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Design of *Aloe vera* leaf slicing machine and its performance study

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Abstract
The Aloe plant belongs to a member of the family *Liliaceae*, which comprises more than 360 different species. *Aloe vera* has a number of uses and mainly they are used as a food preservative and herbal medicine. In manufacturing of whole leaf *Aloe vera* powder, slicing is one of the important unit operations after trimming. Presently, manual slicing is most commonly followed in Indian Aloe industries, which is time consuming, tedious, unhygienic, expensive and sometimes hazardous. The design and development of *Aloe vera* leaf slicing machine is to solve the aforementioned problems. This machine mainly consists of belt conveyor, feed and conveyor roller, chain sprockets, knives, power transmission mechanism and frame. The performance evaluation of the machine was evaluated under three belt conveyor speed (0.251, 0.188 and 0.125 $m.s^{-1}$) and three No. of knives (2, 4 and 8). It was found that 0.251 $m.s^{-1}$ belt conveyor speed with 8 No. of knives was optimized condition. The machine is simple in construction, easy to operate and does not requires special skill. Results of the test carried out showed that the time required to slice equal length of *Aloe vera* with the machine is 24 times less than the manual process. This machine has slicing efficiency of about 90.46% with effective capacity of 648.21 $kg.h^{-1}$.

Keywords: *Aloe vera*, machine, performance, knives

Introduction
The Aloe plant belongs to a member of the family *Liliaceae*, which comprises more than 360 different species. Recently, the family was given the name *Aloaceae* (Eshun and He, 2004) [5]. *Aloe vera* can be processed into various products like gel, extract, powder, juice, etc. Consumers can use *Aloe vera* externally and internally. *Aloe vera* is a medicinal plant that has many health benefits for its users. It is commonly used to heal and cleanse wounds. It has the ability to hydrate and soothe the skin and to reduce inflammation (Arunkumar and Muthuselvam, 2009) [2].

In manufacturing of whole leaf *Aloe vera* powder, slicing is one of the important unit operation after trimming. Presently, manual slicing is most commonly followed in Indian Aloe industries, which is time consuming, tedious, unhygienic, expensive and sometimes hazardous. If the leaves are sliced by hand system, the obtained slices are not of uniform size. The processing of the *Aloe vera* plant for making whole leaf powder involves cleaning, washing, trimming, slicing and drying. Normally, the slicing of the *Aloe vera* leaves can be done manually which is not at all accurate for further processing and so, the slicing machine for *Aloe vera* is required to increase the uniformity of the slicing, prevent the injury, reduce the damages, reduce the time, increase the slicing efficiency and reduce the labour cost. The uniform sized slices obtained from the machine will give a uniform drying for further processing of whole leaf powder which is used in cosmetic and pharmaceutical industries.

Hence, there is a need for mechanization of *Aloe vera* leaf slicing process with reduced damage, increased hygiene and enhanced capacity. Considering the importance of slicing process, the possibility of mechanizing the process of *Aloe vera* leaf slicing becomes very necessary.

An *Aloe vera* leaf slicing machine will be therefore designed to mechanize the process of slicing *Aloe vera* leaf for making whole leaf powder used for external application. It can be used in both pharmaceutical and cosmetic industries.

Materials and Methods

Design of *Aloe vera* leaf slicing machine

The *Aloe vera* leaf slicing machine consisted of slicing head disc with knives, belt conveyor, power transmission system and feed rollers to gather, grip and advance the *Aloe vera* leaves into the slicing section and spring loaded feed roller was provided for different size and thickness of leaves.

The machine was operated by an electric motor and power was transmitted to the *Aloe vera* leaf slicing machine through the bevel gear shaft *via* the gear box drive pulley. It was manually fed with 3-4 leaves at a time through the belt conveyor. The whole *Aloe vera* leaves were passed horizontally (facing tip) against the feed roller through belt conveyor and were sliced into small pieces.

Performance evaluation of *Aloe vera* leaf slicing machine

The performance of *Aloe vera* leaf slicing machine was evaluated under laboratory conditions. The parameters such as slicing length, machine output capacity, slicing efficiency were recorded during the laboratory tests.

