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17414

Distr.
LIMITED

ID/WG.480/9(SPEC.)
6 April 1989

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on Design, Development and Manufacture of Simple Food Processing and Preserving Equipment*

Lusaka, Zambia, 9-13 January 1989

DESIGN AND DEVELOPMENT OF A THRESHING MACHINE IN TANZANIA**

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* Organized by UNIDO in co-operation with the Government of Zambia and the Village Industry Service

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V.89-54297

ABSTRACT.

Threshing is one of the bottlenecks in food processing for Tanzania and other developing countries. This paper highlights on the design, construction and performance of a hand operated bean thresher. A brief outline is given on the development in paddy and sorghum threshing.

The problems of adoption of the threshing and other food processing technologies are briefly discussed.

It is concluded that there is a need to tackle the problems of adoption and explore designs for other food processing machines. This calls for co-ordination and collaboration among the national and international Research and Development institutions.

1.0 INTRODUCTION.

Threshing is a process whereby grains are removed from the part of the plant on or in which they have developed. This is normally carried out by hand or by machine. If cracking or breaking of grain results during the process, it will contribute to deterioration.

In Tanzania, the small-scale farmers who are the major agricultural producers do most of their farm operations manually. Threshing is normally done by women. Several methods are used for threshing:

(i) Spreading the harvested crop on firmbare ground or mats and then beating them with wooden sticks in case of beans and other pulses.

(ii) Spreading the harvested crop in (i) and trampling by foot, driven animals or tractor wheels. This method is used for paddy, sorghum and wheat.

The two methods above are not only time consuming but cause heavy losses in case of trampling where a percentage of grain is not shed. When threshing is done on a hard earth floor, earth and other impurities become mixed with the grain, prejudicing storage and processing.

Many types of mechanical devices have been and are being developed to speed up threshing and to improve efficiency so that whole undamaged produce is obtained. This paper is going to highlight on machines developed or being developed for bean, sorghum and paddy threshing.

2.0 HAND OPERATED BEAN THRESHER.

Beans are widely grown and consumed in all parts of Tanzania. Except for a few areas like West Kilimanjaro and Makuyuni, Arusha the major produces are small scale farmers whose plots are 0.5 to 2.0 hectares. In such a scale of farming, all operations i.e. from field preparation to harvesting and threshing, are done manually.

Harvesting is done by uprooting the entire plant when the pods have fully ripened and dried. The harvested plants are heaped

and bundled ready to be moved to homesteads, if they are located near the fields but where homesteads are far away threshing is done in the fields.

Winnowing of the threshed beans is done entirely depending on natural wind speed. This is accomplished by pouring the material in a winnowing vessel from slightly above ones head onto the ground. For more effective cleaning the vessel is shaken while the material is being poured. However, effective cleaning depends mainly on wind speed which cannot be controlled. The material poured on the ground is likely to be contaminated.

Design and construction of a thresher should increase threshing output and at the same time be able to thresh at high moisture content in order to avoid shattering before harvesting. It should cause no damage to seed and should be easy to operate and maintain.

