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## Effect of blending speed on efficiency and consistency of a grains drink processing machine

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### Abstract

The effect of Blending speed on blending efficiency and consistency of drink produced from a Grains drink processing machine was studied. Three grain types of two varieties each for maize (*zea mays*), soybean (*glycine max*) and guinea corn (*sorghum bicolor*) were blended at speeds of 1400 r.p.m, 1300 r.p.m, 1000 r.p.m and 800 r.p.m using vertical- horizontal blade assembly. The drinks from the grains were also extracted by centrifugal separation using the same machine and the blending efficiency and drink consistency were analyzed. The result obtained showed that blending speed of 1400 r. p. m had the highest blending efficiency of 79.48% and consistency of 89.6% on dehulled white maize when blended for 600 seconds while blending speed of 800 r.p.m had the least blending efficiency and consistency of 20.03% and 24.5% respectively on dehulled yellow maize for the same blending time interval of 600 seconds. The development of this machine would solve the on-demand of automated production of grain drinks in the food industry.

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## Introduction

Size reduction of grain particles is one of the essential steps in drink production from grains. It can be achieved through wet milling operation of various types of grains (Gana, 2011). Wet milling separates the grains kernels into various fractions which allows for the production of multiple food and industrial products including drinks. The wet milling industry was developed in the early 19<sup>th</sup> century with the primary purpose of producing starch from grains such as corn for use in food and laundry product (Kerr, 1950). Research has shown that sorghum may be used to produce a number of food products (Liu *et al.*, 2012). However, in the 1920s, wet mills began production of crystalline dextrose (Newkirk, 1923). A typical corn wet milling plant in the United States spends approximately \$20 to \$30 million per year on energy, making energy efficiency improvement an important way to reduce costs and increase predictable earnings, especially in times of high energy-price volatility (Galitsky *et al.*, 2003).

Beginning in the early 1990's, wet mills began production of high fructose corn syrup starch in addition to other products. Currently, there are approximately 28 wet milling plants in the United States, a large number of them were built in the last few decades (John and May, 2003). Rotation speed also matters and usually has an optimum value. At too low a speed, there is inadequate agitation; but at low speeds, avalanching flow can occur, which is efficient in mixing. At too high a speed, centrifugal force sends all the particles to the perimeter (Clark, 2009)

The grains refining processes involve grain cleaning, steeping and milling. Cleaning is done to remove broken kernels, chaff, cob pieces and foreign materials (John and May, 2003). This process is important because broken kernels can release starch in steep water which can gelatinize, leading to undesirable viscosity during evaporation of steep water into thick liquor (John and May, 2003).

Steeping involves soaking of the corn kernels under the controlled temperature at 48-50°C, for a period of 35-50 hours, (Watson, 1984; Gana, 2011). Water acts as a conditioner so that milling can be performed under optimal condition (Bass, 1988). Steeping softens the corn kernel for milling, inhibits microbial growth and enhances pure starch recovery (Bartling, 1940).

After steeping, the germ becomes soft and rubbery for Hydro cyclones with counter rotating discs and intermeshing fingers to separate. Since the germ is lighter in weight than the rest of the kernel, it is easily separated by centrifugal force. Once removed, the germ is purified to remove starch and protein extracts by washing with water. Oil is then extracted from the germ to produce corn oil.

It was clearly observed that these processing methods have sophisticated features requiring high degree of technical expertise which are scarcely available in third world countries. Although a lot of work has been done locally to mechanize the milling process, it was however observed that no extensive work has been done locally to combine the milling, mixing and sieving of wet grains in a single machine. Thus, the development of grains drink processing machine was undertaken in order to efficiently process grains into hygienic drinks. Therefore this paper is a presentation of the effect of blending speed on blending efficiency and drink consistency produced from a machine that was developed at the Agricultural and Bioresources Engineering Department of the Federal University Technology Minna, Nigeria.

