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Design and Construction of a Hand Operated Mixer Machine for Food Fortification

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Abstract - *Lack of knowledge on balance diet and poverty have contributed to the rise in malnourishment in children and pregnant women in developing countries. Many people in Africa, especially Ghana take in maize flour as their main food. This food can be fortify with highly concentrated vitamins and minerals food (premix) to increase its micronutrient. A low cost technology of a mixer machine was constructed to homogenously mix the premix (Super cereal Plus) together with maize flour of ratio 0.00525:15 kg respectively. The design steps were systematically analyzed to generate the correct data for the final construction of the Hand operated mixer machine. Fortification processes was completed with the mixer machine to ascertain it efficiency. The reading recorded by the Chroma Meter shows that the machine was efficient at 300 to 360 revolution of the crank lever.*

Key Words: **Mixer machine, Malnourishment, Premix, Fortification, Maize flour**

1. INTRODUCTION

Malnourishment are among the challenges face by most developing countries such as Ghana (Muller and Krawinkel, 2005). Such challenges are controlled by enriching vitamins and mineral content of food for the malnourish children and pregnant women. Fortification process of mixing staple food with micro-nutrition food substance is forming an integral part in alleviating malnourishment. Fortification of food aid for vulnerable groups, particular young children, pregnant and lactating women was endorsed at the ICN in the World Plan of Action for Nutrition recommend that "donor countries must ensure that the nutrient content of food used in emergency food aid meets the nutritional requirements if necessary through fortification, or ultimately supplementation" (FAO/WHO, 1992a).

Following this recommendation, Ghana Health Service (GHS) in an inception assessment appraisal, adopted macronutrient premix (Maize Cereal Plus), available in sachets to be mixed with maize flour. However, high concentration of forticant in the food provides high risk to the consumer. On like zinc fortification, excessive iodine can cause iodine-induced hyperthyroidism (IIH) and iodine-induced thyroiditis, and that of Vitamin A causes hypervitaminosis A and chronic, high intake and with time can result in toxic symptoms like liver damage, bone abnomalities and joint pain, alopecia, headaches, vomiting and skin desquamation. This mean that effective mixing of premix and maize flour is of great concern.

This research is to design and construct a hand operated mixer machine that will homogenously mix maize flour together with a high concentrated micro-nutrient substance (premix) of a required quantity. This technology should also be cost effective to a low income person.

2. MATERIAL AND METHODS

The findings through literature review from the internet, the library, and other related literatures, the basic principles of selecting the types and quantity of premix and the food carrier help to establish the technology needed for the analysis and evaluation of the conceptual designs before constructing the machine.

The testing processes was conducted by gradually following the processes of successful fortification, where the prepared premix was mixed together with the maize flour in the hand operated mixer machine. The primary readings was recorded with the Chroma meter and analyzed.

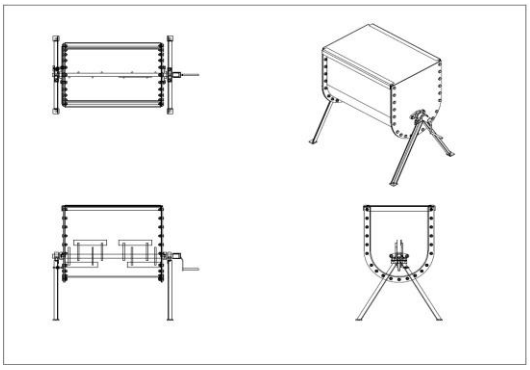
3. RESULT AND DISCUSSION

3.1 Developing Conceptual Designs

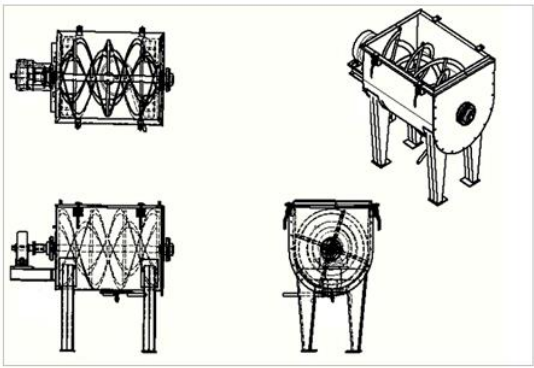
Conceptual designs of the mixer machine was established based on the construction and orientation of the paddle.

