Academic Research International EFFECT OF BLADE TYPES ON THE BLENDING EFFICIENCY AND MILK CONSISTENCY OF A GRAINS DRINK PROCESSING MACHINE

Experiment Findings · April 2012

DOI: 10.13140/RG.2.1.5085.1927

Agidi Gbabo

I. M. Gana
FEDERAL POLYTECHNIC BIDA

Solomon Dauda Musa
Federal University of Technology Minna

EFFECT OF BLADE TYPES ON THE BLENDING EFFICIENCY AND MILK CONSISTENCY OF A GRAINS DRINK PROCESSING MACHINE

Dr. Gbabo, Agidi
National Cereals Research Institute, NIGERIA.
agidides@yahoo.com

Gana, Ibrahim Mohammed
Agricultural Development Project, Minna, NIGERIA.
Ganaibro74@yahoo.com

Dauda, Solomon Musa
Universiti Putra, UPM, Serdang, MALAYSIA.
smdauda@yahoo.com

ABSTRACT

The effect of blades type on blending efficiency and consistency of drinks produced from a grains drink processing machine developed at the Agricultural and Bio resources Engineering Department of the Federal University of Technology, Minna was assessed. Three grain types of two varieties each for maize, soybean and guinea corn where processed using four types of blending blades: horizontal-vertical blade, 4-blade, 2-blade and wheel blade assemblies. The result obtained showed that horizontal-vertical blade assembly had the highest blending efficiency of 78.23% on dehulled white maize while the wheel blade assembly had the least blending efficiency of 09.32% on dehulled yellow maize (pop corn).

Keywords: Blades, grains drink, guinea corn, maize, performance assessment, and soybean

INTRODUCTION

A grains drink processing machine of input capacity of 190.32kg/8hr/day of grains was developed at the Agricultural and Bio resources Engineering Department of the Federal University of Technology Minna, Nigeria. 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.

Grain drinks are usually processed from legumes and cereal such as soya beans, maize, rice, sorghum, millet. It is among the most widely consumed food products in Nigeria and play very important role in the socio-economic life of the people (Gana, 2011). According to (Bogue & Sorenson, 2008) substantial sales of hundreds millions of dollars of gluten-free food were made in 2006, and the sales could reach billions of dollars by 2015.

Like other agricultural products, the processing of the raw-material into the consumable stage entails the following major steps: Cleaning, steeping, wet milling, wet sieving, mixing and cooking. A lot of drinks are currently being processed from grains. For instance *Kunu* is a refreshing drink which is taken as a substitute for soft drink. The various types of these drinks are: *kununzaki, kunungyada, kanunakamu, kununtsamiya, kununbuale, kunun, jiko, amshau and kunungayamba*(Gaffa, Jideani, & Nkama, 2003). It is a staple beverage drink that is relatively cheap and nutritious when compared to carbonated drink (Adejuitan & Adelakun, 2007).

Ogi is another popular drink in Nigeria and in most parts of West African countries. It is a fermented cereal porridge made from maize, sorghum, millet (Adelekan & Oyewole, 2010).

Soya milk is a liquid extract of soya beans, closely resembling dairy milk in appearance and composition. It contains high amounts of protein, iron, unsaturated fatty acids, and niacin but low amounts of fat, carbohydrates, and calcium compared with cow's milk (K. Liu, 1997; L. Liu et al., 2012). Soymilk is also taken as a healthy food because it is cholesterol and lactose free. It is recommended for those who are allergic to milk protein and those who have special health or religious diet requirement (Pomeraz, 1991).

Rice milk is also a type of grain drink processed from rice. It is mostly made from brown rice. It is made by pressing the rice through a diffusion process to strain out the pressed grains. At home level, it is made by boiling rice with a large volume of water before blending and straining the mixture (Smith, 2011).

Almond milk is another milky drink made from ground almonds. It is made at home by mixing ground almonds with water in a blender. It is promoted as an alternative to soymilk for those who are soy allergic (McGee, 2004).

