# Image Processing Techniques for Analysing Food Grains

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***Abstract*—Food consumed in daily diet consists of fruits, cereal grains and spices. Cereal grains are considered to be the most important part as it meets the nutrition needs of the human population. It is necessary to check the quality of food before consuming as it directly impacts on health. Amongst the various food analysis techniques this paper focuses on a semi-automated, an image processing and two machine learning techniques with their advantages and limitations.**

***Keywords— grain size; image processing; kernel; machine vision; inspection; machine learning***

## I. Introduction

Food grains are rich in vitamins, nutrients, minerals and dietary fibres all of which may have individual, synergetic or additive actions that positively affect human health. Also, the presence of phytochemicals in fruits and vegetables are considered to be rich in nutrition. Low-quality food if consumed for long duration result into severe diseases. Sometimes, low-quality grains are mixed with high-quality grains to gain good price in the market. The product made from this kind of mixture generally leads to poor quality food.

Cereal grains can be stored for long duration and transported across countries. India ranks first in the exportation of Basmati Rice across the world[1]. It is necessary to provide a good quality product to customers to meet their nutrition needs and to maintain standard in the international market. Individual Kernel analysis is mandatory for this purpose. Grain quality depends on single kernel features. Compositional analysis and Structural analysis are the two methods for analysing kernel features. Compositional analysis deals with the internal aspects of kernel such as the amount of oil, moisture, fatty acid, protein and amino acid present. Near-infrared (NIR) [2][3], chemical analysis and biological DNA methods are applied for Compositional analysis. Compositional analysis is considered to be a destructive approach for quality analysis as the processed sample cannot be reused again for consumption.

A non-destructive approach is widely used for quality analysis known as Structural analysis, focussing on an appearance of the grain kernel, its length, width, height, colour, glossiness, etc. Structural Analysis can be done manually or through image processing[4]. In the manual analysis the grain samples are investigated by naked eyes or using measuring instruments like vernier callipers or micrometre screw gauge[5]. This is time-consuming and tedious process and requires a skilled analyser. The results obtained from one sample can vary if examined by other analyser. This method addresses generally average parameters and individual kernel parameters are not considered. To test singular kernel parameters Image processing techniques are used, resulting in accurate outcomes, fast processing and eliminating the requirement of a skilled quality inspector.

An image processing approach in food quality analysis is found to be the most acceptable non-destructive and hasty method able to examine single kernel features accurately. Machine learning algorithm can also be used for quality inspection[6].

The rest of this paper is organized as follows: Section II discusses the grain parameters to be measured for quality analysis. Section III emphasizes on the various standards for grain grading. Section IV discusses the techniques of quality analysis. Section V concludes the paper.

## II. Grain Parameters

The determination of the following parameters is important for grading a given sample of food grains.

- *Length and Width*: Food grain length and width are important for determining their class. In terms of "length", rice grains can be classified as a short, medium and long kernel. In Arborio styles "width" can be classified as widest, short, medium and long.
- *Aspect Ratio*: The ratio of length of seed to the width of seed is known as aspect ratio given as follows:

$$Aspect\ Ratio = \frac{Length\,of\,kernel(L)}{Width\,of\,kernel(W)}$$

- *Weight*: The information about the size and density of grain can be obtained from its weight. For consistent seed quality, uniform grain weight is important.
- *Texture*: This defines the common repetitive patterns of seed and gives an idea about the feeling of hardness, adhesiveness, cohesiveness, springiness and gumminess when the grain is consumed.
- *Chalkiness*: It is the opaque area in rice grain which is 50% milky white compared to other rice grains. Percentage of chalky grain present in a given sample can be calculated as follows:

$$\%Chalky\,grain = \frac{Number\,chalky\,seed}{Total\,number\,seed} \times 100$$

- *Adulteration*: The presence of foreign matter or non-quality elements in a given kernel sample is termed as Adulteration. Foreign matter can be dust, stones, chaff or any other impurity. Adulteration decreases the grade of food grains.
- *Whiteness*: This is the major parameter in determining the grade of rice kernels as it determines the milling degree of the individual kernel obtained removing a bran layer from paddy rice seeds.
- *Damaged grains*: Damaged grains are seeds having lower nutrition values through biochemical change resulting into off odours and changes in colour. This can be due to pest damaged, physical damaged and heat exposure. Yellow rice kernels are considered as damaged kernels. Percentage of damaged kernels are calculated as follows:

$$\%Damaged\,grain = \frac{Number\,of\,damaged\,seeds}{Total\,number\,of\,seeds} \times 100$$