2.1 Design and Construction aspects of the thresher.

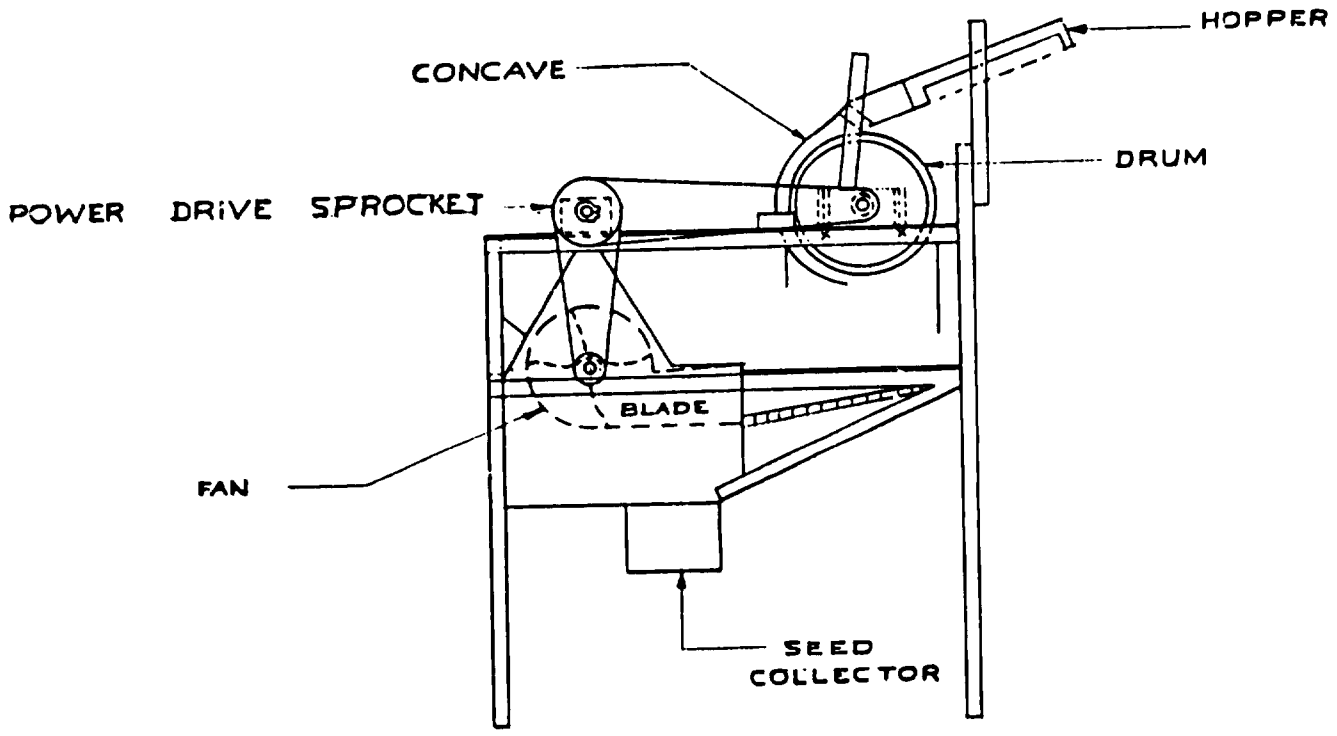
A rubberized cylinder and concave type of thresher was designed and constructed. The set up of the threshing machine is shown on Figure 1.

The drum was constructed from a kapok log which was machined in a lathe machine to 300mm in diameter and 300mm wide. The log was then fixed on to a 20mm mild steel shaft. The shaft was supported by two wooden bearings, one on each side. The bearings were then fixed onto a 50mm x 50mm x 5mm angle iron frame.

Six strips of used tyres were bolted onto the surface of the log. The strips were machined to a uniform thickness. Half of the strips were 6mm thick and the rest were 3mm thick. The different sizes were then fixed alternately.

The concave was made from a 16 gauge sheet metal. The sheet was then curved to follow the curvature of the drum, but with the clearance gradually decreasing from top to bottom. The lower part of the concave was connected to two moveable plates screwed onto the frame so as to enable adjustment of the clearance. Three used tyre ships were also fixed to the concave to serve as rasp bars. The strips were 60mm wide

FIGURE 1. HAND OPERATED BEAN THRESHER



and 5mm thick and were placed 50mm and 20mm apart at the lower part of the concave.

The drum was then connected to a power drive shaft through a bicycle chain. The drive shaft was also supported by wooden bearings which were then fixed onto the frame.

Winnower mechanism was designed and constructed using a 16 gauge mild steel sheet. A fan was constructed from a 20mm mild steel shaft and four 360mm x 210mm curved metal sheets to form fan blades. The blades were arranged radially on the shaft. The blades were then slightly curved forward. The shaft was similarly supported by wooden bearing. Fan housing was made from the sheet metal and fixed in such a way that the clearance between it and the blades is 50mm. The fan was then fixed diagonally below the threshing mechanism. An air duct from the fan was inclined at 20°. Above the duct a screen with 16mm x 20mm holes was placed. Below the screen a collector inclined at 30° was placed. The screen was 220mm below the drum. The fan was driven from the same power drive shaft as that of the drum through a bicycle chain. The arrangement is such that one person could operate the thresher.

