Possible Approaches to Arecanut Sorting / Grading using Computer Vision:A Brief Review

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Abstract-Computer science is involved to the greater extent in agricultural and food science these days. Many Artificial Intelligence and soft computing techniques and technologies are used for classification and defect detection of various products and thus helps in *Better* quality product for the end users. In this paper we focus on the standing of Arecanut in global and Indian market and usage of computer vision and image processing in an Arecanut classification and grading system. It is essential to take into consideration cultural and economic importance of Arecanut to determine the importance of computer vision technology for Arecanut. There are so many challenges to face in order to develop a system for automatic classification of Arecanut using images. Depending on the category and the region they are grown; several varieties of Arecanut are subject to significant difference in color, texture and shape. Various methods are used to process Arecanut mainly focusing on the external appearance of the product. Solution for classifying/grading Arecanut can be developed using its color, size and texture. We have also quoted the important work accomplished in respect of Arecanut from the Computer vision perspective and on some other fruits as well. The main motto of this article is to provide in-depth introduction to Arecanut, Computer Vision, need and applications of vision based technology in classification and grading of Arecanut.

Keywords- Computer Vision; Arecanu;, Classification; Sorting;Grading; Feature Extraction.

I. INTRODUCTION

Agriculture plays a significant role in socio-economic development of the country. It is Indian economy's backbone and it contributes18.5% of the gross domestic product. It accounts for ten percent (10%) of total exports of the country. Over 60 % of India's land area is arable making it the second largest country in terms of total arable land. About 50% of the Indian workforce depend upon Agriculture in the country [1][2]. Being the major contributor for the primary livelihood of mankind, it is a traditional occupation pursued by the majority of population. A stable Agricultural sector assures a nation with food, source of income and source of employment. As the country develops in various cultivation technologies in the recent years, the overall cultivation areas and yields for agricultural produces have increased rapidly, results in greater market value. Although we have a great chance to stand as a major exporter of agricultural produce, in global scenario our share is very low because of reasons like, post-harvest losses in handling and processing various products, unscientific methods that we fallow in our trades and procurement technologies, lack of in depth knowledge in preservation of products and quality evaluation measures. In our country with ever-increase in population there is always a demand for good quality products with greater outlooks. For every agricultural product there is an urge for the concentrated quality determination, which is faster reliable and accurate. Before exporting food and agricultural produce, guaranteeing product identification and quality product is one of the most significant and challenging tasks of the industry. The classification and grading techniques that we do manually, being used to distinguish between different types of fruits and vegetables fully rely on human efforts. Since these techniques involve greater human intervention, they are subject to human errors. As humans are subjected to tiredness and due to the shortage of man power, automated system needs to be incorporated to minimize the work, reduce the process time and errors.

In the last two decades, computer vision is getting a lot of attention of research community. Computer vision based solutions are fast, economic, consistent, which has gone into many different industrial sectors. This Computer Vision includes various steps like image acquisition, pre-processing, enhancement and understanding images and, in general, we can say a high-dimensional data from the real world will be converted to numerical or symbolic information. Totally Computer Vision solutions aim at mimicking the human vision system these days.

Machine Vision applications have its own importance in the field of Agriculture. In Machine Vision numerical and symbolic information of the objects and the image being

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captured are obtained using Machine Vision systems, which also helps in recognizing shape, size, color and texture of various objects. We usually recognize objects in the visible color region. Being humans it is hard to obtain objects in ultraviolet, near-infrared and infrared regions. But it can be done with the help of various Machine Vision systems. The data obtained from objects in low light regions can be very helpful in obtaining pre-harvest plant maturity, disease, or stress scenarios [3]. Machine Vision is very helpful in obtaining fruit and vegetable maturity, variety, quality and ripeness. It is also useful in obtaining safety of the product and quality features, such as composition, diseases, defects, properties and contamination of grains and nuts, fruits and vegetables.