Unlike grains milk, the World Cancer Research Fund (WCRF) and the American Institute for Cancer Research affirmed that at least eleven percent of human populations are linked with excessive dairy milk consumption which results to prostate cancer (McGee, 2004). Another medical study also indicated a possible link between milk consumption and the exacerbation of diseases such as crohn's disease, mimicking symptoms in babies with existing cow's milk allergies and the aggravation of Beheets disease, which were not found in grains drink (McGee, 2004).

It is in recognition of the contributions of these crops to human health, the Federal and various state governments are encouraging the establishment of cottage industries to process these products by utilizing local raw materials to supplement the production capacity of the giant industries. Some of these programs set up by government to achieve this objective include the National Program for Food Security (NPFS), poverty alleviation, etc., to exploit our natural resources (www.en/wiki/soybean, 2010).

Therefore development of appropriate technology in the country for processing grains drink in the agricultural sector cannot be over looked. Thus the development of grains drink processing machine was undertaken in order to efficiently process grains into hygienic drinks. Thus, this paper is a presentation of the effect of blade types on the blending efficiency and consistency of grains drink produced from a machine that was developed at the Agricultural and Bio resources Engineering Department of the Federal University of Technology Minna, Nigeria.

MATERIALS AND METHODS

Material Preparation

Two varieties each of Maize (white maize and yellow maize), sorghum (white guinea corn and yellow guinea corn) and soybean (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 liters 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 blended in the machine using four types of blades. These were horizontal-vertical blade, 2-blade, 4-blade and wheel blade. The grains were intermittently mixed with water at a water to grain ratio of 3:2 liters during blending and sieved in the machine as shown in plate III. Each of the slurry was sieved with 1:7 liters of water in order to thoroughly wash the milled starch from the milk and was allowed to settle down for 15 hrs. The water was decanted and the starch and residue were sun dried to the initial moisture content of their respective grains. The dried starch and residue were weighed using spring weighing machine. The percentage loss, blending efficiency and consistency were then computed using the formula below and the results are presented in tables 1 to 4.

Percentage losses

$$Ls = \frac{A-(M+R)x\,100}{A} \quad \text{---} \ldots\ldots 1$$

Where*Ls*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

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

WhereE_B is the blending efficiency

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

A is initial weight of the grain.

Consistency

$E_c = \frac{M}{A^1} \times 100$ 3

Where: E_C is the consistency of grains drink

M is dry weight of milled starch/milk

A^1 is proximate composition of edible part of the grains.

For white maize (88.7% of A) = 2661

Yellow maize (90% of A) =2700

Soy bean (90.7% of A) = 2721

Sorghum (90.5% of A) = 2715

Machine Description

The grains drink processing machine is made up of the following assemblies and components as shown in plates 1- 3.

Outer casing

The outer casing is a cylindrical vessel which is made up of stainless sheet to prevent corrosion. It has a diameter of 0.29m with two outlet valves fitted at the bottom of the casing in order to allow outflow of separated liquid (milled starch) from the tank to the temporary milled starch tank.

Perforated drum

This is an inner perforated cylinder of 0.264m diameter which is fitted into the outer casing smaller in size (0.264m) than the outer casing with permissible clearance of 0.026m between them. It has a teeth assembly with wire brush at its base. The wire brush prevents bigger particles from blocking the sieve holes at the tank outlet.

Perforated drum cover

This is made of smaller stainless steel. It has a pipe with a bearing at the centre which allows inflow of water into the system during separation and also prevents the drum from getting in contact with the outer casing while in rotation.

Sieve

The sieve is a muslin cloth which is attached to the frame made from stainless sheet. The muslin cloth is fastened to the inner and outer walls of the perforated drum. The frame has cover with stainless steel pipe at the center, through which water flows into the system.

Inner casing (blending casing)

This is made up of stainless sheet and it is only used during blending operation. It prevents the blending blade from tearing the sieving cloth and also minimizes the amount of water loss from the system during blending.

Inner casing cover

This is also made from stainless sheet with 18mm diameter bolt and nut at the center for easy adjustment of the cover, depending on the quantity of grains that are fed into the machine.

