *Basket method*: In this method, bean lots ranging from 2-6 kg can be fermented successfully. Mini baskets made of bamboo matting with a size of 15 cm height and 20 cm diameter can hold 2 kg wet beans. Baskets are lined with banana leaves to facilitate drainage of sweating. Wet beans are then filled in these baskets and covered with banana leaves. Baskets are placed on a raised platform to allow the flow of dripping. After 24 hours, it will be covered with gunny sackings. Beans are to be taken out and stirred well on third and fifth days after initial sweating. Fermentation will be completed in six days and beans can be taken for drying on seventh day.



Heap

Basket

Box

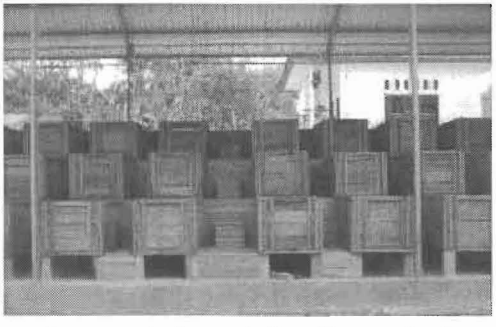


Sack

iii) *Plastic gunny bag method*: Cocoa can be fermented satisfactorily in clean plastic gunny bags without lining. Beans are filled ¾ thcapacity and tie loosely. Keep the bags on an elevated position to facilitate drainage of sweating. On the second day, plastic bags are heaped one over the other and insulated properly to conserve heat by covering with tarpaulin or polythene sheet. Beans are stacked and mixed thoroughly without opening the bags on third and fifth days and restacked. Beans are taken out for drying on seventh day.

Factors affecting fermentation

In addition to the method of fermentation, large number of factors affects the final quality of the beans. The factors are explained below.



Large scale fermentation- Box method

i) *Ripeness of pod*: Pods should be at a fairly uniform state of ripeness. Under ripe or over ripe pods will affect the whole process of fermentation. Cruz *et al.*, (2013) found that under ripe pods do not ferment properly and the temperature of fermenting mass will initially rise to 40°C and then continues to remain at 35°C till the fermentation is over.

ii) *Types of cocoa*: Criollo cocoa gets fermented in 2-3 days while forastero takes 3-7 days. Hence, it is recommended not to mix criollo and forastero types in a lot for fermentation.

iii) *Diseases*: Even if the beans are not destroyed completely due to pod diseases it is undesirable to use such type of beans in a fermentation lot. An increase in free fatty acid content will occur if disease affected pods are used which adversely affect the quality of chocolate.

iv) *Seasonal variation*: The per cent pulp recovery will be less during wet season when compared to dry season (Prasannakumari *et al.*, 2002).

v) *Storage of pods*: Pods stored in shades for 2 or 3 days before fermentation will accelerate fermentation process (Mossu, 1992).

vi) *Quantity of beans*: Minimum quantity of beans to be kept for fermentation is fixed to increase the temperature inside the lot. This is very important to get good quality fermented beans.

vii) *Duration*: Duration of fermentation varies depending on the genetic structure of cocoa mass, the climate, volume and method adopted which varies from 1.5 to 10 days.

viii) *Turning*: Frequency of turning the pods varies depending on the method adopted and the country in which it is processed. Usual practice is to turn on alternate days so as to ensure uniformity.

The end point of fermentation

The end point of fermentation can be judged by observing certain parameters.

i) *Color of beans*: Well fermented forastero beans will show a bleached centre with a brownish ring at the periphery.

ii) *External shell colour*: The pulp which is whitish initially turns to pinkish white after sweating. At the end of fermentation, the shell surface will attain reddish brown colour.

iii) *Smell of fermenting mass*: Faint sweet smell of fresh pulp will change to a characteristic acid smell as fermentation proceeds and persists till the end of fermentation. Over fermented beans will produce an ammonia smell.

iv) *Development of heat*: After setting for fermentation, temperature of the mass increases steadily and reaches a peak of 47 to 49°C by the third day. Then, temperature decreases slowly till the end of fermentation to a range of 45 to 46°C. However, mixing of beans during fermentation will raise the temperature.

v) *Plumpy nature of beans and colour of exudates*: Well fermented beans will be plump and full, and reddish brown exudates flow out on squeezing. Usually, beans in the fermenting lot will not be in same stage of fermentation. Hence, all the beans in a sample drawn from the lot will not show the above mentioned indices. When 50% of the bean is fully fermented it can be presumed that fermentation is complete.

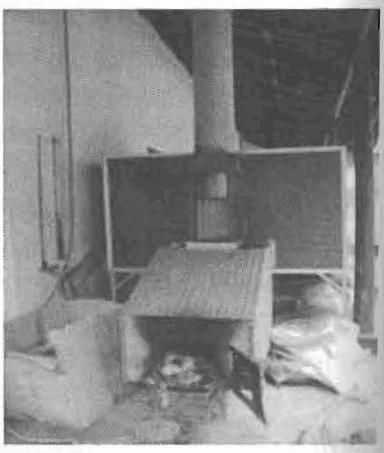
Drying

Fermented beans will have a moisture content of 55%. Main objective of drying is to bring this moisture content to 6-7% for safe storage and transportation. Moreover, drying process is a continuation of the oxidative stage of fermentation and this plays an important role in introducing bitterness and astringency and to develop chocolate brown colour in the final product. Thus, a very quick drying or excessive heating of bean will not be suitable. A very slow drying also will not suit as the beans get mouldy if they continue to remain moist too long. Cocoa can be dried by sun drying or artificial drying.

