Development and Performance Test of Cassava Peeling and Washing Machine.

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ABSTRACT: The cassava peeling and washing machine was designed, fabricated and tested. The machine consists of two chambers joined together as a single machine to perform the work of peeling and as well as washing. The brushes which are in form of shafts were fixed in the upper chamber and they remove dirt and sand aided by plentiful supply of clean water under pressure via water pump. The peeler drum was enclosed by the down chamber with rough and sharp surface that peel and also oriented in a spiral form (auger) for conveyance of the cassava tuber to the outlet chute. A 3hp single phase electric motor supply power to the machine via pulley and belt to the peeler drum shaft. The peeler drum shaft that transfers the drive to the drum was fixed at the centre of the drum. It was observed that the efficiency of the machine was hindered by the speed. The efficiency of the machine was 70% on the speed of rotation of peeler drum at 420 rpm. The analysis of variance (ANOVA) confirmed that speed was an important parameter that affects the performance of the machine.

Keywords: Development, Performance test, Cassava, Peeling, Washing.

1 INTRODUCTION

Cassava (manihot esculeta) is a perennial woody shrub with an edible root, which grows in tropical and sub-tropical areas of the world. Cassava originated from tropical America and was first introduced into Africa in the Congo basin by the Portuguese around 1558. Cassava is rich in carbohydrate, calcium, and vitamin B and C. However nutrients composition differs according to variety and age of the harvested crops, and soil conditions, climate, and other environmental factors during cultivation. It is a popular crop worldwide. It is known for drought tolerance and for thriving well on marginal soils, a cheap source of calories intake in human diet and a source of carbohydrate in animal feed,[6]. Its importance as a major cheap source of calorie intake for both human and livestock in many tropical countries has been widely acknowledged. It is mostly processed traditionally into *garri, fufu and abacha* in Nigeria, and *kokonte and agbelima* in Ghana,[9]. Cassava has becomes one of the prominent crops that are required to be provided for both local consumption and export promotion. Apart from human consumption cassava is also used for animal feed and alcohol production. There is an ever increasing global demand for cassava chips and pellets particularly in China and Brazil. Cassava starch is an ingredient, in the manufacture of dyes, drugs, chemicals, carpets and in the coagulation of rubber latex.

Cassava has relatively few problems in processing, it problems seems to be at the post harvest stage, storage of fresh tuber, mechanization of harvesting and processing. The processing of cassava tubers for industrial or human use involves different operation of which peeling and washing are involved. Cassava root peeling has been practiced as far back as when cassava came into existence, but the instrument for peeling has evolved from stone into simple household knife [4]. The cassava peel has two layers called periderm and the inner layer called cortex.

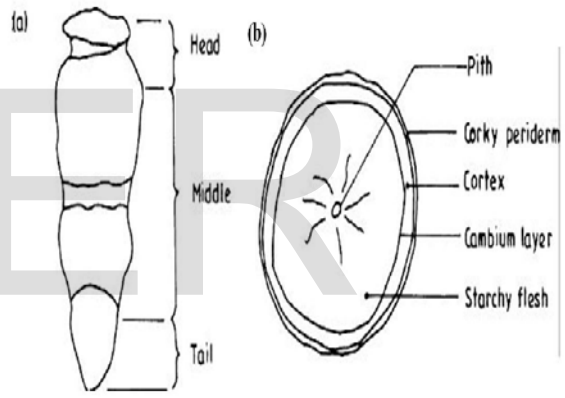

Fig 1: Morphology of the cassava tuber: (a) general morphology and (b) transverse section [2]

The problems encountered in peeling cassava root tuber arise from the fact that cassava roots exhibit appreciable differences in weight, size and shape. There are also differences in the properties of cassava peel which varies in thickness and texture. Thus, it is difficult to design a cassava peeling machine that is capable of efficiently peeling all roots due to the wide differences in properties of roots from various sources. The second stage involved in cassava processing is washing of which it is mostly done by hand-washing effectively but it is time consuming. Cassava washing is independent of the shape, hence the design and construction of a washing system is not as difficult as peeling.