Blending blades

These are interchangeable sets of 2mm thick blades assemblies. 8mm diameter bolts were used to fasten the blade assembly to the central shaft. The blades are: Two blades assembly, four blade assembly, wheel blade assembly and Vertical-Horizontal blades assembly. The two blade assembly is made up of 2 horizontal blades welded to housing at an angle of 180^0. The four blade assembly is made up of 4 horizontal blades welded at an angle of 90^0 to housing. The Wheel blades assembly is made up of 4 horizontal blades linking a circular wheel which is welded to a housing, while the Vertical- Horizontal blades assembly is made up of 4 horizontal blades which are welded to a housing at an angle of 90^0.Each of the horizontal blades has two vertical blades attached to them.

The detachable hopper

The hopper was designed to be attached to the outer casing with the aid of a screw assembly, which consists of screw handle, 2 bolts welded to the machine frame and 2 bolts with a pipe attached to the hopper. It was designed to be detacheable to allow for easy sanitation and disassembling.

Drive and driven assembly

This assembly consists of an electric motor of 7.5Hp and the central shaft with their individual pulleys. The motor and the central shaft are connected by a V- belt.

Perforated drum teeth assembly

This consists of 4 teeth joined to a pipe through which the central shaft passes. The pipes have two 8mm bolts and nuts that hold the central shaft during separation.

Water tank

A calibrated transparent rubber bucket is used as the water tank. It serves as source of water for separation operation after blending and also during cleaning. It was designed in such a way that the water goes into the system through a nozzle and a pipe when required by opening the valve.

Temporary milled starch tank

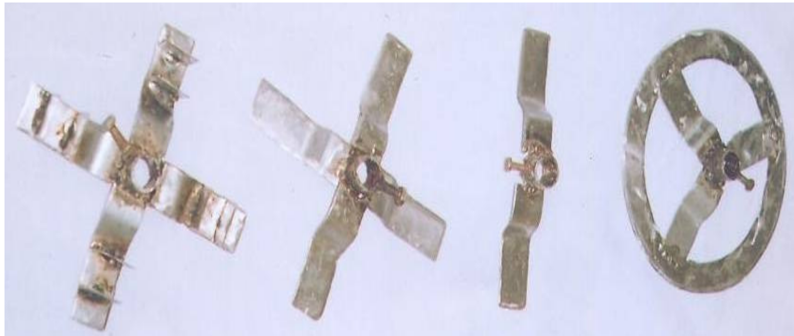
This tank is made from stainless sheet with two inlet valves, one outlet valve and a drain valve at the base for easy cleaning.

Machine Frame

The machine frame is made up of 0.0762m angle iron. Its main function is to hold the water tank, blending, separation, drive and driven assemblies in position and stabilize the system during operation.

Figure 1.Fabricated Grains Drink Processing
Figure 2.Soy Milk during Processing Machine in

Operation



A B C D

Figure 3.Blending Blades

A = Vertical-Horizontal Blade,

B = 4-Blade Assembly,

C = 2-Blade Assembly,

D = Wheel Blade Assembly.

RESULTS AND DISCUSSION

Effect of Blade Type on Blending Efficiency

The effect of blade type on blending efficiency for various grains is presented in tables 1-4. Vertical-horizontal blades assembly which have a total surface area of 0.019m^2 has the highest blending efficiency of 78.23% on dehulled white maize, while wheel blade with surface area of 0.028m^2 assembly has the lowest blending efficiency of 9.32% from dehulled yellow maize when blended with wheel blade assembly at constant blending time of 600 seconds and blending speed of 1300 r.p.m. No significant difference was observed in the blending efficiencies of the 2blades (0.006m^2 surface area) and 4blades (0.012m^2 surface area) for all the individual grains while the horizontal-vertical blade and wheel blade assemblies had blending efficiency values that differ significantly from two other blades. Generally, the horizontal-vertical blade recorded the highest blending efficiencies from 59.26% (soya-bean)-78.23 %(whitemaize) in all the grains while the wheel blade had the least values (9.32 for yellow maize to 20.2% for white maize) for all the individual grains. For the grains, white maize was observed to have the highest blending efficiencies for all the types of blades compared to yellow maize with the lowest values in all types of blades.