Sun drying is the simplest and most popular method in most of the cocoa producing countries. Depending up on the climatic conditions, beans are exposed to sun for about 4-12 days. This method generally gives good quality beans in traditional areas of cocoa production where the weather is sufficiently sunny. In West Africa and in India, beans are dried on raised ground or on concrete floors. In West Indies and South America, wooden drying floors are constructed with movable roof structure, which is referred as 'Boucans' in Trinidad and 'Barcacas' in Brazil (Wood and Lass, 1985). Attempts to improve the efficiency of sun drying using solar cabinets have been made (Mossu, 1992).Whatever be the method adopted, beans has to be spread in very thin layer and with frequent mixing.

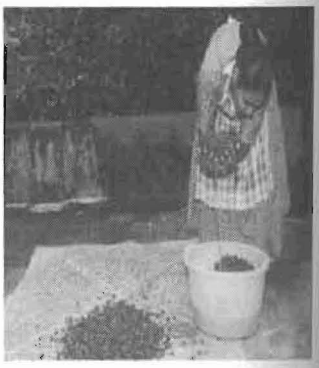
During rainy or wet conditions artificial drying is recommended. Heated air is commonly used to dry cocoa beans artificially. Temperature, rate of air flow, depth of the beans and extent of stirring are important factors affecting quality of artificial dried beans. Maximum permissible temperature for drying is 60°C. A convenient thickness could be about 12 to 15 cm, when mixing is done manually. To obtain optimum quality, cocoa beans are dried at 45°C for 9 hours.

Sun drying



Artificial drying

Secondary processing



Secondary processing involves the conversion of cured beans in to different products. Most important product obtained from cocoa is chocolate. The essence of cocoa and chocolate manufacture lies in the development of flavour obtained by roasting the beans followed by extraction of cocoa butter from the nib to produce cocoa powder. The steps involved are

Cleaning

Beans coming for secondary processing are to be cleaned thoroughly so as to remove foreign matters like broken beans, metallic foreign matter and dust.

Alkalization

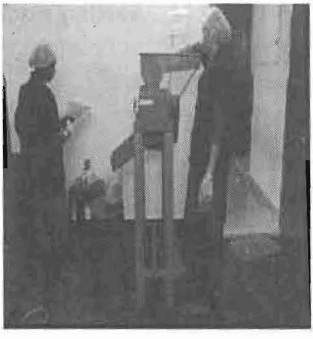
Cocoa beans are treated with alkali to improve the colour and to develop the flavour. This process is generally known as ditching. Alkalization helps to reduce astringency by complex polymerization of polyphenols and decrease the bitterness. Saturated solution of sodium or potassium carbonates or bicarbonates are mostly used while ammonium carbonate, magnesium oxide or carbonate or bicarbonate or mixtures of certain of the above chemicals are favoured by some manufacturers. Alkalized cocoa is commercially known as 'soluble cocoa'.

Roasting

Roasting is the most important step in cocoa processing. Cocoa beans are roasted in hot air and at this step characteristic chocolate flavour and colour are developed. During roasting, undesirable volatiles (acetic acid) are eliminated and moisture content will be reduced to 1-2%. It also decreases astringency and results in the development of aldehydes and ketones essential for cocoa flavour. Biogenic amines which are non volatile formed during roasting do not contribute to flavour of cocoa and cocoa products. Roasting parameters depend upon the raw material, the variety of cocoa and the type of desired flavour. Roasting time ranges from 10-35 minutes at a temperature between 110°C- 160°C. Over roasting causes the development of burnt taste as well as off flavour.

Three types of roasting process namely bean roasting, nib roasting and mass roasting are used commercially. In bean roasting, whole cocoa beans are roasted at a higher temperature and shells are loosened for easy separation from the nibs. The problems like development of off flavour and fat migration to the shell during roasting are overcome by nib roast. In mass roast, the nibs are converted to mass or liquid and then roasting is carried out. This will help to overcome the problem of uniformity in heating of beans.

Kibbling and winnowing



Kibbling process

Kibbling is a process by which the shells are separated from the beans. The purpose of winnowing is to separate the shells from cocoa nibs. Roasted cocoa bean will contain 10-15% shell depending on the source (Prasannakumari *et al.*, 2009).

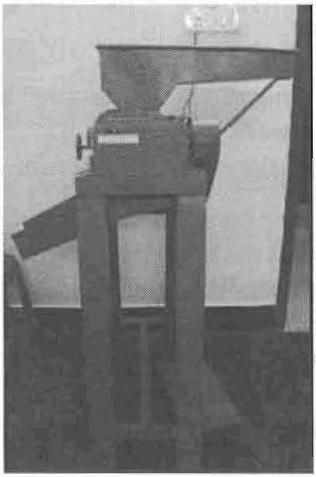
Grinding

The cotyledons are ground to get mass or liquor. Cocoa mass contains about 55-58% fat, which is also known as cocoa butter. This butter has the characteristic of melting at body temperature. Cocoa nibs are ground at relatively high temperature which will result in the production of cocoa mass.