This present research effort is aimed at designing a machine capable of peeling and washing cassava tubers. Other specific objectives include to design and fabricate a cassava peeling and washing machine that is easy to maintain,

economical and less drudgery and also to carry-out the performance test of the machine.

2 MATERIALS AND METHODS

A motorized vertical cassava peeling and washing machine that is efficient and economically viable was designed and fabricated with readily available and cheap materials (suitable engineering materials that could give optimum performance in service). Materials for fabricating the machine were chosen on the basis of their availability, suitability, economic consideration, viability in service etc. The components parts of the machine were designed fabricated and tested. The parts and their quantity are given in the part list below.

2.1 Design considerations

The parameters considered in design and construction of cassava peeling and washing machine include the size and shape of the cassava, moisture content, ease of maintenance and height of the machine.

Shafts design consideration.

The shaft is a cylindrical solid rod for transmitting motion through a set of load carried on it. The shaft uses for the peeling was enclosed by a peeler drum. Therefore, there would be a combined bending and torsional stresses acting on the solid shaft during operation. To determine the shaft diameter, we adopt the formula;

$d^3 = \frac{16}{\pi\delta_{sy}}[(K_b M_b)^2 + (K_t M_t)^2]^{\frac{1}{2}}$.....1

Where;

d = diameter of shaft (mm)

K_b = combined shock and fatigue factor for bending moment.

K_t = combined shock and fatigue factor for torsional moment.

M_b = Resultant bending moment (Nm)

M_t = Resultant torsional moment (Nm)

δ_{sy} = Allowable shear stress (MN/m^2)

π = constant, 3.142

2.2 Brush design

The brushes were made in form of spikes welded on a shaft. Iron brush was chosen because it will withstand the tangential force of the peeling drum. The mild steel shaft on which this brushes were mounted are 2 and both has a length of 1220m. This rod has a total spike group of 36 and each of this group has 6 spikes each having an average length of 115mm. This group was chosen to avoid stoppage of cassava during the peeling process

2.3 Principle of operation of the Machine

The machine is a motorized cassava peeling and washing machine operated by 3hp single phase electric motor. It is made up of two chambers. The first chamber is where the peeling and washing process takes place while the other chamber houses the peeling um and has an opening through which the cassava peels and water goes out. The peeling drum peel the cassava as it rotates through the drive from electric via pulley and belt. As the peeling drum is rotating, cassava will be introduced into the machine through the hopper and the cylindrical peeling drum peels the cassava and at the same time conveys it out of the machine through the help of the auger. The washing process is done through the help of water and brushes mounted inside the machine. The water is gotten from the water tank which is connected to the machine via pipes. Water pump is installed close to the tank to increase the gravity force of water. and the part in the peeling and washing chamber of the machine has so many holes drilled in it ensuring the water is discharged in sprinkler form. The brushes mounted inside the machine removes the dirt also contribute in discharging the peeled and washed cassava out. The peels and dirty water leaves the machine through an opening in the second chamber.

2.4 Testing the Machine

The machine was first run under no-load using an electric motor of 3 hp to ascertain the smoothness of operation for the machines rotating parts. The actual test was conducted using three different feeds rates and speed. Three different speeds were gotten by changing the diameter of the driven pulley. Testing the machine was targeted at evaluating its peeling and washing efficiency and through put capacity. The results obtained were analyzed using analysis of variance (ANOVA).

3 RESULTS AND DISCUSSION

The performance test carried out was to determine the peeling and washing efficiency and throughput capacity of the machine on three different feed rates and speeds. The results obtained are presented in tables 1 to 3 respectively. It was shown in table 1, that the average machine performance was highest at the speed of 420 rpm (72%) and lowest at the speed of 380 rpm (55%) using 15 pieces of cassava tubers. This means that the efficiency of the machine can be reduced, if the speed is higher or lower than 420 rpm.