2.2 Performance of the thresher.

Performance test was carried out at the Sokoine University farm. Two varieties of beans i.e. Canadian wonder and Maasai red were threshed at moisture content (wet basis) of 13.0% and 16.7% respectively. During the test the power drive was not connected to the fan. Handful size samples were randomly picked and weighed at an accuracy of 0.1g. These samples were threshed and the time taken to thresh each sample was measured using a stop watch. The seed completely separated from the pods were collected and weighed. Unopened pods were thumb opened and the collected seeds were weighed separately. The ratio of the opened seeds to the total seeds in the sample was calculated to give threshing effectiveness. A handful of seeds from the threshed lot was randomly picked and weighed. Seeds with visible cracks or pealed seed coats were sorted out and weighed. The ratio of the damaged seeds to the total seeds

in the sample was calculated to give percentage seed damage. The procedure was repeated ten times for each variety.

Performance of the thresher was compared to the traditional threshing method i.e. hand beating. Threshing was done by twenty men and women with an average age of 30 years. Each individual was given 10 to 12 kg of harvested crop to thresh.

Performance of the winnowing mechanism was tested on Canadian wonder and Maasai red at moisture content (wet basis) of 25%. The test was conducted using a 0.75 hp electric motor with variable pulley diameters so that the fan speed could be varied. Fan speed was measured using a tachometer while air velocity was measured using hot wire anemometer.

A 1 kg mixture of hand threshed seeds and chaff were let to fall from the threshing mechanism while the fan is rotated. After the operation material in the seed collector was weighed. Chaff in the container was separated by hand and weighed. Likewise blown off material was collected on a canvas and weighed. Seeds contained in the chaff was sorted and weighed. The effectiveness of separation was then calculated as winnowing from the relationship.

$$I = (a/(a+c))\ (d/(b+d))$$

where:

a = seeds in the seed collector

b = chaff in the seed collector

c = seed blown off with chaff

d = chaff blown off.

2.3 Results.

The results obtained gave a threshing effectiveness of 82.2% and 85.6% for Canadian wonder and Maasai red respectively. Seed damage was found to be very low at 2.7% for both varieties. The threshing capacity was 15kg/hr and 14 kg/hr for Canadian wonder and Maasai red respectively. As far as winnowing is concerned, optimal effectiveness of separation was found to be 94% at 360 rpm fan speed. The winnower throughput capacity was observed to be 240 kg/hr giving 104 kg/hr of cleaned seed. The thresher was found to be very effective in both threshing. and winnowing. However, its capacity has to be increased substantially in order for it to be a good substitute for traditional hand threshing.

3.0 SORGHUM THRESHER.

Sorghum is a common cereal in semi-arid areas of Tanzania It is used for food and for making local beer. Traditionally, threshing is done by hand beating using sticks or trampling by foot and sometimes tractor wheels where available. Figure 2 shows a p.t.o. driven sorghum thresher which has been developed to ease the drudgery of threshing sorghum. Design and construction has just been completed at the Centre for Agricultural Mechanization and Rural Technology (CAMARTEC) in Arusha, Tanzania. Performance test as for the bean thresher is to be done next harvesting season i.e. mid-July to end of September.