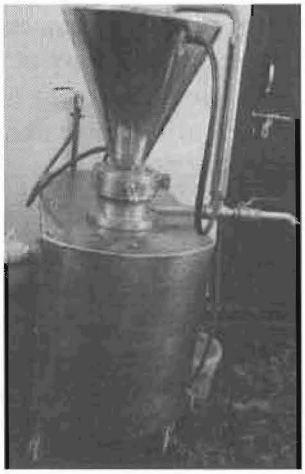
Extraction of cocoa butter from cocoa mass

Cocoa butter is extracted from the cocoa mass or liquor with the help of a hydraulic press. Another method of fat removal is solvent extraction by using butane as the solvent. Powder and butter obtained by solvent extraction will contain solvents which may cause undesirable flavour. Therefore, this has been filtered, neutralized and tempered. Butter under room temperature is hard in consistency, waxy, slightly shiny, pale yellow in colour and oily to touch.

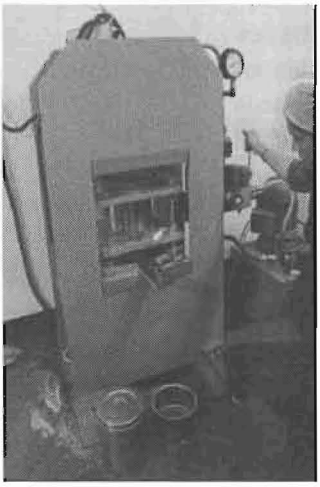
The extraction methods are crucial in cocoa industry so as to minimize the cost of processing, to get maximum extraction yield and to preserve bioactive compounds.



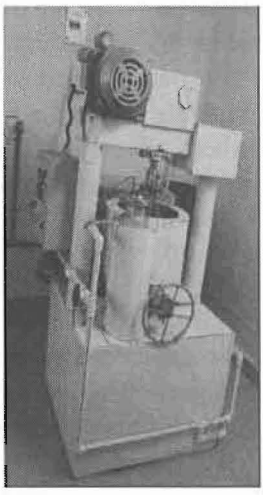
Shelling machine



Colloid mill for Grinding



Hydraulic butter press



Conching and tempering machine

Making of cocoa powder

The cake left behind at the bottom of the press after extraction contains 12-15% butter. This cake is milled and sieved to obtain cocoa powder. There are two types of cocoa powder. High fat powder with 20-25% butter and low fat powder with 10-13% butter. High fat powder is used in drinks while low fat powder is used in cakes, biscuits, ice creams and other products.

Production of chocolate

Chocolate is derived from sugar, milk and cocoa solids which in turn contribute to the flavour, aroma, colour and form of the final product. The proportion of mass, sugar and cocoa butter varies with manufacturers and remains to be a trade secret. Different types of chocolates are

Dark chocolate

This contains chocolate liquor, sugar and cocoa butter. Milk solids are not added in dark chocolate. The cocoa content of commercial dark chocolate varies from 30% (sweet dark) to 70-80% (extremely dark).

Milk chocolate

This is solid chocolate made with milk powder, liquid milk or condensed milk in addition to cocoa powder, cocoa butter and sugar. The percentage of cocoa powder in milk chocolate ranges from 25-29%.

White chocolate

This is made from sugar, milk and cocoa butter.

In chocolate manufacturing, the mixture of mass, sugar and milk powder are combined and it is refined using 2-5 roll refiner. This gives an absolutely homogenous mixture with fine grain size. The mass then become dry and flaky. It is kneaded again in a blender and then cocoa butter is added along with flavouring agent if necessary. Next step is conching which is actually agitating chocolate at a temperature above 50°C for few hours. This stage is very important because it contributes the development of final flavour and smooth texture of chocolate. This process will improve the flavour profile and reduces the concentration of free fatty acids and other volatile by-products of cocoa beans (Giacometti *et al.,* 2015). Temperature during conching depends upon the type of chocolate. For dark chocolate it is between 70-82°C.

Next step is tempering which is done in automatic tempering machines with a reduced temperature of 28-30°C. Objective of tempering is to promote crystallization of fat into a polymeric form. This will help to generate a more stable and acceptable final product. Next step is pressing and includes molding

the chocolate paste into different molds. The molds are shaken continuously in order to distribute the mass evenly without air bubbles. It is refrigerated at 7°C and chocolates are removed by turning out the molds. Finally, wrap chocolates in attractive packages.

Establishment of a small scale chocolate processing unit

The list of equipment required to establish a small scale cocoa processing unit to produce cocoa butter, cocoa powder and milk chocolate are given in Table 1. The cost of equipment varies depending upon manufacturer and capacity.

Table 1. Equipment required to establish a small scale cocoa processing unit

Sl. No.	Equipment	Amount(Lakhs)
1.	Pod breaker	0.50
2.	Roaster (10 kg)	2.00
3.	Grader cum bean breaker cum winnower	2.50
4.	Colloid mill (10 kg)	1.50
5.	Butter extractor (2 kg)	4.00
6.	Conching machine (10 kg)	6.00
7.	Tempering machine (30 kg)	10.00
8.	Packing machine (fully automatic)	8.50
9.	Deep freezer (100 L)	0.15
10.	Refrigerator (230 L)	0.35
11.	Miscellaneous (molds, table top grinder, oven etc)	0.50
	Total	**36.00**