The results obtained from the machine using 20 pieces of cassava tubers as feed rate was shown in table 2. The results shown that the feed rate hindered the efficiency of the machine. At 420 rpm, the average machine performance

was highest (70%) and had the same lowest performance at the speed of 380 and 460 rpm (63%) respectively.

The results obtained using 25 pieces of cassava tubers as feed rate was shown in table 3. The results showed that the average machine performance was highest at the speed of 420 rpm (72%) and lowest at 380 rpm (59%). The efficiency of the machine can be hindered, if the speed goes higher or lower than 420 rpm. The peeling and washing duration of the machine depend on the operator.

Figures 5 to 7 showed the graphs of machine performance at different speeds using 15, 20 and 25 pieces of cassava tubers as feed rates. It was observed that the maximum and minimum performance of the machine was shown on the figure 5 at speed 2(420 rpm) and speed 1(380 rpm) respectively using 15 pieces of cassava tubers as feed rates.

Table 4 showed the analysis of variance (ANOVA) of the results obtained which signified that the speed of the machine was an important parameter that affects the performance of the machine. Feed rate do not affect the performance of the machine significantly according to the analysis of variance results.

4 CONCLUSIONS AND RECOMMENDATION

The cassava peeling and washing machine was designed, constructed and tested. The result obtained showed that the machine performance was 72 % at speed of 420 rpm. The feed rates used on the machine do not show any significant variation on the machine efficiency. A combination of peeling and washing in a single machine reduced the labour cost and time involved in peeling and washing separately. From the test, it has shown that the efficiency of the machine was high and the throughput capacity does not influence the efficiency of the machine negatively. The manual method of peeling and washing or machine peeling and washing separately can be improved and modified. It was found that the irregular or indefinite shape or size of cassava tuber hindered the efficiency of the machine.

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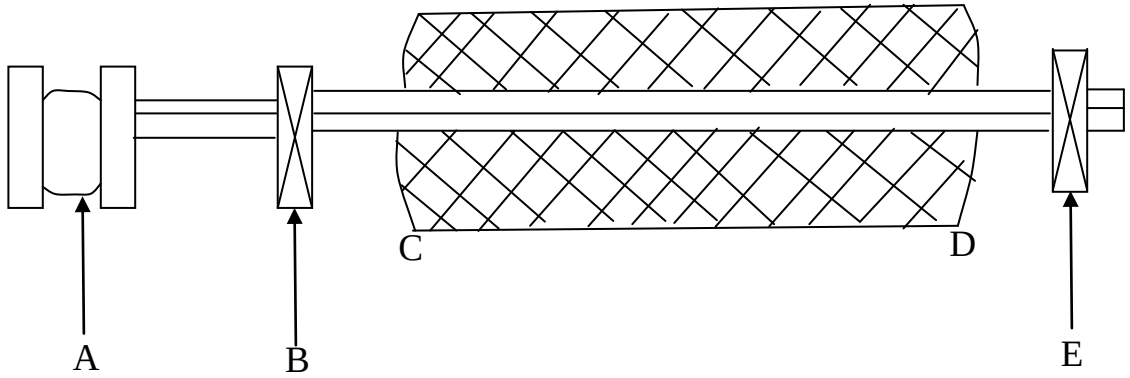

Fig2: Driven Shaft that enclosed with Peeling Drum.