3.1.1 Design Concept A

The maize flour together with the premix in the 'U' housing is mixed by the rotational movement of the paddles. The paddles are well place and position on the crank lever to provide effective mixing and minimum clearance in 'U' housing. This arrangement promote homogenous mix of the food product (see Fig -1 Drawing "A").



Drawing "A"



Drawing "B"

Fig -1: Conceptual design drawings

3.1.2 Design Concept B

Design concept "B" is similar to that of design concept "A", however concept "B" paddles are more intricate and with better mixing abilities. The construction of such intricate paddle add to the manufacturing cost. Concept 'B' drawing in both isometric and orthographic views is shown in Fig -1 Drawing "B".

3.1.3 Concept Evaluation

The design concepts were evaluated on the criteria of cost, ease of manufacturing, ease of maintenance, and efficient mixing of maize flour. These criteria (objectives) for evaluation are ranked equally and hence have equal weight. The scores are tabulated in Table -1.

Table -1: Concept Score

CRITERIA FOR EVALUATION	SCORE CONCEPT "A"	SCORE CONCEPT "B"
COST	4	2
MANUFACTURABILITY	4	2
EASE OF MAINTENANCE	5	3
EFFICIENT MIXING	3	4

The overall total utility scores for concept A and B are 3.80 and 2.85 respectfully (see Table -2). Concept "A" scored the highest value and therefore stand to be the best for consideration. The design is more stable, the easy to design and construct.

Table -2: Decision Matrix for the Mixer Machine

Objective		Cost	Ease of Manufacturing	Ease of Maintenance	Efficient in Mixing	Overall Utility Value
Weight		0.3	0.2	0.15	0.35	
Parameter		Unit	Types of shape	Simplicity of service	Drudgery	
Mixer A	Magnitude	Low	Simple	Easy	Average	3.80
	Score	4	4	5	3	
	Value	1.20	0.80	0.75	1.05	
Mixer B	Magnitude	High	Complicated	Average	High	2.85
	Score	2	2	3	4	
	Value	0.60	0.40	0.45	1.40	

Define of Ranking

1. Numerical ranking start from poor (1) to excellent (5)
2. Weight was assigned
3. Each design was summed-up
4. The high overall score or the utility score indicate favorable design.

3.2 Design Calculation

The design calculation was systematically followed to ensure correct sizing of the various part are selected to control the cost and stability of the mixer machine. The volume of the 'U' housing was first and foremost calculated, followed by shaft diameter and crank lever.

3.2.1 Calculating for the 'U' housing Volume

Data

Under Ghana Health Service (GHS) recommendation on food fortification, a ratio of 0.0175:50 kg of premix-white maize flour was accepted. An average of 15 – 20 kg of maize was also determine to be an average maize flour consumed before the micro-nutrient are lost. The maize flour density 'ρ' is 0.45 g/cm^3.

Assume the diagram shown in Fig -2 is the size of the 'U' housing volume;

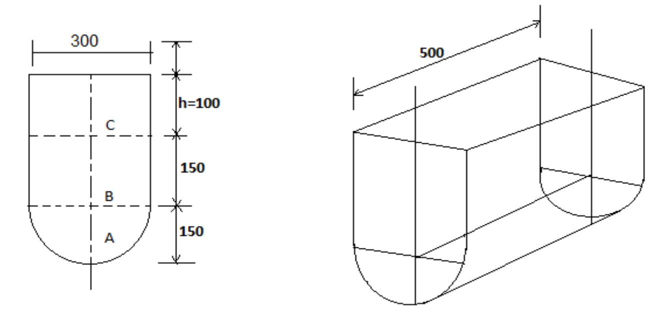


Fig -2: 'U' Housing

Then:

$$\text{Volume 'v'} = \frac{\text{Mass 'm'}}{\text{density '}\rho\text{'}}$$

$$\text{Area } A_A = \frac{1}{2}\left(\frac{\Pi d^2}{4}\right) = \frac{1}{2}\left(\frac{\Pi \times 300^2}{4}\right) = 35342.92\,\text{mm}^2$$

$$\text{Area } A_B = 300 \times 3150 = 45000\,\text{mm}^2$$

$$\text{Total area} \quad A_T = A_A + B_B = 35342.92 + 45000 = 80342.92\ \text{mm}^2$$

$$\text{Volume '}\nu\text{'} = A_T \times L = 8034.92 \times 500 = 40171460\,\text{mm}^3$$

But

$$\text{Density '}\rho\text{'} = 0.45\frac{\text{g}}{\text{cm}^3} = 0.45 \times 10^{-6}\ \text{kg/mm}^3$$

$$\text{Mass 'm'} = \text{volume } (\nu) \times \text{density } (\rho) = 40171460 \times 0.45 \times 10^{-6} = 18.077\,\text{kg}$$

Since the mass (m) falls within the accepted limits of 15 – 20 kg for a house hold consumption, then the design size is acceptable.