Chemistry of chocolate

Cocoa contains more than 300 volatile compounds; the most important components are aliphatic esters, polyphenols, aromatic carbonyls and theobromine, which also prevent rancidity of fat. Pharmacologically active ingredients of cocoa seeds include amines, alkaloids, theobromine, caffeine, theophylline, fatty acids, polyphenols, tyramine, trigonelline, magnesium, phenylethylamine and N-acylethanolamines. A standard chocolate bar (40 to 50 g) contains theobromine (86 to 240 mg) and caffeine (9 to 31 mg) (Matissek, 1997). Characteristic bitter taste of cocoa is generated by the reaction of diketopiperazines with theobromine during roasting. Theobromine is produced commercially from cocoa husks. Cocoa butter contains fatty acids consisting mainly of oleic, stearic and palmitic acids. It also contains myristic, arachidic, lauric, palmitic, linoleic and α- linolenic acids. In cocoa, the polyphenols of particular interest are flavanols, a subclass of flavonoids. Cocoa contains more than 10% flavanol by weight. Chemical composition of beans after fermentation and drying is given in Table 2.

Table 2: Chemical composition (%) of beans after fermentation and drying

Composition (%)	Nib (Max)	Shell (Max)
Water	3.2	6.6
Fat(cocoa butter, shell fat)	57	5.9
Ash	4.2	20.7
Total nitrogen	2.5	3.2
Theobromine	1.3	0.9
Caffeine	0.7	0.3
Starch	9	5.2
Crude fibre	3.2	19.2

Composition of cocoa powder varies depending on roasting, alkalisation and pressing processes undertaken. If standard procedures are followed, normally, cocoa powder contains the components given in Table 3.

Table 3: Composition of cocoa powder

Constituents	Quantity
Moisture (%)	3.0
Cocoa butter (%)	11.0
pH (10% suspension)	5.7
Ash (%)	5.5
Water soluble ash (%)	2.2
Alkalinity of water soluble ash as K_2O in original cocoa (%)	0.8
Phosphate (as P_2O_5) (%)	1.9
Chloride (as NaCl) (%)	0.04
Ash (insoluble in 50% HCl)	0.08
Shell (%) (calculated to unalkalised nib)	1.4
Total nitrogen (%)	4.3
Nitrogen (corrected for alkaloids) (%)	3.4
Protein(%)	20.0
Nitrogen corrected for alkaloids x 6.25(%)	21.2
Theobromine (%)	2.8

Health benefits of chocolate

The chocolates based products have high energy value in relation with its volume. They contain a proportion of carbohydrates and proteins together with B complex vitamins and minerals. Plain chocolates contain 64.8 g carbohydrates, 29.2 g fat, 4.7 g protein, 11 mg sodium, 300 mg potassium, 38 mg calcium, 100 mg magnesium, 140 mg phosphorus per 100 g.

The health benefits of cocoa include relief from high blood pressure, cholesterol, obesity, constipation, diabetes, bronchial asthma, chronic fatigue syndrome and various neurodegenerative diseases (Andujar *et al.*, 2012). Cocoa offers anti-inflammatory, anti-allergic, anti-carcinogenic and antioxidant qualities and has

demonstrated positive effects by imparting numerous health benefits. It is beneficial for quick wound healing, skin care and it helps to improve cardiovascular health and brain health. It also helps in treating copper deficiency. It possesses mood-enhancing properties and exerts protective effects against neurotoxicity. Flavonoid-rich cocoa aids in lowering blood pressure and improving the elasticity of blood vessels. Furthermore, this helps in maintaining a healthy circulatory system (Serafini *et al.,* 2003). Cocoa polyphenols have strong antioxidant properties. The effect of cocoa is more predominant and pronounced in controlling oxidative stress ageing, nutritional deficiency and pathological stress (Allgrove and Davison, 2014). A diet containing cocoa has shown to reduce triglycerides, LDL cholesterol and glucose level. Consumption of cocoa has been shown to be effective in improving insulin resistance and glucose metabolism. Studies have confirmed the protective antioxidant activity of cocoa in the treatment of long term diabetic complications such as diabetic nephrotoxicity. Cocoa extracts, trusted for their therapeutic and wound-healing properties are used to manufacture natural medicinal products. The extracts help in preventing the development of various kinds of infections in the body. Potential benefits of cocoa in preventing high-fat diet-induced obesity have been reported. It is also essential in modulating lipid metabolism and reducing the synthesis and transport of fatty acids. Polyphenols present in cocoa has a capacity to reduce the occurrence of stroke artery diseases, heart failure and cardiovascular disease related mortality (Crozier and Hurst, 2014). Cardio protective properties of cocoa are related to improvement in antioxidant status, metabolic and anti-inflammatory process, regulation of blood pressure etc. Cocoa flavanols help to enhance mood, combat depression, and promote improved cognitive activities during persistent mental exertion. Beneficial effect of cocoa in inhibiting the growth of cancer cells without effecting the growth of normal healthy cells has been reported. Healing effects of cocoa have proven extremely valuable in the treatment of various types of cancers including colon and prostate cancers (Yamagishi *et al.*, 2002). Cocoa has also been found to be effective in maintaining good skin health. Research findings suggest that the consumption of flavonol-rich cocoa helps in decreasing the effects of UV- induced erythema and reducing skin roughness and scaling. Presence of major flavonols like epicatechin and catechin in cocoa has shown beneficial effects in treating neurodegenerative diseases like Alzheimer's.