3.1 Design and Construction Aspects of the thresher.

3.1.1 Materials.

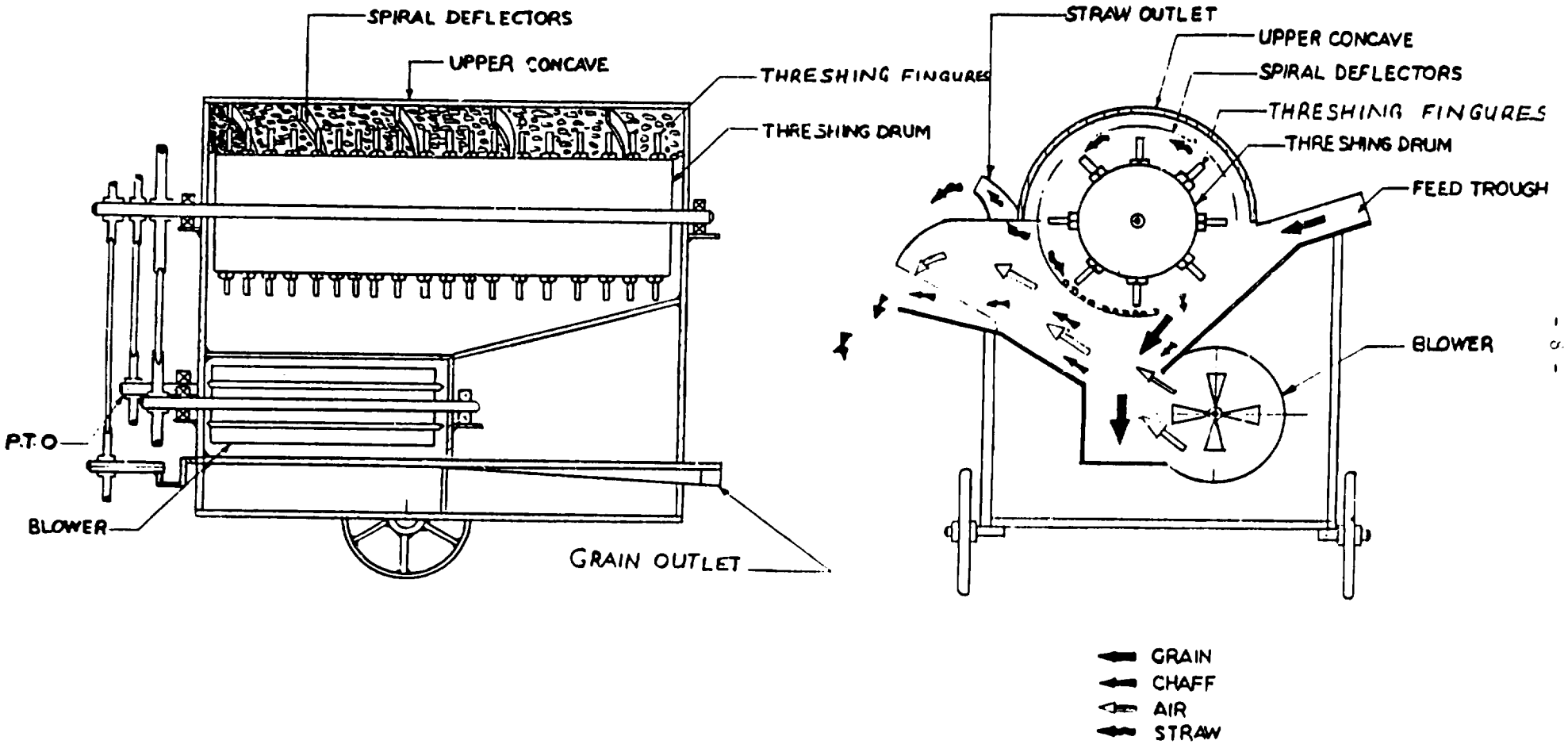
1. Feed trough - Wood 21mm thick.
2. Threshing drum - sheet metal 2mm, mild steel
3. Threshing fingers - steel rods Ø 12mm, mild steel.
4. Threshing drum shaft - Ø 38mm mild steel.
5. Upper concave and spiral deffectors - sheet metal 3.0mm thick, mild steel.
6. Straw thrower paddles and straw outlet - sheet metal 1.5 mm thick, mild steel.
7. Blower housing - sheet metal 3mm thick, mild steel
8. Blower shaft - Ø 31mm, mild steel.
9. Blower blades - wood, 15mm thick.
10. Screen, perforated sheet metal, 1.5mm thick, mild steel.
11. Collecting trough and grain outlet, sheet metal, 1.5 mm sheet metal.
12. Frame of the machine - Angle iron 65mm x 65mm x 8mm mild steel.