As there was no specific test code available for testing of *Aloe vera* leaf slicing machine, the pertinent parameters relevant to machine performance determination were measured and it is shown in the plate 1.

Slicing length

The slicing length of *Aloe vera* leaves mainly depended on the belt conveyor speed and number of knives used. The slicing length of *Aloe vera* after slicing operation was measured in mm by using plastic tape. The slicing length of *Aloe vera* was recorded randomly in the laboratory by laying a 1m2 size frame.

Slicing capacity

Slicing capacity is the quantity of *Aloe vera* sliced in a given time. The slicing capacity was calculated by using the following equation (Akande and Onifade, 2015) [1].

$$Sc = \frac{W_T}{T}$$

Where,

S_c = Slicing capacity ($kg.h^{-1}$)

W_T = Total weight of *Aloe vera* slices (kg)

T = Time taken to slice *Aloe vera* leaves, (h)

Slicing efficiency

The efficiency of *Aloe vera* leaf slicing was obtained in the required small pieces without any damage. The slicing efficiency was calculated by using the following equation (Sonawane *et al*., 2011; Kamaldeen and Awagu, 2013; Akande and Onifade, 2015; Borkar *et al*., 2015; Onifade, 2016) [11, 6, 1, 4].

$$\eta = \frac{W_T - W_D}{W_T} \times 100$$

Where,

η = Slicing efficiency (%)

W_T = Weight of total slices (kg)

W_D = Weight of damaged slices (kg)

Slicing loss

Slicing loss is the measurement of effectiveness of the slicing operation of the machine. Slicing loss was calculated by following equation (Mishra *et al*., 2013) [7] and (Ayodeji *et al*., 2014) [3].

$$S_l = \frac{W_1 - W_2}{W_1} \times 100$$

Where,

S_l = Slicing loss (%)

W_1 = Weight of *Aloe vera* before slicing (kg)

W_2 = Weight of *Aloe vera* after slicing (kg)

Results and Discussion

The performance evaluvation of developed *Aloe vera* slicing machine was evaluated at 3 different belt conveyor speed and 3 No. of knives. The results are discussed below. The effect of belt conveyor speed and No. of knives on slicing length, slicing capacity, slicing efficiency and slicing loss are shown in figures 1, 2, 3 and 4 respectively.

The slicing length of *Aloe vera* leaf increased as the belt conveyor speed and number of knives decreased. Minimum slicing length was found at 0.251 $m.s^{-1}$ belt conveyor speed with 8 No. of knives whereas maximum slicing length was observed at 0.125 $m.s^{-1}$ belt conveyor speed with 2 No. of knives. The effect of belt conveyor speed and No. of knives on slicing length is shown in figure 1. The slicing capacity of machine increased as the belt conveyor speed and number of knives increased. Maximum slicing capacity of *Aloe vera* leaf slicing machine was observed at 0.251 $m.s^{-1}$ belt conveyor speed with 8 No. of knives and minimum was observed at 0.125 $m.s^{-1}$ belt conveyor speed with 2 No. of knives. The effect of belt conveyor speed and No. of knives on slicing length is shown in figure 2. The slicing efficiency of machine increased as the belt conveyor speed and No. of knives decreased.

Maximum slicing capacity of *Aloe vera* leaf slicing machine was observed at 0.125 $m.s^{-1}$ belt conveyor speed with 2 No. of knives and minimum was observed at 0.125 $m.s^{-1}$ belt conveyor speed with 8 No. of knives.

Plate 1: Performance evaluation of *Aloe vera* leaf slicing machine

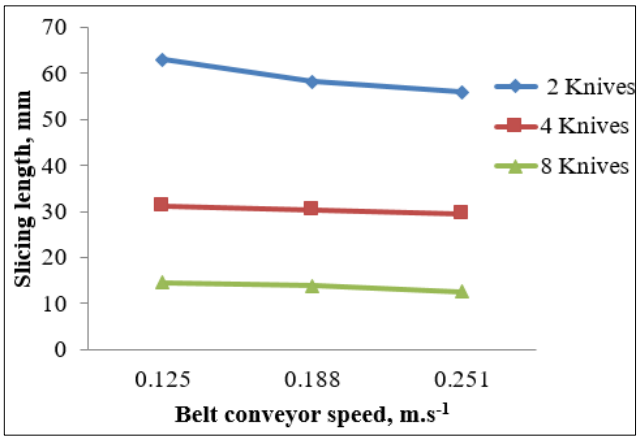

Fig 1: Effect of belt conveyor speed and number of knives on slicing length (mm)