Home level chocolates-from Kerala Agricultural University

Chocolates are usually manufactured in large factories with huge investment. Production of chocolates of acceptable quality was thought to be impossible till 2000. Studies on secondary processing at Kerala Agricultural University on small scale led to the technology of converting beans to bar and production of a

number of cocoa based products without any chemicals or preservatives. This opened up way to utilize cocoa in homesteads, ensure women empowerment, improve income from unit area of land and make available farm fresh and natural chocolates to large sections of the society at comparatively affordable price. One product '*Chocolate 4 U*', a milk chocolate was launched in February 2008.

Milk chocolate (Chocolate 4 U) and White chocolate

Chocolate 4 U

Ingredients: roasted nibs of cocoa- 400 g; cocoa butter- 500 g; powdered sugar- 1 kg; milk powder- 500 g; and vanilla powder (natural) -30 g.

White chocolate

Ingredients: cocoa butter- 500 g; powdered sugar- 400 g; milk powder- 360 g; vanilla powder (natural)-20 g.

Machinery required: wet grinder/small scale tempering cum conching machine and refrigerator

Chocolates are prepared by grinding the different ingredients and adding vanilla essence in a phased manner. Continue grinding for about 7 hours until the mixture reaches moldable consistency.

Pour chocolate on to the molds, shake slightly and refrigerate at 4°C for 2 hours. Pack the chocolates and store in a refrigerator.

Drinking chocolate

Drinking chocolate is prepared by mixing the cocoa powder with sugar in 1:4 ratio and powdering in a mixer. This can be mixed with hot milk (1 teaspoon/ cup) and consumed.

Machinery required: mixer grinder

Cocoa delite (black and white)

Black delite

Ingredients: cocoa powder- 40 g; milk powder-150 g; sugar-150 g; butter-40 g; water-75 ml; vanilla essence- 1-2 drops.

White delite

Ingredients: cocoa butter-40 g; milk powder-150 g; sugar-150 g; butter-40 g; water-75 ml; vanilla essence- 1-2 drops.

Machinery/ equipment: uruli, gas burner, tray.

Dissolve sugar in water by heating. To this, add vanilla essence and butter. When butter gets fully dissolved, add rest of the ingredients, mix the contents thoroughly and cool.

Milk chocolate candy

Ingredients: cocoa powder-800 g; cocoa butter- 350 g; milk- 15 liters; sugar- 4 kg; sugar candy-500 kg; liquid glucose-500 g; ghee- 1 teaspoon.

Machinery/ equipment: milk cooker, uruli, gas burner, tray

Mix sugar, sugar candy and liquid glucose with milk, boil to condense the mixture. After cooling, transfer the contents to a hard bottomed vessel. To this mixture, add cocoa powder, heat and then add cocoa butter. When it comes to bubbling stage, stir the mixture continuously till the mixture starts leaving the sides of the vessel. Transfer this chocolate mass to a tray smeared with ghee and level it. After cooling, mold to different shapes.

Cocoa bite

Machinery/equipment: milk cooker, uruli, gas burner, tray

Cocoa bite can be prepared from the chocolate mass used for making milk chocolate. Make small balls of about 10 g and decorate with cashew nut pieces roasted in ghee. For 7 kg mixture 1 kg roasted cashew nuts can be used.

White chocolate candy

Ingredients: cocoa butter-175 g; milk- 7.5 liters; sugar-750 g; sugar candy-750 g.

Machinery/equipment: milk cooker, uruli, gas burner, tray

Mix sugar and sugar candy with milk and boil. When the mixture is reduced to about 1/3rd add cocoa butter. Stir the mixture continuously. When the mixture starts leaving the sides of the vessel, transfer the content on to a greasy tray. This mass can be molded into chocolates of different shapes. These are packed and stored in a refrigerator.

Cocoa burfi

Ingredients: sugar- 250 g; milk-250 g; coconut-250 g; cocoa powder- 50 g; ghee- 25 g.

Machinery/equipment: milk cooker, uruli, gas burner, tray

Roast grated coconut in ghee until it becomes golden brown and powder it. Boil milk and add sugar, stir continuously till the milk- sugar mixture becomes 3/4 th

of the original volume. Add cocoa powder and stir continuously. Add powdered roasted coconut to the mixture and stir well. Stop the cooking when mass become sticky to touch. Grease a tray with ghee and pour the mass, spread it with spatula and cut it in to uniform pieces.

Cocoa cookies

Ingredients: maida- 500 g; dalda- 400 g; sugar- 300 g; cashew nut- 100 g; cocoa powder- 50 g; salt- a pinch; vanilla essence-1 teaspoon; baking powder- 1 teaspoon.

Machinery/ equipment: hot air oven, roaster, blender

Mix maida, salt and baking powder in a bowl and sieve twice. Soften dalda with the blender and add vanilla essence. Add powdered sugar to the dalda and mix. After this, add sieved maida and knead well. Add powered roasted cashew nuts, cocoa powder and knead thoroughly till no cracks are formed in the mass. Flatten the mass on a tray with 1 cm thickness and cut with the mold and put the cookies in a preheated hot air oven, bake at a temperature of 185°C for 20 minutes.

Cocoa nutribar

Ingredients: puffed rice- 300 g; corn flakes- 300 g; rice flakes- 200 g; oats- 200 g; sugar- 400 g; cashewnut- 100 g; jaggery- 200 g; liquid glucose- 300 g; raisins- 100 g; cocoa powder- 100 g.

