A Cleaning and Grading Machine for Inca Peanut Seeds after Shelling Process

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Abstract. *Due to the fact that after the shelling process, there might be contamination of nuts and dust, the cleaning and grading of shelled Inca Peanuts seeds need to be done before the next process. Thus, from this study, the researchers would like to build a nut cleaning and grading machine for Inca peanuts, which is composed of 2 parts: a blower and a separator. The blower, which is used to eliminate the shell, is 45x90x60 cm in size and incorporates a seed scatter pad. The separator consists of a 2 layered sieve with exit channel sizes of 20 and 18 mm, which are used to separate the whole nuts, unshelled pods, broken kernels, and the small contaminants using the channel. According to the study, the appropriate conditions for the process are when the cleaning machine is operated at a camshaft speed of 520 rpm and a velocity of 2.8 m/s, which will result in an average cleaning efficiency of 97.83%, a percentage of seed loss at 11.61%, and an average working capacity of 240.81 kg/hr.*

Keywords:

Cleaning machine, Inca peanuts, shelling

1. Introduction

The Inca peanut (*Plukenetia volubilis L*) is a plant in the Euphorbiaceae family, which has an appearance similar to a star. Its original source is in the Amazon forest [1]. The kernels of Inca peanuts contain 41.4% oil. The oil is composed of 85-90% unsaturated fat, and is significantly rich in quality nutrients for humans, such as Omega 3, 6, and 9, as well as Vitamins A and E [2]. The processing of Inca peanuts mainly uses the kernels. Therefore, they need to be peeled out of their shells. However, after the application of the shelling machine, it was revealed that the quantities of pods, nuts, broken kernels, whole kernels, and shells had been 19.46%, 40.73%, 2.12%, 3.11%, and 34.58%, respectively, [3] which meant that they could not be processed for consumption or for distribution. Before continuing to the next process, the cleaning and the grading processes to separate the nuts, broken nuts, and broken kernels from the perfect whole kernels must be accomplished. For this reason, the objective of this research was to design and construct a cleaning and grading machine for the whole kernels of Inca peanuts on the basis of differences in sizes and weights of the seeds and shells for the cleaning, seed scatter pad, and blower to separate out the light-weight seeds. [4] Moreover, the application of the differences in size and weight of seeds and shells was added to the grading process by releasing the seeds through a sieve separator with 2-layers [5] for the next production process.

2. Materials and Methods

2.1 Study of Physical Properties

In regards to the examination of the physical properties of Inca peanuts, the 100 samples that passed through the shelling machine were analyzed [3] by measuring the sizes of the pods, nuts, and kernels, including their width, length, and their thickness. In addition, other qualifications that relate to their physical properties, such as the seeds' weights, their Geometric mean diameters, and their sphericities were examined. [6]

2.2 Design and construction

The cleaning and grading machine for whole kernels of Inca peanuts consists of 2 main compositions which are the shell blower with the size of 25x90x60 cm and the seed scatter pad. The application uses the seed scatter pad and the blower to eliminate the shells. The sieve contains 2 layers with hole sizes of 20 and 18 mm for grading the unshelled pods, whole nuts, broken nuts, and the small contaminants out of each layer.

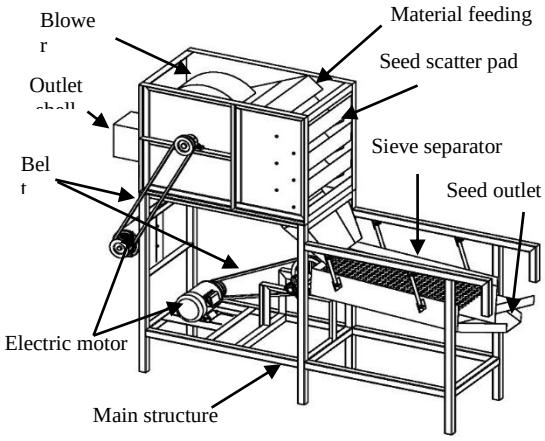

Fig. 1: Draft of Cleaning and Grading Machine for whole kernels of Inca Peanuts.

2.3 Test

The study compared the 2 factors affecting the cleaning and the grading of nuts by applying the 2x3 factorial experiments. The factors were as follows: a) 3 levels of velocity: 2.6, 2.8, and 3.0 m/s, and b) 3 levels of camshaft speed for the sieve, which was 480, 500, and 520 rpm, respectively. Inca peanuts were used as the samples for this study. After passing the shelling machine 5, the rate of seeding was set at 216.85 kg/hr. The indicators were the efficiency of grading, the percentage of shell contamination, and the percentage of loss.

3. Results and Discussion

3.1 Physical Properties

According to the primary physical study of Inca peanuts, which were passed through the shelling machine 5for Inca peanuts, it was first found that the equipment had been able to separate the outer shell and the big nuts from the complete ones. The details are shown in Table 1.