I. ARECANUT

'Arecanut', is botanically popular as Areca catechu. It is a tropical plant that we can find in the regions of South East Asia. Areca belongs to Arecaceae family and the palm tree species. Arecanut (Arecanut catechu) is a common masticator nut, consumed by all sections of the population, region, religion, cutting across caste, age and gender in India. In Indian subcontinent the fruit or nut of this Areca tree is popular as betel nut or supari. In the Western Ghats, Eastern Ghats, East and North Eastern regions of India, Arecanut or betelnut (*Areca catechu*) is grown as an important commercial crop. In India it has its own importance in the social, cultural and religious celebrations and has huge impact on economic life of people. It is also a commodity of commercial, economic and conventional importance. It contributes about 21,000 cores of rupees to Gross National Product. Its economic importance is such that 6.25 million people in India earn their lively hood through areca industries.[4]

II. HISTORY OF ARECANUT

Arecanut forms an essential requisite in religious and social ceremonies and its use dates back to Vedic period. Reference to Arecanut is found in Rig-Veda (2000 BC)[5]. *Dhanwantari Nighantu,* an ancient text of Indian system of medicine mentions the use of Arecanut as one of the five natural aromatics (*Panchasugandhikam*) with pepper, clove, nutmeg and camphor[6].

The origin of the Areca nut cannot be traced exactly, but in Philippines or Malaysia it probably originated. Initially in Vietnam and Malaysia the use of nut for chewing started, as the 'stimulating' effect of the alkaloids present in the nut. From this region the areca nut travels to the other part of Asia continent and got recognized as a cash crop[7].

III. ARECANUT- A GLOBAL SCENARIO

Globally it is initially cultivated in India, China, Burma, Indonesia, Myanmar and Bangladesh. India tops in the production where China and Bangladesh stood next to India. In 2013-14 the production of Arecanut from an area of over 9.5 lakh hectares in the world was over 13 lakh tones. India ranks first when it comes to both area (47%) and production (54%) of Arecanut. China (20% in production and 5% in area) ,and Bangladesh (9% in production and 17% in area and), and Indonesia (14% production and 14% in area) are the major Areca producing countries in the world.[8] Myanmar and Thailand also contributes to Areca production but in a very smaller scale. The global productivity of Arecanut is about 1.25 tons/ha. Indian productivity almost matches with the world productivity of (1.20 tons/ha). In the mid-eighties major expansion happened in Areca growing area and Areca growing stared in many of the countries of the world. China stands first with a productivity of 4164.76 kg/ha, where Myanmar stands with a productivity of 2264.15 kg/ha and the third position taken by Thailand. Although India ranks first in global production, it is ranked 4th in terms of productivity, whereas Malaysia, Bangladesh and Indonesia stands in 5th, 6th and 7th positions following India in the 4th. [9]. Global Areca belt can be presented as in Figure 1 and Figure 2.

IV. ARECA PRODUCTIVITY IN INDIA

In the global scenario, India is the major producer and consumer of Arecanut. Karnataka, Tamil Nadu, Kerala, Assam, Meghalaya and West Bengal contributes major share in the Arecanut production of the country.During 2013-14 production of Arecanut in the country crossed 7 lakh tons. As per the recent estimates area under Arecanut during 2013-14 was 445,000 ha and production was 729,810 tons. Karnataka stands first in the Arecanut production with a production of 457,560 tons from an area of 218,010 ha.[10] in the country. West Bengal Meghalaya and Assam holds minor shares in terms of area and production during 2013-14. In India 80 per cent of the country's production is given by Karnataka and Kerala. West Bengal, Odessa, Tamil Nadu, Andra Pradesh and Maharashtra also expanded the Areca cultivation in recent years. The Karnataka almost doubled the area of cultivation during the last 15 years. Area and Production of Arecanut in various states of the country is given in Figure 3.

V. Classification of Arecanut

Arecanut can be classified in to various categories depending on the countries and different regions of it.

As it can be used for several purposes, many individual industries differentiate Arecanut into several types according to their need and usage. Maturity, color, glossy appearance, moisture content, weight, size, shape, texture etc. determine the grade and class of Arecanut. Arecanut is basically classified in to its two categories, that is, raw Arecanut and processed Arecanut. It is also termed as with husk and without husk respectively. Raw Arecanut is further classified into four categories that is, *Hasa, Bette, Gorabalu* and *Chali)*. The hierarchical structure is given in figure 5. *Hasa* is a premature state of Arecanut and it weighs less but it is costliest among the varieties of Arecanut. *Bette* is a transition state of nut between immature to mature Arecanut. *Gorabalu* is matured Arecanut and it can be easily identified with its properties of color, hardness etc. Whereas *Chali* is t ypical raw Arecanut which is dried along with its husk and later on used after removing its outer shell[11].Processed Arecanut is classified in to many types based on its applications. General classification is in to 5 types that is, *Hasa*, *Bette*, *Rash iIdi*, *Gorabalu* and *Chali*. Further *Hasa*, *Bette* and *Chali* are again classified in to 7 of its categories, whereas *Rashi* and *Idi* are classified in to 3 different categories. *Gorabalu* is classified in to 4 different categories[11].The different varieties of Arecanut can be seen in the Figure 5.1, 5.2, 5.3, 5.4, 6.1, 6.2, 6.3, 6.4, 6.5.