Now, adding $1/3$ allowance for the volume.

$$\text{Area } A_C = \tfrac{1}{3} A_T . = . \tfrac{1}{3} \times 80342.92 = 26780.97.mm^2$$

Keeping the size of width, 300 mm and finding the height 'h' of Area C. Height 'h' is calculated to be 89.27 approximately about 100 mm.

3.2.2 Calculating for the Shaft Diameter

Data

The selected stainless steel for the construction of the mixer machine is 304L type with the following mechanical properties:

Ultimate tensile stress	δ_{ut}= 586Mpa
Ultimate shear stress	τ_s= 0.75δ_{ut}
Weight of flour	W_f = 15kg
Weight of 'U' housing of the flour	W_u = 15kg
Weight of baffles	W_b = 1.6kg
Weight of crank lever	W_c = 1.9kg

Assuming the maximum force to operate the crank lever with a handle length of 150 mm is 200 N (Gupta, 2010) and considering Factor of safety to be four (4); then, *Solving for Working or Design Stresses*

Given:

Ultimate tensile stress $\delta_{UT} = 586\,\text{MPa}$

Ultimate shear stress $\tau_s = 0.75\,\delta_{ut} = 0.75 \times 586 \times 10^{-6} = 439.5\,\text{MPa}$

Working or design stress

$$\delta_D = \frac{\textit{Ultimate tensile stress}}{\textit{foS}} = \frac{586}{4} = 146.5\ \text{N}/\text{mm}^2$$

Working or design strain

$$\tau_D = \frac{\textit{Ultimate. shear stress}}{\textit{foS}} = \frac{349.5}{4} = 109.875\ \text{N}/\text{mm}^2$$

Maximum torque acting on the shaft

$$T = Fr = 200 \times \frac{150}{1000} = 30\ \text{Nm}$$

Assuming 15 kg of maize flour, then, the weight to be mixed is 15 kg then the weight will equal 147.15 N.

Forces Acting On the Shaft

Fig -3 shows the forces that act on the entire shaft. The concentrated load at ‘B’ is an equivalent of the uniform distributed load (maize flour) of b’-b’.

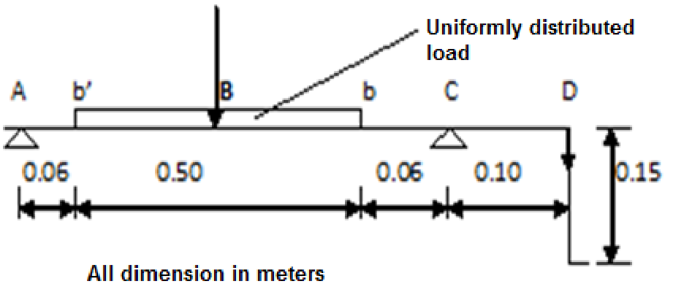
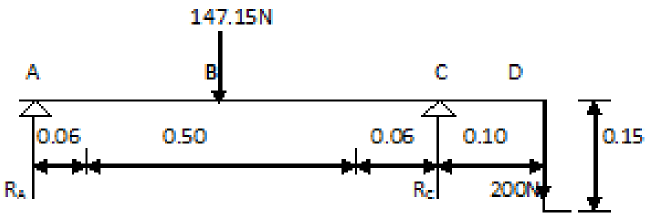