## III. Grain Standards

Grain standards are required to define some important criteria for categorisation of given grain sample in grades. Numerous organisations define their own standards depending on their geographical location, environmental parameters, consumer needs and nutrition factors. There is also a possibility that an organization is following more than one standard for categorization according to consumer needs. The organisation defines standards based on colour, appearance, cooking and packaging techniques. Four different organisations standards for classification of food grain quality have conversed below:

**Bureau of Indian Standards(BIS)[7]**:
BIS has proposed standards for maize, wheat, paddy, rice, barley and other pulses in terms of discoloured, insect damaged, broken and slightly damaged. Let X be the quantity of particular category seed defined by standard. Then the percentage of 20 grams of sample containing X category seed is given as follows:

$$\%X\ category\ seed = \frac{Number\ of\ X\ category\ seed}{Total\ number\ of\ seed} \times 100$$

**The African Rice Standard Organisation(ARSO)[8]**:
ARSO give definitions for milled, parboiled, husked, paddy, glutinous rice and coloured seeds like immature, black, chalky, red, yellow and amber kernels. This standard grants a maximum allowable percentage of foreign matter present in a given sample. It also defines the hygiene, packaging, sampling methods, contaminants and ingredients for rice. Considering $L$ as the maximum length of whole kernel present in the sample, ARSO classifies kernels into whole, head and broken as shown in Fig. 1.

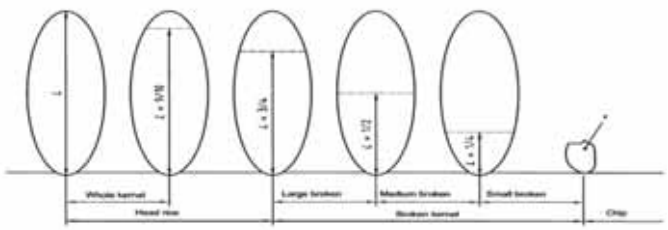

Figure 1. **African Rice Standard Organisation[8]**

1. Head rice: Seed length greater than $\frac{3L}{4}$.
2. Whole Kernel: Seed length between $L$ to $\frac{9L}{10}$.
3. Broken Kernel:
   a. Large broken: Seed length between $\frac{3L}{4}$ to $\frac{L}{2}$.
   b. Medium broken: Seed length between $\frac{L}{2}$ to $\frac{L}{4}$.
   c. Small broken: Seed length less than $\frac{L}{4}$.

**Directorate of Marketing and Inspection(DMI)[9]**:
DMI has provided standards for different pulses, fruits, tea, amla, vegetables, tobacco, edible nuts and fibre crop. Based on the foreign matter, damaged grains, immature grains, moisture content in a given sample of grain DMI classifies maize and wheat kernels into grade I, II, III and IV.

**Cambodia Milled Rice Standard[10]**:
Cambodia standard grants definitions for paddy rice, brown rice, milled rice, foreign odour, foreign matter, damaged and immature kernels. Colour-based classification is also granted such as the red, red-streaked and yellow kernel. Cambodia milled rice classification is shown in Fig. 2.

1. Whole kernel: kernel length between $9mm$ to $10mm$.
2. Head kernel: kernel length between $8mm$ to $9mm$.
3. Big broken: kernel length between $2.5mm$ to $8mm$.

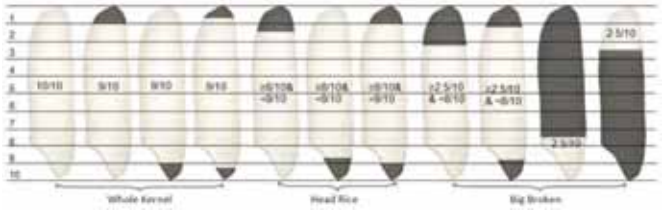

Figure 2. **Cambodia milled rice[10]**

## IV. Techniques

Manual sorting mechanism for grading food grains is a time-consuming and wearisome process. There are chances of breaking the grain heads during the measurement of dimensions through vernier calliper or micrometer screw gauge. There are various methods for food quality analysis amongst which four techniques include, a semi-automated method explaining the need for image processing, an off-line image processing, machine learning and an on-line machine learning techniques have been discussed.

**Kernels separation by Sieving Method[11]**:
This is the semi-automated method use for separating granules in fractions according to their size and determine the weight of these fractions for analysis. A set of sieves with different hole size kept in chronological order are used to collect kernels. Granules can be collected in their respective sieves by manual shaking shown in Fig. 3a which does not require electrical connection. Another way is to attach a vibrator shown in Fig. 3b which demand an electrical connection. The sample is poured into the top tower of sieves and vibration at the base results in the collection of kernels in respective sieve size.