## Materials and method

### Material preparation

Two varieties each of Maize (*zea mays*) (white maize and yellow maize), sorghum (*sorghum bicolor*) (white guinea corn and yellow guinea corn) and soybean (*glycine max*) (large seeded and small seeded) grains were obtained from Minna main market, in Niger State, Nigeria. About 3000g of each of these grains were sorted and cleaned. The

maize and sorghum samples were soaked in 6 litres of water at room temperature for a conventionally accepted recommended duration of 36 hours (Gaffa *et al.*, 2003), while those of soybeans were soaked in the same quantity of water at room temperature for 12 hours (www.en/wiki/soybean, 2010).

*Experimental procedure*

The soaked grains were milled, mixed and sieved using the fabricated grains drink processing machine. Samples of grains of white maize, yellow maize (pop corn), white guinea corn, red guinea corn, soybean ‘A’ (large seeded) and soybean ‘B’ (small seeded) weighing 300g each were blended within the machine at speeds of 1400r.p.m, 1300 r.p.m, 1000r.p.m and 800r.p.m for 600 seconds using Horizontal-Vertical blades assembly. Ratio 3:2 litres of water was added to the samples intermittently during the blending operation and the slurry was sieved with ratio 1:7 litres of water in order to thoroughly wash the milled starch from the milk as shown in fig. 3. (Gana, 2011).

In order to obtain dry quantities of starch and residue the starch was allowed to settle down for 14hrs before the water was decanted and the starch and residue were sun dried to initial moisture contents of their respective grains as shown in figs, 5 and 6. The dried starch and residue were weighed using spring weighing machine and the percentage loss, blending efficiency and consistency were computed using the formula below and the result is presented in table 1.

i) Percentage losses

$$L_s = \frac{A - (M + R) \times 100}{A} \dots\dots\dots 1$$

where  $L_s$  is percentage losses

A is initial weight of the grains

M is weight of milled starch (dried to the same M.C with A)

R is weight of dry residue (dried to the same M.C with A)

The blending efficiency is given as

$$E_B = \frac{M}{A} \times 100 \dots\dots\dots 2$$

Where:  $E_B$  is the blending efficiency

M is dry weight of milled starch/milk (dried to the same M.C with A)

A is initial weight of the grain.

*Machine description*

The present invention generally relates to the on-demand dispensing of spoonable or drinkable products of unique attractive appearance. More particularly, the invention relates to a dispensing device and method that allows to serve on demand, and in an automated manner, combinations of food components having a pleasing distinctive appearance in the cup (Herrick *et al.*, 2010)

The machine was made from stainless steel materials. It was designed in order to carry out the major operations of blending of the seed, mixing the blend materials with water extraction of the drink in a single unit. The major components of the machine include blending units, water holding tank, rotary perforated drum assembly and power unit. The blending operation is achieved by disengaging the perforated drum from rotation while the central shaft is in motion while the separation operation is achieved by allowing the perforated drum to rotate together with the central shaft as shown in figs, 3 and 4.

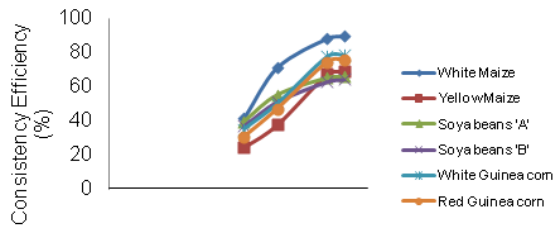
**Results and discussion**

*Effect of machine speed on consistency*

The effect of blending speed on consistency of the various grains is presented in fig 1. Blending speed of 1400 r.p.m has the highest consistency of 89.60% from dehulled white maize, while blending speed of 800rpm recorded the lowest consistency of 24.46% at blending speed of 800 r.p.m on dehulled yellow maize at constant blending time of 600 secs.