Physical Properties	Type		
	Pod	Nut	Kernel
One seed weight (g)	1.72±0.35	0.93±0.23	0.63±0.16
Width (mm)	19.78±1.14	16.32±1.07	12.48±1.11
Length (mm)	22.99±1.58	18.79±1.05	14.59±1.77
Thickness (mm)	14.79±1.22	8.52±0.85	7.40±0.96
Geometric mean diameter, (mm)	18.86±1.07	13.75±0.85	11.02±1.15
Sphericity	0.82±0.04	0.73±0.03	0.76±0.04

Table 1: The physical properties of Inca Peanuts

Table 1 indicates that the sphericity of the pods, nuts, and kernels were close to 1, which represents a high level of sphericity. Therefore, a sieve with round holes was selected. The longest sides of pods, nuts, and kernels had the mean measurements of 22.99, 18.79, and 16.48 mm, respectively. This data was used to select the size of the sieve's holes to be used for grading purposes. The machine was designed to use sieves in 2layers. The purpose of the first layer is to separate the shells and the unshelled pods. The refore, the size of the holes was 20 mm. The second layer, which was used to separate the nuts and the large kernels, had holes18 mm in size. As for the broken kernels and pieces of broken kernels, they would pass through the metal outlet.

3.2 Performance test

According to the comparative test of factors affecting the cleaning and the grading of the nuts, there were 2 factors involved: the 3 levels of velocity at 2.6, 2.8, and 3.0 m/s, and the 3 levels the camshaft speed, which were 480, 500, and 520 rpm. The indicators are the efficiency of grading, the percentage of shell contamination, and the percentage of kernel loss. Details are as seen in Table 2.

Speed (rpm)	Velocity (m/s)	Performance indicator	Outlets			
			A	B	C	D
480	2.6	% Shells	0.66	1.64	2.81	94.88
		% Pods	69.56	30.44	0.00	0.00
		% Nuts	2.75	96.76	0.50	0.00
		% Broken nuts	0.00	55.52	44.48	0.00
		% Kernels	0.00	9.44	86.62	3.94
		Cleaning efficiency	94.88			
		% Seed loss	3.94			
		Capacity (kg/hr.)	184.95			
	2.8	% Shells	0.11	0.19	0.80	98.90
		% Pods	75.62	24.38	0.00	0.00
		% Nuts	3.48	96.33	0.18	0.00
		% Broken nuts	0.00	48.93	51.07	0.00
		% Kernels	0.00	22.12	68.17	9.71
		Cleaning efficiency	98.90			
		% Seed loss	9.71			
		Capacity (kg/hr.)	221.70			
	3.0	% Shells	0.15	0.14	0.39	99.32
		% Pods	83.51	16.49	0.00	0.00
		% Nuts	4.42	95.34	0.24	0.00
		% Broken nuts	0.00	76.62	23.38	0.00
		% Kernels	0.00	20.76	57.46	21.78
		Cleaning efficiency	99.32			
		% Seed loss	21.78			
		Capacity (kg/hr.)	231.66			
500	2.6	% Shells	0.40	1.28	3.60	94.72
		% Pods	86.68	13.32	0.00	0.00
		% Nuts	9.75	90.07	0.18	0.00
		% Broken nuts	0.00	76.12	23.88	0.00
		% Kernels	0.00	19.05	75.54	5.40
		Cleaning efficiency	94.72			
		% Seed loss	5.40			
		Capacity (kg/hr.)	187.32			
	2.8	% Shells	0.22	0.61	1.74	97.44
		% Pods	77.91	22.09	0.00	0.00
		% Nuts	4.97	94.54	0.49	0.00
		% Broken nuts	0.00	50.07	49.93	0.00
		% Kernels	1.26	13.02	74.24	11.48

* A = Sieve separator layer 1 (20 mm.), B = Sieve separator layer 2 (18 mm.), C = separator layer 3, D = Outlet shell

Table 2: Working performance of the cleaning and grading machine for Inca Peanuts seed after the shelling

Speed (rpm)	Velocity (m/s)	Performance indicator	Outlets			
			A	B	C	D
500	2.8	Cleaning efficiency	97.44			
		% Seed loss	11.48			
		Capacity (kg/hr.)	227.35			
520	3.0	% Shells	0.03	0.14	0.37	99.46
		% Pods	77.48	22.52	0.00	0.00
		% Nuts	4.06	95.64	0.29	0.00
		% Broken nuts	0.00	61.70	38.30	0.00
		% Kernels	0.00	9.44	67.32	23.24
		Cleaning efficiency	99.46			
		% Seed loss	23.24			
		Capacity (kg/hr.)	242.03			
520	2.6	% Shells	0.73	1.07	3.70	94.50
		% Pods	83.89	16.11	0.00	0.00
		% Nuts	4.76	95.02	0.21	0.00
		% Broken nuts	0.00	68.65	31.35	0.00
		% Kernels	0.00	4.04	92.24	3.72
		Cleaning efficiency	94.50			
		% Seed loss	3.72			
		Capacity (kg/hr.)	216.78			
	2.8	% Shells	0.24	0.54	1.39	97.83
		% Pods	85.02	14.98	0.00	0.00
		% Nuts	11.38	88.45	0.17	0.00
		% Broken nuts	7.81	49.58	42.61	0.00
		% Kernels	0.00	15.72	72.66	11.61
		Cleaning efficiency	97.83			
		% Seed loss	11.61			
		Capacity (kg/hr.)	240.81			
	3.0	% Shells	0.23	0.16	0.71	98.89
		% Pods	88.92	11.08	0.00	0.00
		% Nuts	12.39	87.34	0.27	0.00
		% Broken nuts	0.00	73.48	26.52	0.00
		% Kernels	1.25	13.59	57.07	28.08
		Cleaning efficiency	98.89			
		% Seed loss	28.08			
		Capacity (kg/hr.)	258.36			