3.1.2 Theoretical working speeds.

If the threshing drum is directly coupled to the tractor's p.t.o. shaft the following speeds can be obtained:

Speed of threshing drum	540 rpm
Speed of blower	1091 rpm
Speed of pulley for the sieving mechanism	160 rpm.

FIGURE 2 :


SPIRAL DEFLECTORS
UPPER CONCAVE
THRESHING FINGURES
THRESHING DRUM
P.T.O
BLOWER
GRAIN OUTLET
STRAW OUTLET
UPPER CONCAVE
SPIRAL DEFLECTORS
THRESHING FINGURES
THRESHING DRUM
FEED TROUGH
BLOWER
GRAIN
CHAFF
AIR
STRAW

The minimum and maximum reciprocating velocities of the sieve are 1 m/s and 1.38 m/s respectively. Modification of the drive system with the tractor p.t.o. is necessary to attain a higher working speed.

3.2 Sorghum threshing.

Sorghum heads are piled on the feed trough and then using a stick they are pushed through the inlet to the threshing chamber. The sorghum heads are threshed by a high speed rotating threshing drum which is equipped with steel fingers. The upper concave is fixed with spiral deflectors which axially convey the mass being threshed forward. The far end of the threshing drum has straw thrower paddles which catch the threshed straw and throws them out. The threshed grains and chaff fall through an air stream from the blower where the chaff and other lighter material are blown out and the grains fall on the reciprocating screen. The screen seives out the clean grain which fall on the collecting tray leaving behind remnants of small piece of straw which are cascaded away. The grain is collected through the grain outlet and bagged.

4.0 THE DOUBLE OPERATION PADDY THRESHER

Rice is a common staple grain in Tanzania which is increasingly becoming important. As for sorghum, threshing of paddy is done by hand beating or trampling. Figure 3 is a double operation manual thresher designed by TIRDO in Arusha.

4.1 Design and Construction aspects of the thresher.

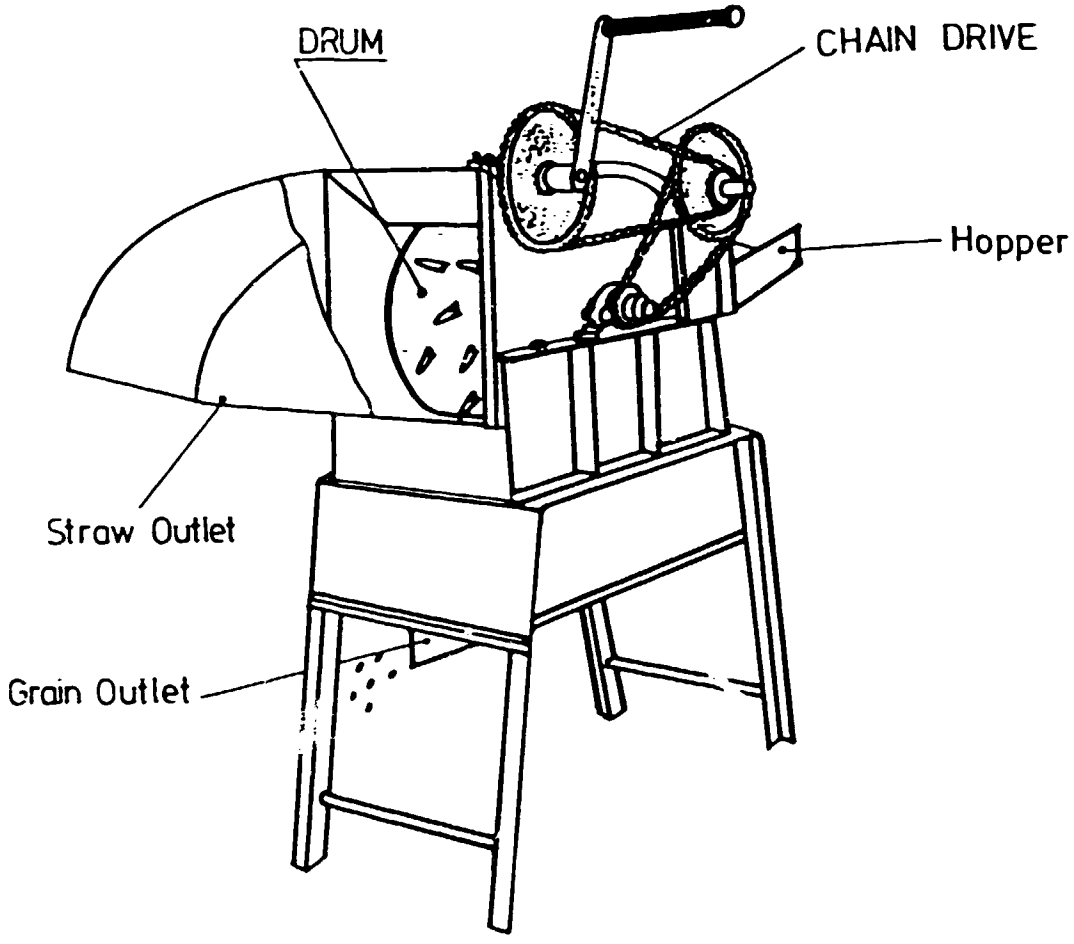
The design aims at simplicity of construction, ease of operation and low cost, combined with rapid and thorough threshing.