VI. USES OF ARECANUT

Arecanut is mainly used in medicinal filed for the preparation of various medicines. The habit of chewing Arecanut is almost common in Indian subcontinent. Although, production of Arecanut concentrated in few states of the country, the commercial product has it's importance throughout the nation. There are mainly two kinds of processed Arecanut, *Chali* (ripe sun dried nuts) and *red boiled type* (tender or mature nuts). Dakshina Kannada and parts of Uttara Kannada districts of Karnataka produce this *Chali* kind of Arecanut. This *Chali* Arecanut is mainly used in making of scented *supari* and it has huge commercial demand in Northern India. There is a huge market demand for varieties of red boiled nuts that are produced in other states of the country. Almost 20 per cent of total areca production in the country is consumed as ripe fruit [8]. As per the various markets throughout the country, there are more than 150 types of Arecanut are produced, these areca types differs in maturity, processing conditions and taste characteristics. The husk of nuts which is an primary sub-product of the Arecanut industry, is mainly used in the preparation of particle, paper and board etc. Where the leather industry uses the *'Chogaru'*, a by-product obtained from the tender Arecanut for converting hides into skins as it is rich in Tannins [4].

VII. RELATED WORK

To the best of our knowledge classification of Arecanut has not been done completely using computer vision. There have been some techniques proposed for classification of particular types of Areca nuts and there are also several techniques proposed so far for the purpose of classification of fruits, food and seeds. In respect of areca (AjithDanthi&Suresha M) proposed several techniques to classify both raw and processed areca nuts. Few robust algorithms proposed for classification of areca can be given as, Suresha M and AjithDanti[12] proposed a technique to grade Arecanut into two different classes, Boiling and Non-boiling nuts. Here the Arecanut YC_BC_R color space is obtained by converting RGB images. Then the three sigma control limits on color features are obtained for effective segmentation of Arecanuts. Then Color features are used for grading of Arecanuts with the help of support vector machines (SVMs) into respective categories. They have used k-fold cross validation method to state the efficiency of the approach. SureshaM, AjithDanti and S K Narasimha Murthy [13] proposed a technique to classify the Arecanuts using Haar wavelets. A method is proposed to use Wavelet decomposition for feature extraction. The statistical feature energy is derived from the approximationcoefficients for each level of decomposition and color features are also extracted from Arecanut image for classification. Here they have used decision tree classifier for classification of Arecanuts. Many tree splitting rules are used like gini diversity index, twoing rule and entropy. Proposed algorithm is verified for Arecanut images with cross validation method and achieved good success rate. Suresha M and AjithDanti[14] have also proposed a technique to grade raw Arecanuts as well. They have used color as a main feature for Areca nut grading. Initially the segmentation is done using threshold based segmentation algorithm. In the segmented region, only red and green components are used to classify the Arecanuts by suppressing the blue color components. Average red and green component of a areca nut is extracted. Arecanut is classified into various categories based on the extracted features. A combination of KNN and SVM classifier is used to classify different types of areca nuts. The test result showed that the system have achieved a success rate of up to 98% among raw areca nuts. Suresha M and AjithDanti[15] have also proposed a technique for classification of Arecanut based on texture features. To segment the Arecanut images they have used