The Effect of Blade Type on Dry Weight of Residue

The effect of blade type on dry weight of residue of various grains is presented in tables 1-4. The wheel Blade with surface area of 0.028m^2 has the highest dry weight of residue of 2792.52g from dehulled yellow maize while the vertical-horizontal blade with surface area of 0.0193m^2 has the least dry weight of residue of 466.25g when white maize was dehulled at blending time of 600 seconds and speed of 1300 r.p.m.

The high quantity of dry residue obtained from the blade with surface area of 0.028m^2 could be as result of the less blending (grinding) effect of the blade on the grains leading to the production of more coarse particles that could not be easily dissolved in water. Conversely, the least quantity of dry residue obtained from the vertical-horizontal blade with surface area of 0.0193m^2 could be as result of greater blending (grinding) effect as confirmed by its higher blending efficiency.

The quantity of residue produced by using the 2blades and 4blades for individual grain did vary significantly as shown in tables 1-4, while those produced by the vertical horizontal and the wheel blade assemblies vary significantly. Also, in all the grains white maize produced the least quantity of residue while yellow maize had the highest quantity of residues.

ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 2, No. 3, May 2012

The Effect of Blade Type on Dry Weight of Milled Starch/Milk and Drink Consistency

The quantity of milled starch/milk is a direct index of the consistency of the grains drink. The effect of blade type on dry weight of milled starch/milk is presented in tables 1-4. The blade with surface area of 0.0193m^2 (vertical-horizontal) had the highest quantity of dry weight of milled starch of 2349.23g and highest consistency of 22.71% from dehulled white maize, while blade with surface area of 0.028m^2 (wheel type) had the least quantity of dry weight of 280.03g of milled starch and correspondingly lowest consistency of 10.37% from dehulled yellow maize at a speed of 1300 r.p.m and blending time of 600 seconds.

Milled starch production and drink consistency was observed to be higher for white maize compared with other grains for all types of blades tables 1-4. Yellow maize recorded the least milled starch production with corresponding lowest consistencies for all blade types. It was also observed that there was an increase in the quantity of milled starch with corresponding increase in surface area except that there was a deviation with the results obtained with the wheel blade assembly (Gao, Ierapetritou, & Muzzio, 2011). The least values obtained from the wheel blade with surface area of 0.028m^2 could be as a result of the blade design which does not give enough space for the grains to get in contact with the blade cutting surfaces. This observation agreed with the result of an earlier study conducted by (Bridson et al., 2007; Wagner et al., 2009) where blade design was found to have the most significant effect on the apparent particle size distribution of process material (Lactose).

Table 1.Results of Effects of Vertical-Horizontal Blades Assembly on Weight of Dry Residue, Weight of Milled Starch/Milk Percentage Loss and Blending Efficiency

S/NO	*Type of Grain*	*Weight of Dry Residue (g)*	*Ave. Weight of Dry Residue (g)*	*Weight of Milled Starch/Milk (g)*	*Ave. Weight of Milled Starch/Milk (g)*	*Percentage Loss (%)*	*Blending Efficiency (%)*	*Consistency Efficiency (%)*
1	Dehulled White Maize	464.30 468.10 466.35	466.25	2351.18 2347.38 2349.13	2349.23	0.51	78.23	88.28
2	Dehulled Yellow Maize	1170.30 1173.40 1188.02	1177.24	1825.11 1822.01 1807.39	1818.17	0.153	60.61	67.34
3	Soy Bean ‘A’	1024.49 1019.40 1015.33	1019.74	1773.18 1778.27 1782.34	1777.93	6.74	59.26	65.34
4	Soy Bean ‘B’	1080.40 1091.00 1087.80	586.40	1717.33 1706.73 1709.93	1711.33	6.74	57.04	62.89
5	White Guinea Corn	890.20 883.33 873.67	882.40	2104.37 2111.24 2120.90	2112.17	0.181	70.00	77.80
6	Red Guinea Corn	976.32 980.00 972.82	976.38	2014.23 2024.57 2015.73	2018.17	0.18	67.21	74.33