Machinery/ equipment: roaster, mixer grinder

Roast puffed rice, rice flakes, corn flakes, oats and cashew nuts separately. Crush all the items. Roast raisins in ghee. Make syrup of jaggery, sugar and liquid glucose in to a thread consistency and mix all the roasted ingredients, roasted raisins and cocoa powder in to the syrup. Pour the mass in to a greasy tray and spread uniformly with a spatula. Cut the nutribar into pieces of 1.5 cm thickness, 11 cm length and 3 cm width.

Cocoa pudding

Ingredients: sugar-600 g; china grass- 3 packet; milk- 6 packet; milkmaid- 1 tin; cocoa powder- 30 g; cherries- 100g.

Machinery/equipment: milk cooker, refrigerator

Boil milk and sugar. Boil and melt china grass in water. Add melted china grass in boiled milk and stir. Then, add cocoa powder and milkmaid and mix well. After cooling, pour the mixture in to pudding plates and decorate with cherries.

Cocoa sip up

Ingredients: milk- 4 packet; water- 4 glass; sugar- 1 kg; cocoa powder- 10 g; vanilla essence- 2 teaspoon.

Machinery/ equipment: milk cooker, refrigerator, packing machine

Boil water, milk and sugar until it becomes ¾th of the original volume. Add cocoa powder in to half a cup of hot milk and pour it in to the whole mixture. Add vanilla essence to the mixture. After cooling, fill in the sip up covers and seal.

Cocoa ice cream

Ingredients: milk- 2 liter; sugar- 500 g; corn flour- 6 teaspoon; chocolate 4 U- 200 g; whipping cream- 1 cup; milkmaid- 200 g.

Machinery/ equipment: milk cooker, deep freezer

Boil milk with sugar. Add corn flour- milk paste to the mixture and make custard. After cooling, refrigerate for 4-5 hours. Blend the custard and add chocolate mass and vanilla essence. Whip the whipping cream in another bowl till it becomes a peak. Add whipped cream and milkmaid to the custard mix and blend together. Keep it in the freezer for 6 hours. After 6 hours again blend the mixture thoroughly, cover the tray with aluminium foil and keep for another 6 hours in the freezer.

Chocos

Ingredients: sugar- 500 g ; milk powder- 500 g; cocoa powder- 6 teaspoon; cocoa butter- 200 g; cashew nut- 1 cup; vanilla essence- 200 g.

Machinery/ equipment: uruli, gas burner, tray

Mix sugar and vanilla essence in water and boil. Add cocoa butter to the boiling mixture. Keep it for cooling. After cooling add cocoa powder and milk powder along with roasted cashew bits. Make the mixture into small balls.

Success stories in cocoa processing sector

Cost of production of milk chocolate is approximately Rs.300/kg when materials are purchased from retail market. Cost of production is expected to come down significantly when the activity is initiated on regular basis. Cost of branded chocolates varies from Rs. 1000-1500/kg. In recent times in tourist hot spots a number of homemade chocolate units have come up and is spreading like a cottage industry in India. Training for secondary processing is given at regular basis at Cocoa Research Centre under Kerala Agricultural University which resulted in the establishment of processing units by self help groups. List of

chocolate units started by women who were trained in the centre are listed below.

1. Sargasree chocolates, Karalam, Thrissur
2. Kukkoos chocolates, Poonkunnam, Thrissur
3. Real dreams, Guruvayoor, Thrissur
4. Pentas cocoas, Thrissur
5. Bliss chocolates, Thodupuzha, Idukki
6. Mariyan chocolates, Idukki
7. Leela foods, Kottayam
8. Roshni organic farming club, Kozhikode
9. Devamrutham herbal products, Kollam
10. CARD (Christian Agency for Rural Development) Krishi Vigyan Kendra, Pathanamthitta
11. Kids chocolates, Krishnapuram, Thrissur
12. Tasty chocolates, Puranattukara, Thrissur
13. Madhurima, Madakkathara, Thrissur

In addition to this, certain entrepreneurs have established sophisticated cocoa processing units. One example is Mr. Boby of Chalakudy who have a chocolate unit with a capacity to manufacture 100 kg chocolate per day.

Scope of by-product utilization

Processing of cocoa both at primary and secondary levels gives a large quantity of waste materials. Disposal of waste is a major problem of cocoa growing countries. Research on utilization of these indicates that by-products can be made from cocoa waste.

Pod husk

About 70-78% of pod weight is constituted by pod husk. These are generally discarded after collection of beans. Pod husk contain crude protein (5.69-9.69%), fatty substances (0.03-0.15%), glucose (1.66-3.92%), nitrogen free extract (44.21-51.27%), crude fibre (33.19-39.45%), theobromine (0.20-0.21%) and ash (8.83-10.18%). Cocoa pods can be used as potential fiber sources for pulp and paper production to promote the concept 'from waste to well' and 'recyclable material to available product' for reducing the environmental problem (Daud *et al.*, 2013). Dry pod contains 5.3-7.08% pectin and is higher than the pectin content of orange pulp, lemon pulp and apple pomace, the established raw

materials for pectin (Marsiglia *et al.*, 2016). Nitrogen and phosphorus content of cocoa pod husk is comparable to farmyard manure from animals (Simpson and Oldham, 1985).

Pod husk contains less theobromine than cocoa shell and makes it a less dangerous feed stuff. Incorporation of 20% pod husk in cattle feed had shown beneficiary effect (Ashade and Osineye, 2013).