4.1.1. Materials.

- The threshing drum is made of wood and 4mm mild steel wire loops.
- The hopper and cover is made of 0.8mm sheet metal, mild steel.
- The threshing drum shaft is Ø 16mm, mild steel.
- Bicycle chain and sprocket drive.
- The frame of the machine is made of wood.
- The grain outlet is made of 0.8mm sheet metal, mild steel.

DOUBLE OPERATION MANUAL THRESHER

FIGURE 3



4.1.2 Working speed and daily output.

The minimum manual speed of the machine is 300 rpm but the machine can be hand driven up to the speed of 1,?00 rpm. The maximum output of the thresher is 1,500 kg of dry paddy for a 7-hour day.

4.2 **Paddy threshing.**

Harvested paddy with its straw is piled on the hopper. The machine is hand driven until it reaches a speed of 1,000 rpm and then the paddy is fed onto the threshing drum. The term "double operation" is derived by the fact that during the process, the threshed paddy is passed through a sieve on the bottom of the threshing drum while the straw is thrown out by wire loops through the straw outlet.

The crop being threshed must be dry enough i.e. 15 - 17% moisture content wet basis to achieve complete separation of paddy from the straw.

5.0 PROBLEMS OF ADOPTION.

The adoption of the above **and** other simple food processing technologies has been very slow due to the following:

a) The cost of raw materials is ever high especially for steel. This makes it difficult for small scale farmers to buy the technologies developed. The potential manufacturers also become reluctant to take up developed technologies from Research and Development (R & D) institutions to manufacture them in large scale.

b) Lack of co-ordination among the R & D institutions. This results in duplication of efforts and uneven use of the scarcely available resources.

c) Inadequate R & D engineers to take up the challenge of the ever rising demand for food processing equipment. This limits design and development in this area.

d) Social and cultural barrier e.g. threshing and winnowing has in many areas been considered a women job hence limiting the use of developed technologies. In some cases, activities like threshing and winnowing has been taken

as a social event where women meet for gossiping and exchanging social jokes while working.

6.0 CONCLUSION.

With the successful development of threshing machines for beans, sorghum and paddy the element of drudgery may be solved. In view of the growing importance of such crops not only as food crops but also as a source of income for the farmers, there is a need to tackle the problems of adoption to improve the threshing operation and reduce drudgery.

Design for other food processing machines should be explored and this calls for co-ordination and collaboration among the national and international Research and Development institutions.

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