watershed segmentation. Mean Around features and GLCM features are extracted in the segmented regions. Here they have used Mean around features, combined (Mean around-GLCM) features and Gray level co-occurrence matrix (GLCM) features for Classification of Arecanut. They have used Decision tree classifier for the classification of Arecanut, and the classification was done in to six classes (Api, Black *Bette*, Red *Bette*, *Chali*, Minne, Gotu). The technique gives the convincing results as well. For the testing purpose the Cross validation method is used and found that, the GLCM features have given success rate of 97.65%. Mean Around features have given success rate of 98.28%. Mean Around-GLCM features have given success rate of 99.05%.Suresha M, AjithDanti and Narasimha Murthy S K[16] proposed a technique for classification of Arecanut. In this work HSV images were obtained from respective RGB images. Then the segmentation was done by extracting the saturation channel with the help of threshold based segmentation method. Then for Arecanut images, the LBP have been applied. With the help of LBP, image histogram, Gabor, GLCM features have been obtained. Then with histogram features, correlation distance metric classification has been done and then classification has been done with Gabor, GLCM and combined (GLCM-Gabor) features using kNN classifier. The obtained results show that combined features gave convincing results and the success rate is directly proportional to k value. Harish Naik T and SureshaM[17] proposed a technique to classify raw Arecanut with husk in to various categories using color features of the components. In this paper they have used RGB, HSV and YCbCr color spaces of Arecanut at the stage of feature extraction. And then Classification is done using kNN and SVM classifiers. Whereas HSV color model gives the good success rate when compared to other color models.Kuo-Yi Huang[18] proposed a technique to classify Arecanut into 3 major categories (Excellent, Good and Bad). In his work detection line (DL) method was used for segmentation of defected Arecanuts with diseases or insects. Then in the process of feature extraction Six geometric features namely the principle axis length, axis number, compactness, area, the secondary axis length, perimeter and, 3 color features, that is, the mean gray level of an Arecanut image on the R, G, and B bands, and defects area were used. And then the back-propagation neural network classifier was used to sort the quality of the Arecanut. The presented methodology gives the accuracy of 90.9%. Siddesha S, S K Niranjan and V N Manjunath Aradya[19] proposed a technique to differentiate color segmentation techniques for crop bunch in Arecanut. In their work they mainly focused on exploring different color segmentation techniques such as, Watershedsegmentation, Thresholding, K-means clustering, Fuzzy C Means (FCM), Fast Fuzzy C Means clustering (FFCM) and Maximum Similarity based Region Merging (MSRM). Then with the help of different Arecanut image datasets the evaluation was done based on the segmentation results. Siddesha S, S K Niranjan and V N Manjunath Aradya[20] proposed the texture based grading of Arecanut. In that different texture features are extracted from Arecanut by using Wavelet, Gabor, Local Binary Pattern (LBP), Gray Level Difference Matrix (GLDM) and Gray Level Co-Occurrence Matrix (GLCM) features. Nearest Neighbor (NN) classifier was used for classification. To demonstrate the proposed model's performance, the test was conducted using a dataset of 700 images belongs to 7 different classes. Along with the help of Gabor wavelet features they have achieved the classification rate of 91.43%.

Similar to Arecanut there are several technologies developed to grade and classify various types of fruits, vegetables and seeds based on Color, Shape and Texture. Some of the important works are: P. Sudhakara Rao et al.[21] proposed a techniques which used HSI model for sorting and grading of fruits by color and developed a system for sorting of Apples based on color, shape and size. Here the color of the image is calculated by using advanced image processing algorithms and then by considering median density of Hue as a grading criterion, color inspection of apples achieved around 98 % accuracy. Yousef Al Ohali [22] has proposed a system for grading of dates using Computer Vision. They have used RGB images of the date fruits and from these images they have extracted some external quality features such as flabbiness, size, shape, intensity and defects. Based on the extracted features and with the use of back propagation neural network classifier, they classified dates into three quality categories grade 1, 2 and 3. And for preselected date samples, testing was conducted and the accuracy of the system was checked. The test results showed that the system can sort 80% dates accurately. Hassan Sadrniaet al [23] comes up with a technique to classify the long type watermelon concentrating on the fruit shapes. Primarily the physical characteristics of watermelon such as volume, dimensions, density, mass, spherical coefficient and geometric mean diameter were measured. For normal and non-standard fruit shape relations and correlations coefficient were obtained. Sudhakar Rao et al[24] proposed six different techniques to obtain the size of different category of apples by applying various geometrical models. He used different models like circle method, parabola method, ellipse method, principal axis method, radius and area signature method and coefficient of variation method in his technique. A Esehaghbeygi et