Mucilage consistency

Concentration of alcohol in the sweating is about 2-3% and of acetic acid is 2.5%. Sweating contains water (79.2-84.2%), dry substances (15.2-20.8%), citric acid (0.77-1.52%), glucose (11.60-15.32%), sucrose (0.11-0.92%), pectin (0.90-1.19%), proteins(0.56-0.69%) and salts (K, Na, Ca, Mg) (0.41-0.54%) with a P^H of 3.2-3.5. Sweating can be used to make jelly or jam. Cocoa sweating is also used for making alcohol and vinegar.

Dias *et al*, (2007) successfully made fruit wine by fermenting fresh cocoa pulp using *Saccharomyces cerevisiae* strain. Since, high amount of pectin and sugar are present in cocoa pulp, it can be used for making juice and jelly (Malaysian cocoa board, 2004). In Ghana, unfermentable pulp is used for making jam (Cocoa Research Institute of Ghana, 2010_a). Gin and brandy from cocoa pulp are commercially available in Ghana (Cocoa Research Institute of Ghana, 2010_b).

Shell or testa

Availability of bean shell is of the order of 11-12% of dry beans. It contains 2.8% starch, 6.0% pectin, 18.6% fibre, 1.3% theobromine, 0.1% caffeine, 2.8% total nitrogen, 3.4% fat, 8.1% total ash, 3.3% tannins and 300 IU vitamin D. The yield of furfural is about 5-6%. The fat present in cocoa shell with a lipid profile similar to cocoa butter can be extracted and used (Okiyama, 2015) for different purposes. Even though, chocolate aroma was found to be less pronounced, it will not significantly affect the overall acceptability of the products. Cocoa shell ash is also used as an alkalizing agent for cocoa nibs. Shell is found to be very good mulch and it is used in anthurium, orchid and foliage plants.

Future scope of research

Quality of primary processed cocoa beans depends upon the free fatty acid content. High amount of free fatty acid will reduce the quality and economic value of cocoa beans (Guehi *et al.*, 2008). The reason for accumulation of free fatty acid is due to unscientific practises followed during fermentation and storing (Hiol, 1999). Therefore, a thorough research has to be done in order to standardise different steps of primary processing in such a way that the amount of free fatty acid falls within the prescribed limit.

Scope of entrepreneurship development in cocoa processing sector in India

India produces a large range of cocoa and non-cocoa based confectionery items, besides other cocoa-based products. Production of confectioneries, except chocolates, is reserved for the small-scale sector. However, there are several large companies with an established markets and brands in cocoa and non-cocoa confectionery items. Confectionery output grew at a compound rate of 6 to 7% in recent years. Chocolate production is growing at the rate of 10 to 15% a year.

Total area under cocoa in the country is presently 81,274 ha, which comes to only about 1.5% of the coconut and arecanut area in India. In terms of area, Kerala was the leading cocoa growing state in the country till recently but there has been significant enhancement in area in Andhra Pradesh as an intercrop both in coconut and oil palm plantations. In terms of production, Kerala leads with 8,500 MT, followed by Andhra Pradesh (5500 MT), Karnataka (2500 MT) and Tamil Nadu (1500 MT). The annual production of cocoa in India is about 16329 MT; whereas the annual requirement to run the chocolate factories throughout the year is estimated to be 27216 MT.

India plans to increase its cocoa production by 60% in next four years to meet rising demand from the chocolate industry and to cut dependency on costlier imports. Chocolate consumption is gaining popularity in the country due to increasing prosperity coupled with a shift in the food habits, pushing up the country's cocoa imports. Experts opine that there is huge scope for expanding area under cocoa considering the rising demand and firm global price. Cocoa requirement is growing, around 15% annually. Per capita consumption of chocolates in India has increased from 40 g per person per year in 2005 to 110-120 g. Though, this is a very significant jump in consumption, it is still very nascent, leaving enough room for growth. A delectable combination of rising income, changing lifestyles and a young population's growing penchant for indulgence has transformed India into one of the world's fastest growing chocolate markets. Moreover, adults also have developed a culture of gifting chocolates in special occasions instead of traditional sweets. A report from French investment bank Societe Generale predicts that in the next five years, global confectioners will see highest growth in four markets which are India, Mexico, China and Brazil.

Safety and quality aspects of cocoa products

Quality requirements

The word 'quality' includes all the important factors of flavour and purity. It also covers the physical characteristics, which have a direct influence on value and accessibility of a lot of cocoa beans. The quality of a sample is primarily judged by the flavour of chocolate made from it. It also depends on factors such as bean size, shell percentage, fat content and number of defective beans. Cocoa of good quality will have the inherent flavour of the type of cocoa together with the relevant physical characters and freedom from defects.

Different aspects of quality are discussed here under:

Flavour

Flavour is developed during fermentation and roasting (Niemenak *et al.*, 2014). Flavour is assessed by tasting the chocolate made from a sample by a panel of experienced tasters. Flavour varies with the type of cocoa. Criollo and Trinitario give the finest of them all. Forestero types like Amelonado, Amazon and hybrids give 'bulk' cocoa, which constitute about 90- 95% of the worlds' supplies. Flavour of bulk cocoa varies from country to country. Common off-flavours detected in both fine and bulk cocoa are:

Mouldy: This arises due to the presence of moulds inside the beans. Sample with as low as 4% of mouldy beans impart an off- flavour to the chocolate. This off- flavour cannot be removed by processing.