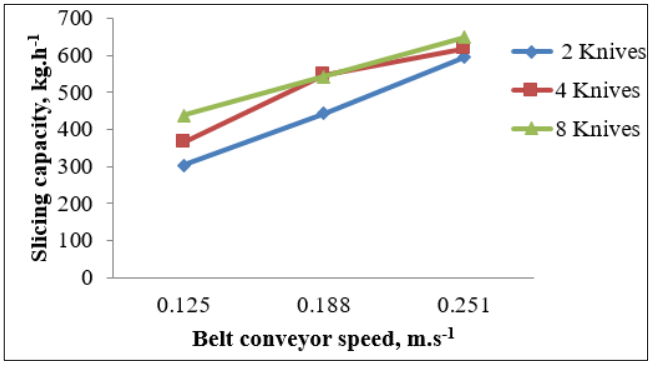

Fig 2: Effect of belt conveyor speed and number of knives on slicing capacity ($kg.h^{-1}$)

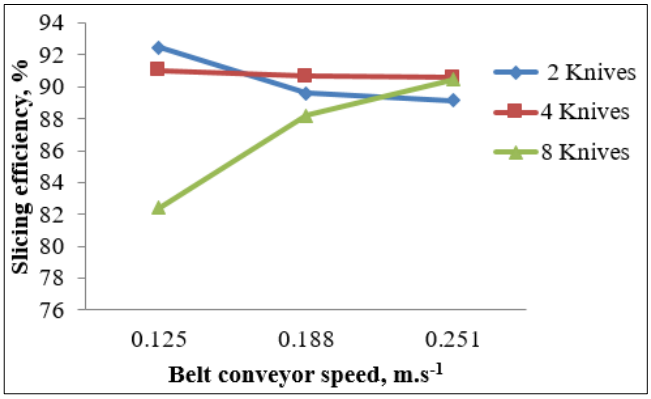

Fig 3: Effect of belt conveyor speed and number of knives on slicing efficiency (%)

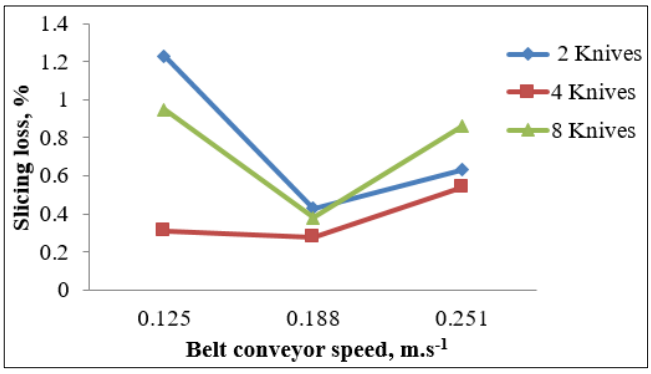

Fig 4: Effect of belt conveyor speed and number of knives on slicing loss (%)

The slicing loss of machine decreased as the belt conveyor speed and number of knives decreased and it increased as the number of knives decreased. Minimum slicing loss of *Aloe vera* leaf slicing machine was observed at 0.125 $m.s^{-1}$ belt conveyor speed with 4 No. of knives and maximum loss was observed at 0.125 $m.s^{-1}$ belt conveyor speed with 2 No. of knives.

In conclusion, the overall dimensions of the machine were 1100 mm in length, 700 mm in height and 400 mm in width. The machine designed and developed and was capable of slicing the *Aloe vera* leaves in the form of thin uniform slices. The machine was simple in construction and operation with low cost. The capacity of the machine was 648.21 $kg.h^{-1}$ and efficiency was 90.42%. The production cost of machine is 39000/- This mechanical method of slicing using the developed machine is non-hazardous, fast and hygienic compared to traditional manual slicing.

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