Table 2.Results of Effects of 4- Blades Assembly on Weight of Dry Residue, Weight of Milled Starch/Milk Percentage Loss and Blending Efficiency

S/NO.	*Type of Grain*	*Weight of Dry Residue (g)*	*Ave. Weight of Dry Residue (g)*	*Weight of Milled Starch/Milk (g)*	*Ave. Weight of Milled Starch/Mi*	*Percentage Loss (%)*	*Blending Efficiency (%)*	*Consistency Efficiency (%)*
1	Dehulled White Maize	945.30 942.45 937.47	941.74	2050.27 2053.12 2058.10	2253.83	0.14	68.46	77.18
2	Dehulled Yellow Maize (pop	1685.30 1690.70 1696.76	1690.92	1310.22 1304.82 1398.76	1304.60	0.14	43.49	48.32
3	Soy Bean 'A'	1200.35 1196.66 1198.40	1198.47	1597.35 1501.04 1599.30	1599.23	6.74	53.31	58.77
4	Soy Bean 'B'	1263.65 1270.33 1257.31	1264.10	1534.35 1527.42 1540.44	1534.07	6.73	51.14	56.38
5	White Guinea Corn	1490.45 1495.30 1501.26	1416.70	1804.15 1799.30 1793.35	1798.93	0.18	59.96	67.40
6	Red Guinea Corn	1390.35 1389.40 1385.21	1388.32	1604.17 1605.12 1609.31	1606.20	0.182	53.54	59.16

Table 3.Results of Effects of 2- Blades Assembly on Weight of Dry Residue, Weight of Milled Starch/Milk Percentage

S/NO.	*Type of Grain*	*Weight of Dry Residue (g)*	*Ave. Weight of Dry Residue (g)*	*Weight of Milled Starch/Milk (g)*	*Ave. Weight of Milled Starch/Milk (g)*	*Percentage Loss (%)*	*Blending Efficiency (%)*	*Consistency Efficiency (%)*
1	Dehulled White Maize	940.30 950.33 954.60	948.41	2055.34 2045.31 2041.04	2047.28	0.15	68.23	76.93
2	Dehulled Yellow Maize (pop	1718.45 1720.34 1722.08	1720.29	1277.14 1275.25 1273.51	1275.30	0.147	42.51	47.23

3	Soy Bean 'A'	1227.35 1222.30 1217.16	1222.27	1570.35 1575.40 1580.54	1575.43	6.77	52.51	57.89
4	Soy Bean 'B'	1385.90 1383.40 1388.52	1386.00	1408.84 1408.34 1409.22	1411.80	6.84	47.06	51.89
5	White Guinea Corn	1315.60 1313.65 1311.46	1313.57	1679.20 1681.15 1683.34	1681.23	0.173	55.98	61.92
6	Red Guinea Corn	1625.33 1616.35 1613.31	1618.33	1369.47 1378.45 1381.49	1376.47	0.17	45.88	49.65

Table 4.The Effect of Wheel Blade Type on Blending Efficiency, Quantity of Dry Residue and Milled Starch/Milk

S/NO	*Type of Grain*	*Weight of Dry Residue (g)*	*Ave. Weight of Dry Residue (g)*	*Weight of Milled Starch/Milk (g)*	*Ave. Weight of Milled Starch/Milk (g)*	*Percentage Loss (%)*	*Blending Efficiency (%)*	*Consistency (%)*
1	Dehulled White Maize	2395.50 2397.35 2384.71	2392.52	600.15 598.30 610.94	604.27	0.48	20.12	22.71
2	Dehulled Yellow Maize (pop corn)	2710.00 2713.44 2723.36	2715.60	285.63 282.19 272.27	280.03	0.48	09.32	10.37
3	Soy Bean 'A'	2278.42 2280.50 2281.92	2280.28	519.26 517.18 515.76	517.40	7.08	17.22	19.02
4	Soy Bean 'B'	2390.30 2388.45 2380.45	2386.40	407.25 409.25 417.25	611.70	7.08	13.71	15.13
5	White Guinea Corn	2686.80 2685.55 2687.18	2686.51	307.98 309.23 307.60	308.27	0.50	10.27	11.35
6	Red Guinea Corn	2700.43 2708.20 2714.08	2707.57	294.37 286.60 280.72	287.23	0.50	09.57	10.58