Fig -3: Forces acting on shaft

Horizontal Forces Acting On the Shaft



Taking moment about A

$$\sum M_{RA} = 0 = [-(Rc \times 0.62) + (147.15 \times 0.31) + (200 \times 0.72)]$$

$$0.62\, R_C = 45.617 + 144$$

$$R_C = 305.83\,N$$

$$\sum F = 0 = [147.15 + 200 - 305.83 - R_A] = 0$$

$$R_A = 41.316\ N$$

Obtaining Maximum Horizontal Moment

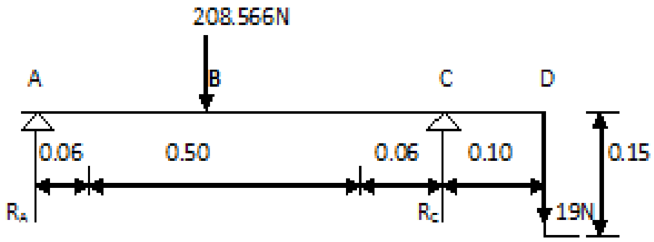
$$\text{BM at A, } M_{AH} = 0$$

$$\text{BM at B, } M_{BH} = (41.316 \times 0.31) - (147.15 \times 0) = 12.808\,Nm$$

$$\text{BM at C, } M_{CH} = (41.316 \times 0.62) - (147.15 \times 0.31) + (305.83 \times 0) = -20\,Nm$$

$$\text{BM at D, } M_{DH} = (41.316 \times 0.72) - (147.15 \times 0.41) + (305.83 \times 0.1) - (200 \times 0) = 0$$

Vertical Forces Acting On the Shaft



Taking moment about A

$$\sum MR_A = 0 = [-(R_C \times 0.62) + (208.566 \times 0.31) + (19 \times 0.72)]$$

$$0.62\, R_C = 64.655 + 13.68$$

$$R_C = 126.35\,N$$

$$\sum F_{RA} = 0 = [208.566 + 19 - 126.35 - R_A] = 0$$

$$R_A = 101.22\,N$$

Obtaining maximum bending moment

$$\text{BM at A, } M_{AV} = 0$$

$$\text{BM at B, } M_{BV} = (101.22 \times 0.31) - (208.566 \times 0) = 31.38\,Nm$$

$$\text{BM at C, } M_{CV} = (101.22 \times 0.62) - (208.566 \times 0.31) + (126.35 \times 0) = -1.9\,Nm$$

$$\text{BM at D, } M_{DV} = (101.22 \times 0.72) - (208.566 \times 0.41) + (126.35 \times 0.1) = 0$$

Resultant Moment at Various Points

The resultant moment at B

$$M_B = \sqrt{12.808^2 + 31.38^2} = 33.89\,Nm$$

And resultant moment at C

$$M_C = \sqrt{(-20)^2 + (-19)^2} = 20.09\,Nm$$

The Maximum Resultant Moment is at B (see APPENDIX A), which is $M_B = 33.89$ or 34 Nm

Let 'd' = diameter of the shaft equivalent

The twisting moment:

$$T_e = \sqrt{M^2 + T^2} = \sqrt{34^2 + 30^2} = \sqrt{2056} = 45.34 \text{ Nm}$$
$$= 45.34 \times 10^3 \text{ Nmm}$$

But

$$T_e = \frac{\Pi}{16} \times \tau \times D^3$$
$$45.34 \times 10^3 = \frac{\Pi}{16} \times 109.875 \times d^3$$
$$d = \sqrt[3]{2206.36} = 12.81 \text{ mm}$$

The Bending Stress

$$M_e = \frac{1}{2}(M + \sqrt{M^2 + T^2}) = \frac{1}{2}(34 + \sqrt{34^2 + 30^2})$$
$$= \frac{1}{2}(34 + 45.34) = 39.67 \times 10^3 \text{ Nmm}$$

But

$$M_e = \frac{\Pi}{32} \times \delta_D \times d^3$$
$$39.67 \times 10^3 = \frac{\Pi}{32} \times 146.5 \times d^3$$
$$d = \sqrt[3]{2758.69} = 14.03 \text{ mm}$$

For safe operation of the mixer machine the larger diameter of the shaft must be considered, where shaft diameter **'d' = 14.328 mm**, say **20 mm.** Therefore the shaft diameter that has to be used in the construction of the mixer machine should be approximately **Ø20 mm**

3.2.3 Design of the Crank Lever

Assuming mild steel of type 1090 was used for the crank lever (Fig -4), the maximum length of the lever arm on which a force of 200N is to be applied is 150 mm and designing the lever arm for 25% more bending moment, according to Gupta (2010), then;