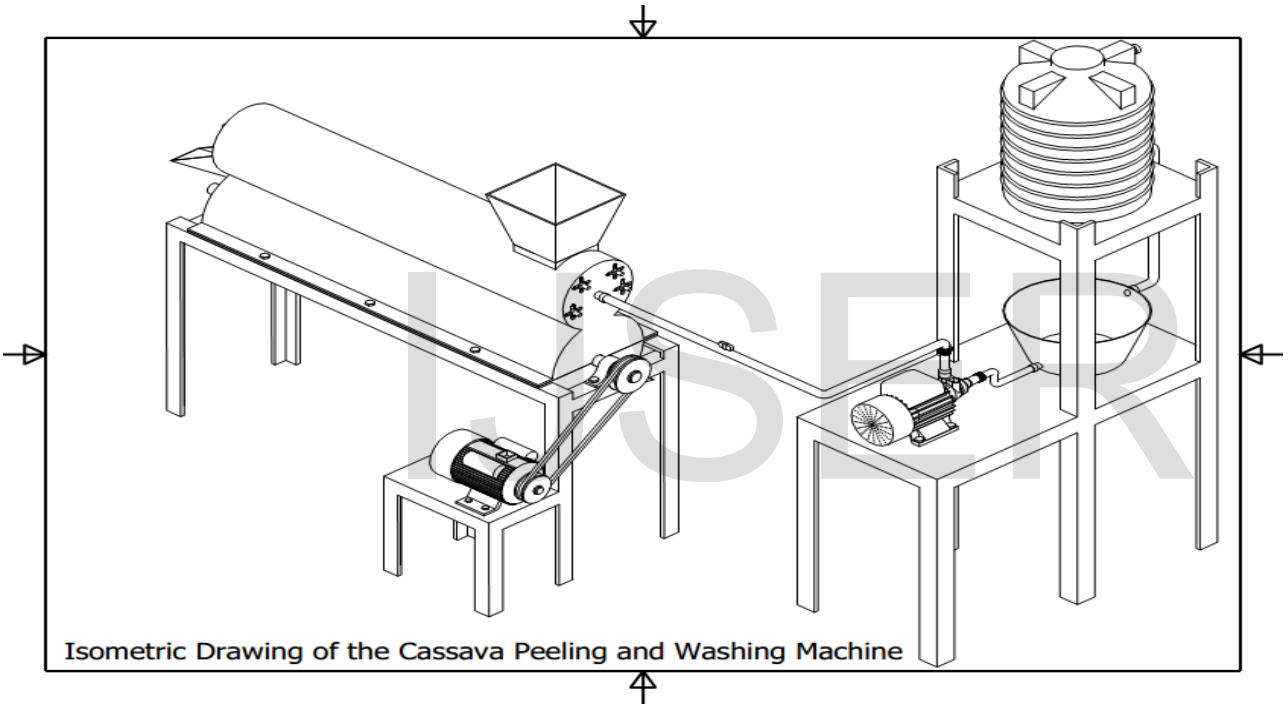

Fig 3 Isometric View of Cassava Peeling and Washing Machine

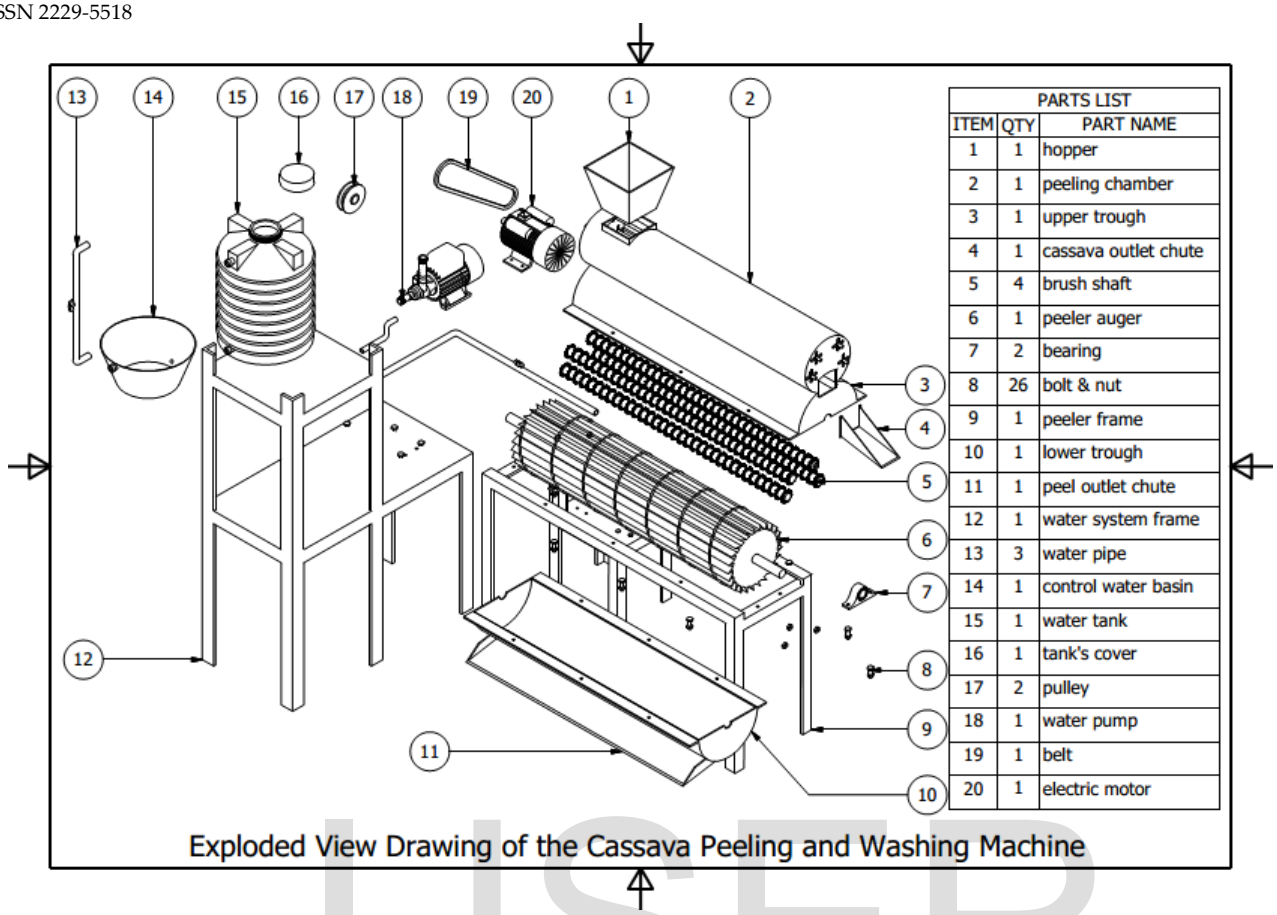

Fig 4: Exploded View of the Cassava Peeling and Washing Machine

Table1: Peeling and Washing efficiency of the machine using 15 pieces of cassava tubers

Speed (rpm)	No of cassava introduced	No of cassava peeled completely	No of cassava washed completely	No of cassava not peeled completely	No of cassava not washed completely	No of cassava peeled & washed completely	percentage No of cassava peeled & washed completely
380	15	10	11	5	4	9	60
	15	9	10	6	5	7	47
	15	10	9	5	6	9	60
	15	8	12	7	3	8	53
	15	9	10	6	5	8	53
	Average						55
420	15	12	13	3	2	12	80
	15	10	14	5	1	9	60
	15	11	12	4	3	10	67
	15	13	13	2	2	13	87
	15	10	11	5	4	10	67
	Average						72
460	15	11	13	4	2	9	60
	15	10	12	5	3	10	67
	15	11	11	6	4	11	73
	15	12	10	3	5	10	67
	15	10	10	5	5	10	67
	Average						67

Table 2: Peeling and Washing efficiency of the machine using 20 pieces of cassava tubers