al.[25] comes up with a Machine Vision technique for evaluation and classification of peach. Primarily to categorize peaches, the physical features such as size and color were measured and Peaches were categorized into three quality classes of red-yellow, yellow-red, and yellow. With the proposed technique the size and color classification achieved the success rate of 96% and 90% respectively. Spot detection algorithm for white and brown skin spots, achieved the accuracy of 85% and 97% respectively. RaziehPourdarbani, Hamid Reza Ghassemzadeh, HadiSeyedarabi, Fariborz ZaareNahandi, Mohammad MoghaddamVahed[26] did a comparative study in classifying different types of dates between human vision and machine vision. Here k-means classifier method was used to classify the date based on the color components and the results are compared with human vision results. The result showed that computer vision results are *better* when compared to human vision results. Y. Wang et al (2010) [27] designed a system where based on fruits surface color Fruit quality inspection is done. Fruit image is taken first and then histogram of Hue and Saturation of fruits surface color is calculated. Then the 3 layer back propagation network is designed, the Back Propagation gives the output as quality description of given tested fruit. Training of Back propagation network is performed. They performed experiment on banana and result obtained is accurate. H. Dang et al (2010)[28] developed a system for fruit size detection. The basic steps performed in this are preprocessing, edge detection, fruit size detection and based on size grading of fruit is done. As a first step filtering of image is done with help of faster median filter algorithm, results in removing noise and detection of good edge. In edge detection, the image taken is converted into grey image. Then OSTU method is used to get binary image. For edge sequence detection 8-connected boundary method is used. Then fruit size detecting algorithm is used in order to calculate size of fruit. Natural symmetry is taken into consideration in order to calculate the diameter of fruits. For accurate result two edge points are searched.

VIII. POSSIBLE APPROACHES FOR ARECANUT

A. Based on Color

Color is the most significant feature in defining the visual quality of any fruit. Most of the available technology determines color of fruit by comparing the fruit color with the existing predefined reference colors [29]. Arecanut can be classified with the help of color features. In raw Arecanut color plays a prominent role as most of the raw Arecanut classification will be done based on color only. For example *Hasa* or *Api* will be Greenish in color, whereas *Bette* or *Idi* will be in a transition state from Greenish to Yellowish and *Gorabalu* will be Yellowish in color. So by extracting the mean color values or by extracting color histograms we can classify raw Arecanut with the help of color features.

B. Based on Shape

Shape means graphical data that contains location, size and rotational effects are filtered out. The cost of many products is directly related to their size.

Arecanut can be graded and classified based on shape. In classification of raw Arecanut although a shape feature can be used to differentiate various types of Arecanut but we cannot rely on it completely, we should also consider some supported features as well. However, for processed Arecanut shape feature can be a very good descriptor in classifying different types of Arecanut as there are lot of differences in the shapes of processed Arecanut.

C. Based on Texture

Textures are the important features in computer vision, which will help to partition the images into different regions of interest and then classify the regions [30]. The model for analyzing texture selection extracting the feature critical in classification based on texture. Numerous techniques have been proposed for obtaining the texture. An image texture is a set of metrics calculated in image processing designed to quantify the obtained texture of an image. Image texture gives us information about the spatial arrangement of color or intensities in an image or selected region of an image.

Like in the case of Arecanut, Texture features are best suited for classification of fruits. We can consider Texture as a single feature or along with any shape or color features in classification and grading of Arecanut. As the color and shape of varieties of Arecanut are similar we cannot rely only on color and shape features. Since textures of Arecanut are unique, we can consider texture as a major descriptor for Arecanut.

D. Hybrid Approach

As there is a huge challenge in handling classification and grading of areca nut with color, shape and texture features alone, we can use hybrid approach by combining above features. Some researchers have already developed a few technologies to classify Arecanut by combining color, shape and texture features and they are giving convincing results as well. An example for Hybrid approach is, using shape

features as primary classifier before considering color, which is prominent in Areca, as the grading parameter, results in easy and better classification with less error and high accuracy.

IX. CONCLUSION

Different image processing based techniques are taken into consideration in this paper for the classification of Arecanut with various characteristics such as color, shape and texture etc. Computer vision systems have been used extensively in the real world for inspection and evaluation purposes as they can provide faster, efficient, healthful, precise and clear assessment. Till today classification of Arecanut is done manually with the skills developed by long practice, invariably wrought with human errors. Therefore there is a dire need for the technology that minimizes manpower and efficiently increases productivity. Error free assessment of Arecanut can best be achieved through computer vision systems. Still there are certain challenges, such as, relatively the growth or up wake of computer vision technology in commercial sectors is very slow. Even though researchers produce efficient, adequate and accurate algorithms, processing speeds didn't meet the modern day manufacturing requirements. However, the review reveals that although being culturally and economically important, work done in respect of Arecanut is inadequate and still much needs to be done.