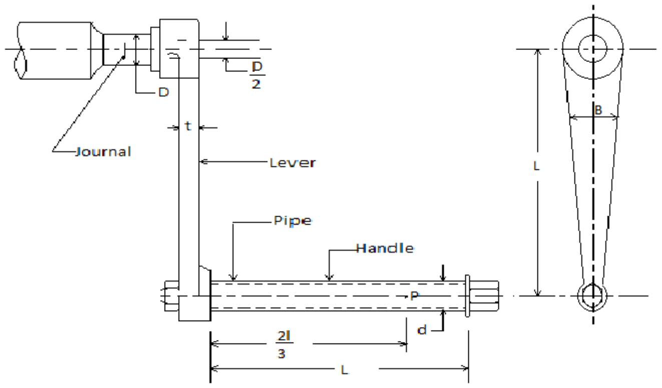


Fig -4: Crank lever

Data

A cranked lever has the following dimensions:

Length of the handle	l = 130 mm
Length of the lever arm	L = 150 mm
Overhang of the journal	x = 50 mm
Force	P = 200 N
The banding stress	δ_{UT} = 400 MPa
Ultimate shear stress	$\tau_S = 0.75\,\delta_{UT}$ MPA

Working or design stress;

$$\delta_D = \frac{\textit{Ultimate bending stress}}{\textit{foS}} = \frac{410}{4} = 102.5 \text{ N/mm}^2$$

Working or design strain;

$$\tau_D = \frac{\textit{Ultimate. shear stress}}{\textit{foS}} = \frac{0.75 \times 410}{4} = 76.875 \text{ N/mm}^2$$

Calculating the Diameter of the Handle

Let d = diameter of the handle in mm.

Since the force applied acts at a distance 1/3 length of the handle from its free end, then the maximum bending moment,

$$M = \left(1 - \frac{1}{3}\right) P \times l = \frac{2}{3} \times 200 \times 130 = 17.33 \times 10^3 \text{ Nmm} \quad \text{.......... (i)}$$

Section modulus, $Z = \frac{\Pi}{32} \times d^3 = 0.0982 d^3$

Therefore, resisting bending moment;

$$M = \sigma_b \times Z = 102.5 \times 0.0982 d^3 = 10.0655 d^3 \text{ Nmm} \quad \text{................. (ii)}$$

From equations (i) and (ii);

$$d^3 = \frac{17.33 \times 10^3}{10.0655} = 1721.723$$

$$d = \sqrt[3]{1721.723} = 11.985 \text{ or } 12 \text{ mm say } 15 \text{ mm}$$

Calculating the Cross-section of the Lever Arm

Let 't' = thickness of the lever arm in mm, and

'B' = width of the lever arm near the boss, in mm.

Since the lever arm is designed for 25% more bending moment, then the maximum bending moment, M;

$$M = 1.25\,P \times L = 1.25 \times 200 \times 150 = 37.5 \times 10^3 \text{ Nmm}$$

Section modulus,

$$Z = \frac{1}{6} \times t \times B^2 = \frac{1}{6} \times t \times (2t)^2 = 0.667\,t^3 \quad \text{.... (assuming } B = 2t)$$

We know that bending stress (σ_b),

$$102.5 = \frac{M}{Z} = \frac{37.5 \times 10^3}{0.667 t^3} = \frac{56.22 \times 10^3}{t^3}$$

$$t = \sqrt[3]{554.324} = 8.215 \quad \text{say } 10 \text{ mm}$$

and $B = 2t = 2 \times 10 = 20 \text{ mm}$

Then the Bending moment on the lever arm near the boss (assuming that the length of the arm extends up to the centre of the shaft) is given by

$$M = P \times L = 200 \times 150 = 30 \times 10^3 \text{ Nmm}$$

and the section modulus,

$$Z = \frac{1}{6} \times t \times B^2 = \frac{1}{6} \times 10\,(20)^2 = 666.67 \text{ mm}^3$$

Therefore, induced bending stress;

$$\sigma_b = \frac{M}{Z} = \frac{30 \times 10^3}{666.67} = 45 \text{ N/mm}^2 = 45 \text{ MPa}$$

The induced bending stress is within safe limits of operation.

We know that the twisting moment,

$$T = \frac{2}{3} \times P \times l = \frac{2}{3} \times 200 \times 130 = 17.33 \times 10^3 \text{ Nmm}$$

And the twisting stress (T),

$$17.33 \times 10^3 = \frac{2}{9} \times B \times t^2 \times \tau = \frac{2}{9} \times 20\,(10)^2\,\tau = 444.44\tau$$

$$\tau = 17.33 \times \frac{10^3}{444.44} = \frac{39 \text{ N}}{\text{mm}^2} = 39 \text{ MPa}$$

The induce shear stress is also within limits.