Generally, all the grains produced their highest consistency drinks (64.26%-89.60%) at blending speed of 1400 r.p.m while the least consistency range of 24.46%-41.48% was obtained at blending speed of 800 r.p.m.

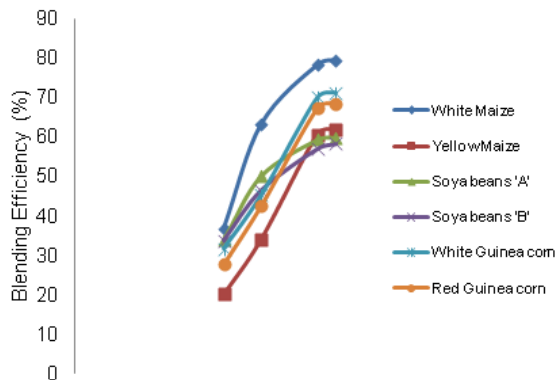
For dehulled white maize there was significant difference in drink consistency between blending speed of 800 r.p.m (41.48) and blending speed of 1000 r.p.m (71.26%), but there was no significant difference in consistency between blending speed of 1300rpm (88.28%) and 1400rpm (89.60%). This observation is the same for all the other grains.



**Fig 1.** Relationship between consistency and Blending Speed at Constant Blending Time of 600 secs using Vertical-Horizontal Blade.

*Effect of blending speed on blending efficiency*

The effect of blending speed on blending efficiency of the various grains is presented in fig.2. Blending efficiency of the machine increased significantly with increasing speed from 800rpm to 1300rpm but was almost constant at speeds of 1300rpm to 1400rpm for all grains. However, blending dehulled white maize with speed of 1400 r.p.m had the highest blending efficiency of 79.5% while blending dehulled yellow maize at a speed of 800 r.p.m produced the least machine blending efficiency of 20.02% at 600 seconds blending duration.



**Fig 2.** Relationship between Blending Efficiency and Blending Speed at Constant Blending Time of 600secs using Vertical-Horizontal Blade.

As indicated earlier, the blending efficiency of 78.23% at speed of 1300 rpm was not significantly

different from the value 79.48% obtained at a speed of 1400rpm for the dehulled white maize.



**Fig. 3.** Fabricated grains drink machine in operation.



**Fig. 4.** Soy milk during processing.



**Fig. 5.** Dry milled starch. A = Pop corn, B = Red Guinea corn, C = White guinea corn.



**Fig. 6.** Dry residue from red guinea corn after processing.

The high blending efficiency observed in all the grains when blended with speeds of 1300rpm and 1400 rpm could be as a result of high shear force generated due to high speed of rotation (centrifugal force) of the central shaft. This observation agrees with the result of an earlier study (Jayesh, 2009) where speed of blending was found to be a key factor to blending efficiency whereby lower blending speeds provides lower shear forces and higher blending speeds provides higher shear force and segregation of the granules.

### **Conclusion and recommendation**

The test on the machine was concluded. The results obtained were discussed and the following conclusions were made:

1) Both machine blending efficiency and drink consistency were found to increase with speed. The highest blending efficiency for all the grains range from 57.4%(soybean B) - 79.48% (white maize) and drink consistency of 63%(soybean B)- 89.60%(white maize) were recorded at blending speed of 1400 rpm for 600 secs using vertical-horizontal blade assembly.

2) The highest machine blending efficiency and drink consistency of 79.4% and 89.48% were recorded by blending white maize while the least values of 20.02% blending efficiency and 24.46% consistency were observed by blending yellow maize.

3) The values of the blending efficiency of the machine and drink consistency at blending speeds of 1400rpm were 79.48% and 89.6% respectively while the values obtained at blending speed of 1300rpm were 78.23% machine blending efficiency and 88.23 % drink consistency.

4) As a result, a machine speed of 1300rpm is recommended in order for the machine to have more dynamic stability and operate smoothly.

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