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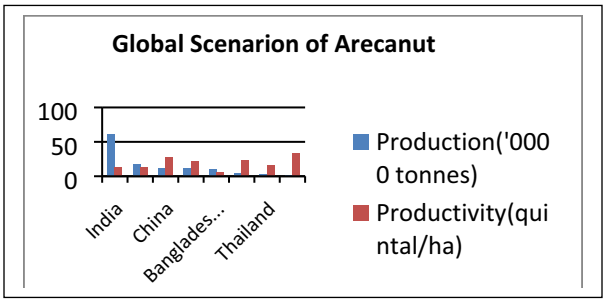
Figure.(1) Global Arecanut Map



Figure(2) Global Arecanut Production and Productivity

ARECANUT - AREA, PRODUCTION AND PRODUCITIVTY IN INDIA

State	2011-12			2012-13			2013-14		
	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)
Andhra Pradesh	0.56	0.28	489	0.58	0.37	628	0.48	0.26	536
Assam	68.70	60.08	874	67.33	89.00	1322	68.04	89.00	1308
Goa	1.73	2.87	1659	1.73	2.88	1668	1.74	2.90	1664
Karnataka	216.17	350.11	1620	221.35	355.28	1605	218.01	457.56	2099
Kerala	104.55	121.62	1163	101.78	118.23	1162	100.01	100.02	1000
Maharashtra	2.20	3.58	1626	2.20	3.58	1626	2.20	3.58	1626
Meghalaya	15.45	21.75	1408	16.06	23.03	1433	17.11	24.68	1443
Mizoram	5.01	12.39	2473	7.57	4.32	570	10.14	6.05	597
Nagaland	0.22	0.12	535	0.22	0.12	535	0.22	0.12	535
Tamil Nadu	6.51	15.96	2451	6.66	11.91	1789	6.70	8.62	1287
Tripura	4.70	9.92	2111	4.70	9.92	2111	4.70	9.92	2111
West Bengal	11.39	21.16	1857	11.39	21.16	1857	11.39	21.16	1857
Andaman & Nicobar Islands	4.22	5.95	1410	4.23	5.88	1392	4.23	5.88	1392
Pondicherry	0.06	0.08	1283	0.06	0.08	1250	0.06	0.08	1250
All India	441.46	625.84	1418	445.84	645.73	1448	445.00	729.81	1640

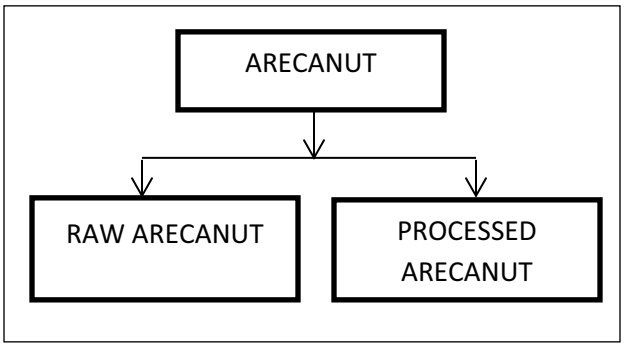


Figure (4) Classification of Arecanut

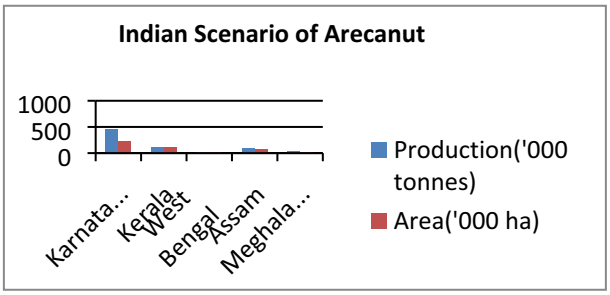


Figure (3) Area and Production of Arecanut in various states of the country

Figure. (4.1) Raw and Processed Arecanut

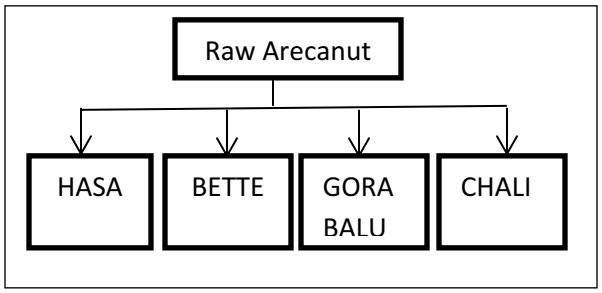


Figure (5) Hierarchical Structure of Arecanut

Fig(6.1) ***Hasa*** **Fig(6.2)** ***Bette***

Fig(5.1) ***Hasa*** **Fig(5.2)** ***Bette***

Fig(6.3) ***RashiIdi*** **Fig(6.4)** ***Gorabalu*** **Fig(6.5)**

Fig(5.3) ***Gorabalu*** **Fig(5.4)** ***Chali***