Checking the cross-section of lever arm for maximum principal or shear stress.

Maximum principal stress,

$$\sigma_{b(\max)} = \frac{1}{2}\left[\sigma_b + \sqrt{(\sigma_b)^2 + 4t^2}\right] = \frac{1}{2}\left[45 + \sqrt{(45)^2 + 4(39)^2}\right]$$

$$= \frac{1}{2}(45 + 90.05) = 67.5 \text{ N/mm} = 67.5 \text{ MPa}$$

and maximum shear strain

$$\tau_{\max} = \frac{1}{2}\sqrt{(\sigma_b)^2 + 4t^2} = \frac{1}{2}\sqrt{(45)^2 + 4(39)^2} = 45 \text{ N/mm}^2$$

$$= 45 \text{ MPa}$$

The maximum principle and shear stress are also within safe limits of operation.

Diameter of the journal

Let D = diameter of the journal,

Since the journal of the shaft is subjected to twisting moment and bending moment, its diameter is obtain from equivalent twisting moment.

$$T_e = P\sqrt{\left(\frac{2l}{3} + X\right)^2 + L^2} = 200\sqrt{\left(\frac{2 \times 130}{3} + 50\right)^2 + (150)^2}$$

$$= 40.585 \times 10^3 \text{ N/mm}^2$$

And to calculate for the diameter of the journal, the equivalent twisting moment (T_e)

$$40.585 \times 10^3 = \frac{\Pi}{16} \times \tau \times D^3 = \frac{\Pi}{16} \times 76.875 \times D^3 = 15.094 D^3$$

$$D = 13.905, \quad \text{say } 14 \text{ mm}$$

The final design values and drawings were used to construct the mixer machine for the food fortification (see Fig-5) and the cost analysis can be found in Appendix-C.

Fig-5: Hand Operated Mixer Machine.

Fig -7: Taking reading of food fortification

3.3 Testing the Machine

To test the homogenous mix of the mixer machine a recommended amount of premix and white maize flour of ratio of 0.0175:50 kg was considered. Consideration was also taken on the recommended estimated amount of food fortification (15 – 20 kg) by individual household before the micro-nutrient are lost. Therefore, a premix of 5.25 g was mixed with 15 kg white maize flour.

$$thus,\ a_{premix} = \left(\frac{0.0175}{50}\right) \times 15 = 0.00525 = 5.25g$$

The maize flour of 15 kg and a premix 5.25 g were both poured into the Hand Operated Mixer machine (Fig -6). After securing the cover lid on the 'U' chamber, the hand lever was turn to start the fortification process.

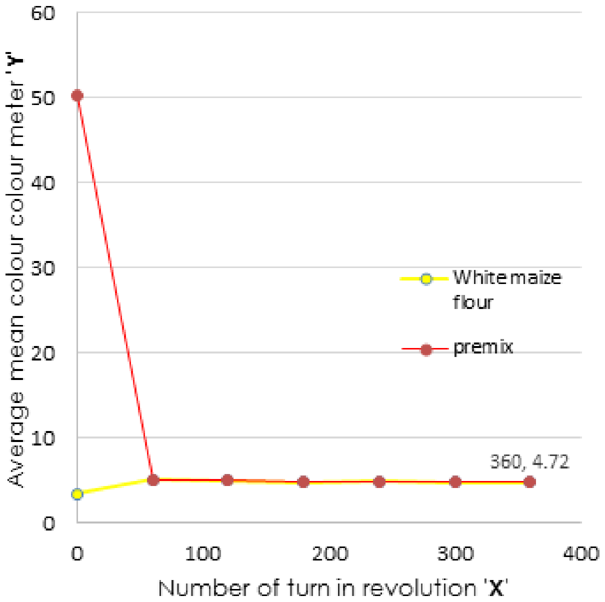
Fig -6: White maize flour and premix (powdered colour premix)

The based-colour of both white maize flour and premix were recorded using the Chroma Meter. After every 60 revolutions turns of the hand lever, random sample of the food fortification is collected and record (Fig -7) to ascertain the mixing level. The Chroma Meter readings of the fortificant is recorded in appendix B.