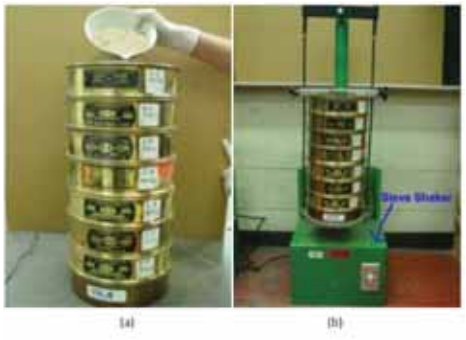

Figure 3. **(a) manual shaking of sieves set (b) Sieves set with shaker.[11]**

Following are the limitations of this method:
1) Applicable only for circular kernels.
2) Extracts only the size and weight feature of kernels.
3) Foreign material, colour, chalkiness, damaged and moisture content cannot be determined.
4) Results may vary if same sample is processed again.
5) In the case of non-circular seeds, the probability of the kernel passing vertically through sieve is high.

**Grain analysis by Digital Image Analysis SeedCount 324[12]**:
This is one of the off-line grain analyser techniques analysing stationary kernels features. In this method, rice seeds are placed manually in a preparation tray. Rice seeds are gently spread on grid tray and all seeds are separated to fit one kernel in one single slot. Each slot must contain one kernel while capturing an image. These tray grids have a particular address for image analysis. The tray

is put into the scanner as shown in Fig. 4 and results on colour, chalkiness, length, width and aspect ratio are obtained by the image processing.


Figure 4. **SeedCount tray in scanner cabinet[12]**

Following are the limitations of this technique:
1) It does not deal with connected kernels.
2) The probability of head break during tray preparation is high.
3) Due to the constraint on total number of grids in tray, only 1350 rice kernels can be processed at a time.
4) Requirement of grid size varies for analysis of different grain size.
5) Results may change with variation in camera angle and/or light intensity.
6) The time required for sample preparation is more.
7) Kernel weight is not considered.

**Rice grain analysis by Image acquisition system[13]:**
This is another off-line grain analyser technique investigating different varieties of rice kernels produced in the Philippines by the use of a machine vision system and multilayer neural networks for automatic identification of the shapes, sizes, and variety of samples for 52 rice grains belonging to five varietal groups. This method extracts 13 kernel features according to trained multi-layered neural networks. Fig. 5 shows the experimental set-up of this technique.

Figure 5. **Pictorial of image acquisition system[13]**

Following are the limitations of this technique:
1. A tedious task for arranging 52 non-connected seeds.
2. The grain kernels used for initial learning process must be standardised according to the rice industry standards.
3. Results may vary if the light intensity, camera position and/or camera parameters are changed.

**Kernel quality analysis by Automatic grain quality inspection[14]**:
This is one of the on-line grain analyser techniques which extracts the features of moving kernels. Kernels are kept on a moving conveyor belt having predetermined matrix positions. Two CCD cameras are used to capture image of grains. The machine learning algorithm is implemented in the system to increase smartness and boost the calculation of parameters. This technology can process 1200 rice as well as wheat kernels per minute with maximum 24 kernel positions in one matrix. This method needs less sample preparation time as compared to other techniques discussed.

Following are the Limitations of this method:
1) High speed and good resolution cameras are required.
2) A fast processor is necessary.
3) The probability of missing a few kernels is present.
4) Kernel weight is not extracted.

## V. Conclusion

In this paper, four techniques for food quality analysis have been discussed. The first technique is a semi-automated machine which deals only with the size and weight of kernels and not with colour, damaged and adulterated kernels. For extending the feature detection capability of machine, image processing techniques are used. Second technique is based on image processing, third and forth techniques are based on machine learning. Digital Image Analysis SeedCount 324 and Image acquisition system are an off-line grain classification techniques which limits itself in a particular number of kernels analysis at a time. Hence it cannot be used in large scale industries which require processing of large number of kernels. The other on-line automatic grain quality inspection technique is useful for analysing huge quantity of kernels and requires less intervention of an operator. Image acquisition system and automatic grain quality inspection technique are based on a machine learning algorithm. Machine learning method requires training in the initial stage with a large number of kernel images to increase the accuracy of the system. Accuracy of system may changed by applying different hyper-parameters values during training. Considering the various issues, a Grain Analyser system should have features of non-destructiveness, automatic sampling which does not require any tray preparation or sample pre-preparation task. It should accommodate various types of grain. The software used in system must support local and remote analysis. The software should be scalable in terms of adding different grain samples and standards at later stage. Foreign particles, chalkiness, insect damaged grains must be detected and reported.

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