CONCLUSION

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

1. The machine blending efficiency was found to be 78.23% when dehulled white maize (soaked for 36 hours) was processed with blending speed of 1300 r.p.m for 600 seconds using horizontal-vertical blade assembly.
2. Horizontal-vertical blade assembly produced the highest efficiency for all grains under study.
3. The quantity of the residue for animal feed formulation can be varied depending on the operation desire. High quantity of residue can be obtained from the machine by selecting blade with smaller cutting surface.
4. The higher the blending effect of blade the lesser the quantity of residue produced.

REFERENCES

Adejuitan, J., & Adelakun, O. (2007). Evaluating the Quality Characteristics of Kunu Produced from Dry-Milled Sorghum. *African Journal of Biotechnology, 7*(13), 2244-2247.

Adelekan, A., & Oyewole, O. (2010). Production of Ogi from Germinated Sorghum Supplemented with Soybean. *African Journal of Biotechnology, 9*(42), 7114-7121.

Bogue, J., & Sorenson, D. (2008). *Marketing of Gluten-free Cereals and Beverages.*: Elsevier Inc, New York,.

Bridson, R. H., Robbins, P. T., Chen, Y., Westerman, D., Gillham, C. R., Roche, T. C., & Seville, J. P. K. (2007). The effects of high shear blending on α-lactose monohydrate. *International Journal of Pharmaceutics, 339*(1–2), 84-90. doi: 10.1016/j.ijpharm.2007.02.022

Gaffa, T., Jideani, I. A., & Nkama, I. (2003). Traditional Production, Consumption and Storage of Kunu-a non Alcoholic Cereal Beverage. *Journal of Plant Foods for Human Nutrition., 57*(1), 73-81.

Gana, I. M. (2011). Development and Testing of Grains Drink Processing Machine. *Thesis for the Award of Masters Degree in the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Nigeria.*

Gao, Y., Ierapetritou, M., & Muzzio, F. (2011). Investigation on the effect of blade patterns on continuous solid mixing performance. *The Canadian Journal of Chemical Engineering, 89*(5), 969-984. doi: 10.1002/cjce.20530

Liu, K. (1997). Soybeans: Chemistry, Technology and Utilization. *Gaihtersburg, Md: Aspen Publishers. ISBN 0-3842-1299-4.*

Liu, L., Herald, T. J., Wang, D., Wilson, J. D., Bean, S. R., & Aramouni, F. M. (2012). Characterization of sorghum grain and evaluation of sorghum flour in a Chinese egg noodle system. *Journal of Cereal Science, 55*(1), 31-36. doi: 10.1016/j.jcs.2011.09.007

McGee, H. (2004). On Food and Cooking: The sciences and Lore of the Kitchen, Completely Revised and Updated. New York, NY., 13.

Pomeraz, Y. (1991). Functional Properties of Food Components. 2nd ed. California Academic Press, Inc. USA.

Smith, D. (2011). How to make your own Rice Milk. *www.ehow.com/how_4846889_own-rice-milk html. Retrieved 23/3/2012.*

Wagner, D. H., Ramanathan, S., Taylor, M. L., Brown, A. B., Staben Wobker, M. E., & Prior, M. W. (2009). The thermodynamics of high shear blending. *Powder Technology, 193*(2), 195-199. doi: 10.1016/j.powtec.2009.03.020

www.en/wiki/soybean. (2010). Retrieved May 10, 2010.