Table -3 gives the initial average mean colour readings of white maize flour and premix as 3.38 and 52.27 respectively. After 60 revolution of turn of the Hand Lever, an average random of the first mean colour reading was recorded as 5.04 (Graph -1). The premix colour later drop to about 1/10 of its initial mean colour whiles the white maize flour initial mean colour was increased by 49.11%. The percentage changes in gains and losses of mean colour of white maize flour and premix continues until the fifth (300 revolution) reading where it become insignificant. This stability continues until the sixth (360 revolutions) reading, where colour reading was absolutely insignificant. This gives an indication of a successful food fortification.

Table -3: Average Mean Colour Reading of Food Fortification.

Number of turn in revolution 'X'	Average Mean Colour Reading 'y'/ 0°	
	White maize flour	Premix
0	3.38	52.27
60	5.04	
120	4.96	
180	4.78	
240	4.82	
300	4.73	
360	4.72	

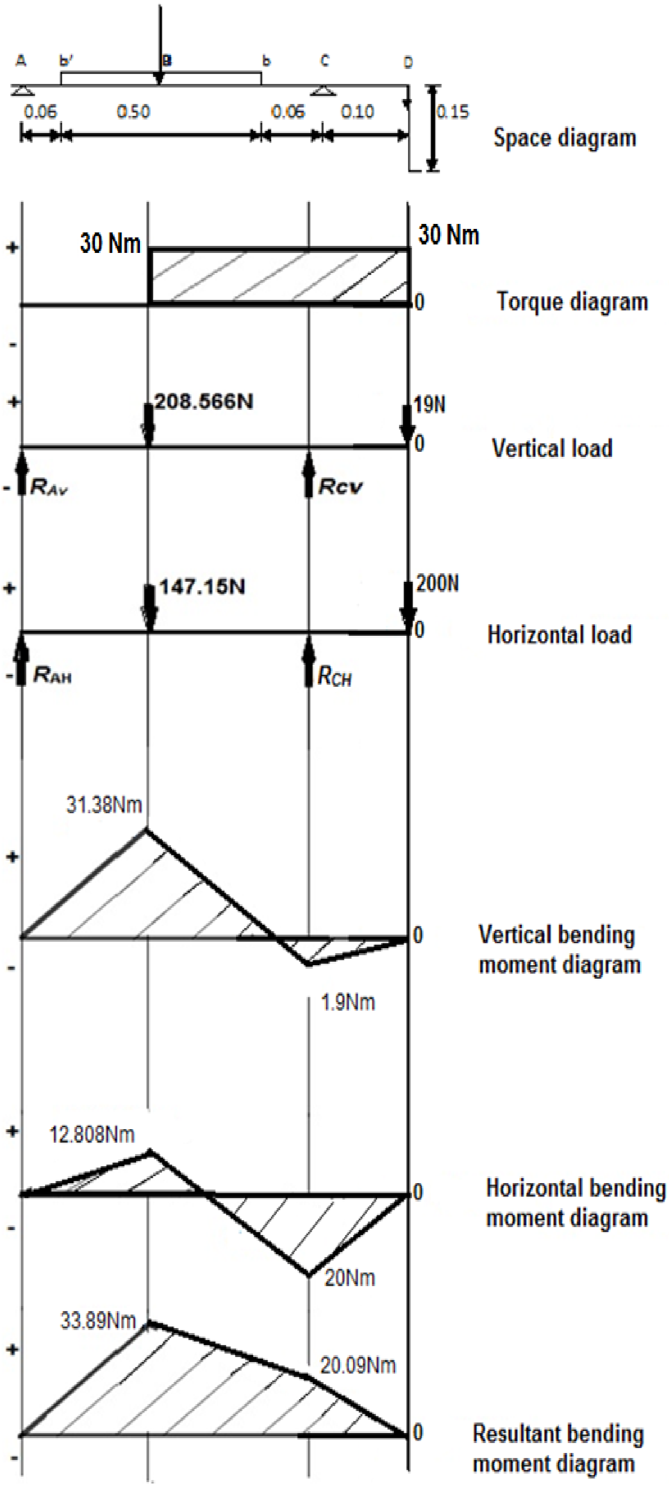


Graph -1: Number of Turn against Average Mean Colour Reading of Food Fortification

4. CONCLUSION

The mixing of the maize flour with premix (highly concentrated mineral and vitamins) to increase its vitamins and mineral content was successful. Though, a simple technology was used, the recorded data by the Chroma Meter indicates that homogeneous mixing was achieved. The challenge faced by malnourish children and pregnant women living in developing countries can therefore be minimized.