* A = Sieve separator layer 1 (20 mm.), B = Sieve separator layer 2 (18 mm.), C = separator layer 3, D = Outlet shell

Table 2:(Continued) Working performance of the cleaning and grading machine for Inca Peanuts seed after the shelling

From Table 2, it 3, the results of the test of cleaning Inca peanuts with the velocities at 3 levels (2.6, 2.8, and 3.0 m/s), and camshaft speeds at 3 levels (480, 500, and 520 rpm) are shown. It was found that when the velocity was increased from 2.6 to 2.8 and then to 3.0 m/s, respectively, the results indicated a reduction in hull residue percentages, while the kernel loss percentage increased. Moreover, when the camshaft speed increased from 480 to 500, and then to 520 m/s, the percentage of grading and the working capacity was also increased, while the percentage of shell mixing and broken kernels out of the outlet B (the outlet for the nuts) was reduced.

Source of Variation	F-ratio		
	Cleaning Efficiency	% Seed loss	Capacity
Speed (S)	0.78ns	5.11*	2.87ns
Velocity (C)	39.72**	296.59**	9.42**
Interaction			
SxV	0.44ns	3.56*	0.11ns

* Significant ($p<0.05$), ** Significant ($p<0.01$), ns Non-Significant

Table 3 Statistical Analysis of the Shelling Machine transforming the Nuts to Kernels

In Table 3, it can be seen that the differences in speeds had had no effect on the percentage of cleaning, but had differently affected the percentage of seed loss with a statistical significance of 0.01. After considering the impact of interactional effects, it was revealed that the interactional effects regarding the percentage of seeds loss had shown a significance level of 0.05.

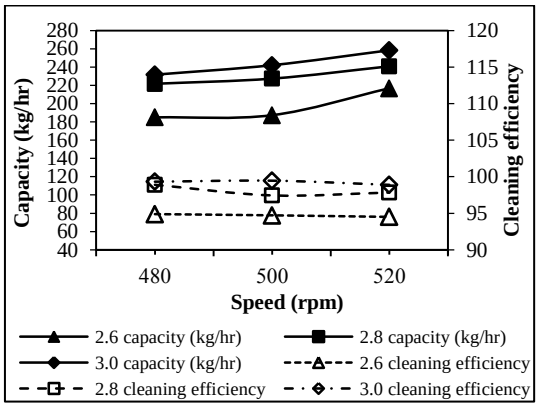

Fig. 2: Relationships between camshaft speed and velocity affecting percentage of cleaning and working capacity

Fig. 2 illustrates that the velocity had had an effect on the percentage of cleaning which tended to increase when the velocity had been increased from 2.6 to 2.8, and then to 3.0 m/s. Simultaneously, increases in the camshaft speed from 480 to 500, and then to 520 rpm had led to a reduction in cleaning percentages. Under these conditions, the working capacity tended to increase when the velocity and the camshaft speed had been increased.

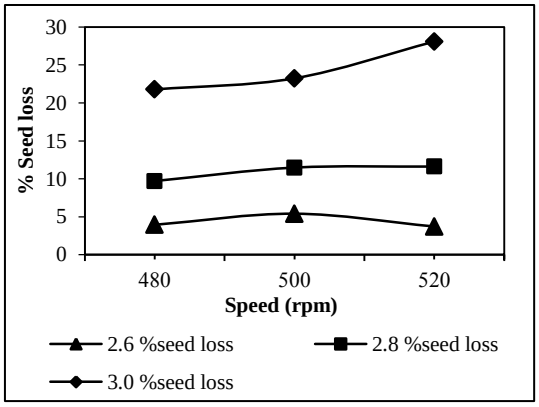

Fig. 3: Relationships between camshaft speed and velocity affecting percentage of seed loss.

Fig. 3 indicates that the velocity and the camshaft speed had affected the seed loss percentage. The loss of seeds had tended to increase when the velocity had been increased from 2.6 to 2.8, and then to 3.0 m/s and when there was an increase of camshaft speed from 480 to 500, and then to 520 rpm, respectively.

4. Conclusion

According to the study, the appropriate conditions for using the cleaning machine for nuts is a camshaft speed of 520 rpm and a velocity of 2.8 m/s. Under these conditions, the average percentage of cleaning efficiency is at 97.83%, the percentage of seed loss is 11.61%, and the average working capacity is 240.81 kg/hr.

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Biography

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