Smoky: Contamination by smoke during drying or during storage can cause off- flavour. This off- flavour can be removed during chocolate manufacture.

Acidic: This is due to the presence of excessive amounts of volatile (acetic acid) and non volatile (lactic acid) acids. During manufacture, acetic acid is reduced to an acceptable low level, but lactic acid is not removed.

Purity or wholesomeness

It is essential that the cocoa beans delivered to the market are pure. It should not contain any impurities. In recent years, more importance is given to hygiene and safety at all levels of production and manufacture of food products. Important sources of impurities in cocoa beans are pesticides, bacteria and foreign matter.

Consistency

Quality of cocoa cured in a particular site and send to different places should be consistent. This is essential because the chocolate manufactures aims to produce chocolate of consistent quality. To some extent, consistency of bulk cocoa can be achieved by blending cocoa of the same grade standard.

Yield of edible material

A number of factors affect the yield of edible material or nib and cocoa butter.

Bean size and uniformity: Average weight of cured dry bean should be at least 1.0 g. The traditional criterion is that not more than 12% of the beans should be outside the range ± one third of the average weight.

Shell percentage: Shell should be loose, but strong enough to remain unbroken during normal handling. It should be free from lumps of dried pulp. Main crop of West Africa usually has a shell content of 11-12%.

Fat content: Cocoa grown under optimum conditions produce beans with 56-58% butter in the dry nib.

Moisture content: For safe storage the moisture content of cocoa beans should be around 6-7%.

Foreign matter, flat beans and insect damaged beans: Presence of these will reduce the quality of usable beans.

Cocoa butter characteristics

- Good quality cured cocoa beans will contain about 0.5% free fatty acid.
- Cocoa butter consists of triglycerides i. e. fats, which are made up of glycerol and three fatty acids, of which one is unsaturated. Manufacturers prefer cocoa butter that is relatively hard and consistent. Cocoa butter from West African countries gives the desired properties.

The cut test to assess quality

It is the standard method for assessing quality as defined in quality standards (Shamsuddin and Dimmick, 1986). It defines the major off- flavours- mouldy and unfermented beans based on visual examination of a cross section of the nib. Other defects, which can affect the keeping quality of cured cocoa are also detected. It is a guide to the degree of fermentation.

Cut test involves cutting 300 beans lengthwise taken from a random sample of cocoa. Based on the colour, beans are categorized as fully fermented, partly brown; partly purple, fully purple and slaty. Fully fermented beans are those which are almost brown. The beans, which are showing blue or violet colour on the exposed surface come under the second category. The fully purple category includes beans showing complete blue, purple or violet colour, over the whole exposed surface. The slaty beans are unfermented beans.

It is not possible to prepare a sample with 100% fully brown beans and it is not desirable to attempt to do so. Partly brown and partly purple are not defective ones and should be present at least to the extent of 20%. A proportion of 30-40% is acceptable, but sample with more than 50% is objectionable as these may give rise to astringent flavour to the finished product.

Safety of cocoa beans

Adulteration is the main problem in cocoa commodity. Empty shells of cocoa, fine grains of soil, rocks are often found as adulterants (Anton, 2017).

Chemical safety

Pesticide and fungicide residues in cocoa products are another major problem even though cocoa pods are not directly exposed to these chemicals. Systemic fungicide or pesticide in plants will affect the fermentation process. There is a potential danger of heavy metal content if fermentation is carried out in polluted environment.

Microbial safety

Salmonella and other enteropathogenic bacteria are the main threat for microbiological safety in cocoa beans, products, powder or chocolates. *Salmonella* posse's acid resistant strains so they can survive in cocoa beans even after fermentation and drying. To overcome these problems good agricultural practices can be adopted during cocoa processing.

International cocoa standards

The International cocoa standards were agreed at a meeting of producing and consuming countries held in Paris in 1969 (Wood and Lass, 1985). These standards form the basis of the grading regulations of several cocoa producing countries. Cocoa of merchantable quality is defined as

- Fermented, thoroughly dry, free from smoky beans, free from abnormal or foreign odours and free from any evidence of adulteration.
- Reasonably uniform size, reasonably free from broken beans, fragments and pieces of shell, and be virtually free from foreign matter.

Maximum percentages of mouldy, slaty and insect damaged, germinated or flat beans in Grade 1 will be 3% each and in Grade 2, maximum limits are 4, 8 and 6% respectively.

Conclusion

Cocoa originating from beans of the cocoa tree is an important commodity in the world and the main ingredient in chocolate manufacture. Its value and quality are related to unique and complex flavours. There is no single key component that determines the final flavour character. Both nonvolatile and volatile chemical components contribute to the cocoa aroma. Specific cocoa aroma arises from complex biochemical and chemical reactions during the post harvest processing of raw beans, and from many influences of the cocoa genotype, chemical make-up of raw seeds, environmental conditions, farming practices, processing, and manufacturing stages.

Cocoa and cocoa-based products such as chocolate are one of the major natural sources of dietary flavonoids because of its high content of polyphenols, epicatechin, catechin and their oligomers, and the procyanidins. Factors such as rising cocoa prices and lack of supply-chain infrastructure in India have not exactly dampened the enthusiasm of chocolate manufacturers. Chocolate industry in India is growing at nearly 20% every year. Still, there is a huge opportunity to expand our chocolate portfolio in the country in the coming years.

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