Speed (rpm)	No of cassava introduced	No of cassava peeled completely	No of cassava washed completely	No of cassava not peeled completely	No of cassava not washed completely	No of cassava peeled & washed completely	percentage No of cassava peeled & washed completely
380	20	13	14	7	6	13	65
	20	12	16	8	4	11	55
	20	14	15	6	5	12	60
	20	14	16	6	4	14	70
	20	13	17	7	3	13	65
	Average						63
420	20	14	16	6	4	14	70
	20	15	15	5	5	14	70
	20	13	17	7	3	12	60
	20	16	15	4	5	16	80
	20	15	16	5	4	14	70
	Average						70
460	20	13	12	7	8	13	65
	20	14	16	6	4	14	70
	20	13	16	7	4	12	60
	20	12	17	8	3	12	60
	20	14	16	6	4	12	60
	Average						63

Table 3: Peeling and Washing efficiency of the machine using 25pieces of cassava tubers

Speed (rpm)	No of cassava introduced	No of cassava peeled completely	No of cassava washed completely	No of cassava not peeled completely	No of cassava not washed completely	No of cassava peeled & washed completely	percentage No of cassava peeled & washed completely
380	25	18	20	7	5	15	60
	25	17	22	8	3	14	56
	25	15	18	10	7	13	52
	25	16	19	9	6	15	60
	25	17	17	8	8	17	68
	Average						59.2
420	25	20	22	5	3	20	80
	25	16	21	9	4	15	60
	25	18	23	7	2	18	72
	25	20	21	5	4	19	76
	25	19	22	6	3	18	72
	Average						72
460	25	16	20	9	5	15	60
	25	16	21	9	4	16	64
	25	17	22	8	3	15	60
	25	19	18	6	7	18	72
	25	18	19	7	6	18	72

	Average						66

Table 4: ANOVA for the effect of Speed and Feed rate on the machine performance

Sources of variations	Sum of Squares	Degree of Freedom	Mean Square	Computed F
A (Speed)	1.56	2	0.78	0.014
B(Feed rate)	228.23	2	114.12	1.998*
AB	229.56	2	114.78	2.010
Error	114.21	2	57.11	
Total	573.56	8		

Significant at 5% probability level

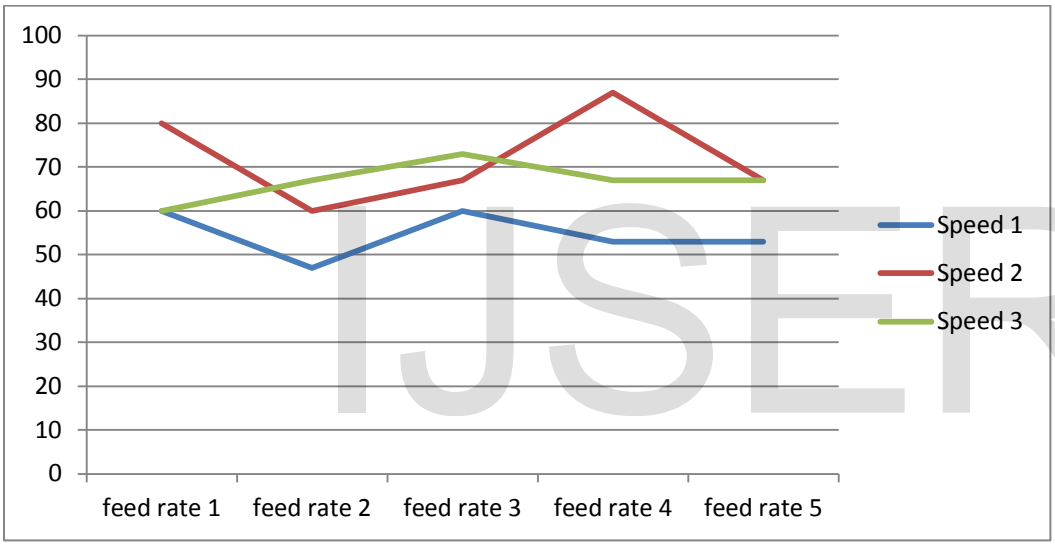

Fig. 5: performance of the machine at different speeds using 15 pieces of cassava tubers

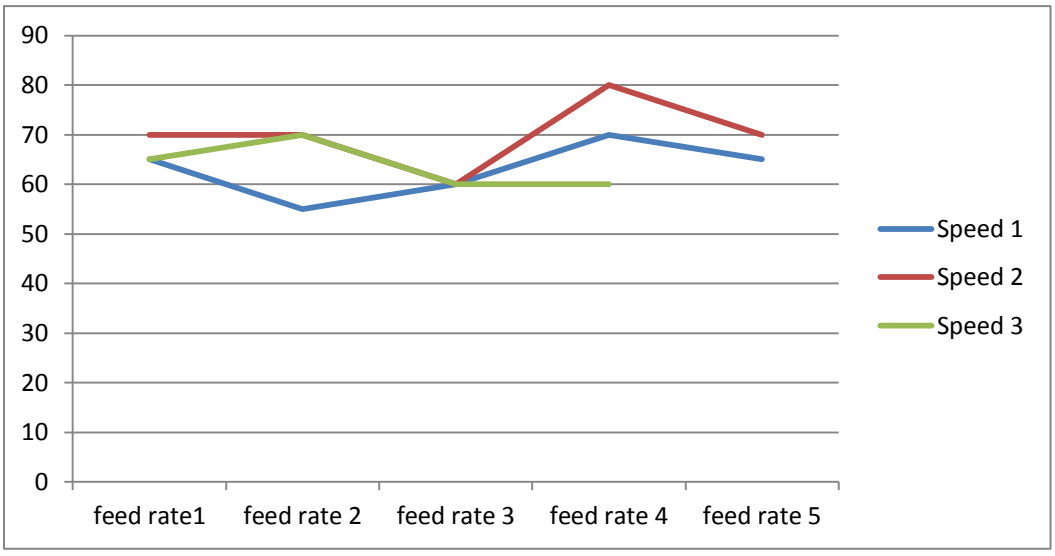

Fig. 6: performance of the machine at different speeds using 20 pieces of cassava tubers

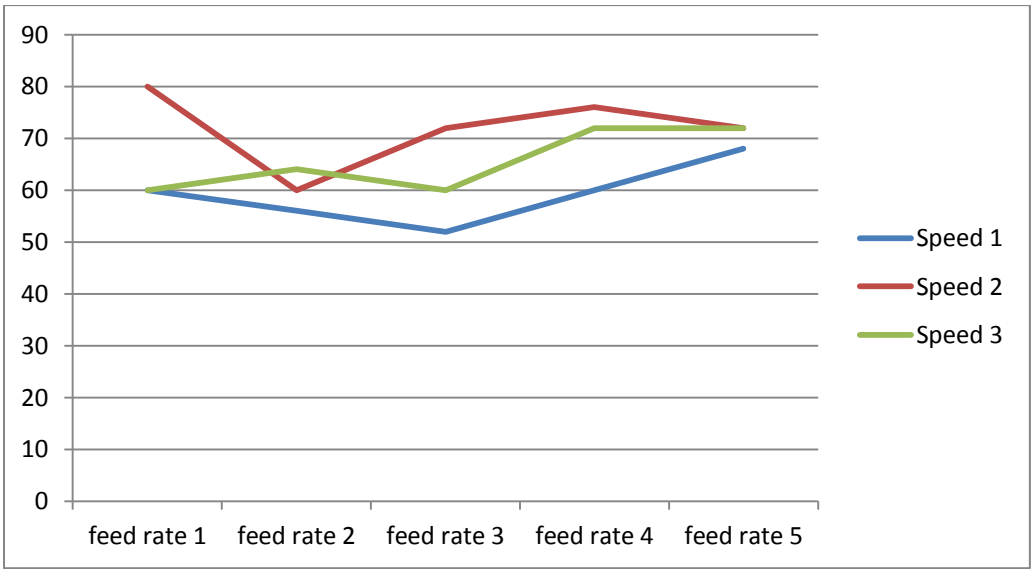

Fig. 7: performance of the machine at different speeds using 25 pieces of cassava tubers

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