APPENDIX A: FORCES AND MOMENT DIAGRAM



***APPENDIX B*: AVERAGE MEAN COLOUR READINGS**

White maize flour based-colour

```
P00            7M 4D 23:26
001
L  92.71 a -0.35 b +3.39
002
L  92.57 a -0.36 b +3.41
003
L  92.44 a -0.38 b +3.29
004
L  92.53 a -0.39 b +3.39
005
L  92.51 a -0.40 b +3.40
- - - - - - - - - - - -
P00            7M 4D 23:26
 (n=  5)       7M 4D 23:28
MAX
L  92.71 a -0.35 b +3.41
MIN
L  92.44 a -0.40 b +3.29
MEAN
L  92.55 a -0.38 b +3.38
SD
L   0.10 a  0.02 b  0.05
```

Premix based-colour

```
P00            7M 4D 23:31
001
L  84.98 a +1.33 b+50.59
002
L  84.73 a +1.30 b+50.52
003
L  84.93 a +1.36 b+50.01
004
L  84.85 a +1.34 b+50.08
005
L  84.82 a +1.40 b+50.17
- - - - - - - - - - - -
P00            7M 4D 23:31
 (n=  5)       7M 4D 23:31
MAX
L  84.98 a +1.40 b+50.59
MIN
L  84.73 a +1.30 b+50.01
MEAN
L  84.86 a +1.35 b+50.27
SD
L   0.09 a  0.03 b  0.25
```

60 revolutions

```
P00            7M 4D 23:55
001
L  92.53 a -0.76 b +5.00
002
L  92.66 a -0.72 b +5.14
003
L  92.49 a -0.71 b +5.02
004
L  92.51 a -0.78 b +5.05
005
L  92.45 a -0.72 b +4.97
- - - - - - - - - - - -
P00            7M 4D 23:55
 (n=  5)       7M 4D 23:56
MAX
L  92.66 a -0.71 b +5.14
MIN
L  92.45 a -0.78 b +4.97
MEAN
L  92.53 a -0.74 b +5.04
SD
L   0.08 a  0.03 b  0.06
```

120 revolutions

```
006
L  92.48 a -0.70 b +4.87
007
L  92.50 a -0.67 b +4.83
008
L  92.56 a -0.76 b +5.01
009
L  92.43 a -0.75 b +4.82
010
L  92.48 a -0.72 b +4.87
- - - - - - - - - - - -
P00            7M 4D 23:55
 (n= 10)       7M 5D  0:02
MAX
L  92.66 a -0.67 b +5.14
MIN
L  92.43 a -0.78 b +4.82
MEAN
L  92.51 a -0.73 b +4.96
SD
L   0.06 a  0.03 b  0.10
```

180 revolutions

```
P00            7M 5D  0:08
001
L  92.57 a -0.67 b +4.75
002
L  92.53 a -0.68 b +4.78
003
L  92.50 a -0.68 b +4.80
004
L  92.43 a -0.69 b +4.77
005
L  92.45 a -0.78 b +4.81
- - - - - - - - - - - -
P00            7M 5D  0:08
 (n=  5)       7M 5D  0:09
MAX
L  92.57 a -0.67 b +4.81
MIN
L  92.43 a -0.78 b +4.75
MEAN
L  92.50 a -0.70 b +4.78
SD
L   0.05 a  0.04 b  0.02
```

240 revolutions

```
P00            7M 5D  0:15
001
L  92.39 a -0.77 b +4.88
002
L  92.41 a -0.67 b +4.82
003
L  92.53 a -0.65 b +4.82
004
L  92.58 a -0.67 b +4.83
005
L  92.32 a -0.65 b +4.76
- - - - - - - - - - - -
P00            7M 5D  0:15
 (n=  5)       7M 5D  0:15
MAX
L  92.58 a -0.65 b +4.88
MIN
L  92.32 a -0.77 b +4.76
MEAN
L  92.45 a -0.68 b +4.82
SD
L   0.10 a  0.05 b  0.04
```

300 revolutions

```
P00            7M 5D  0:21
001
L  92.50 a -0.68 b +4.71
002
L  92.51 a -0.65 b +4.66
003
L  92.39 a -0.79 b +4.83
004
L  92.32 a -0.74 b +4.76
005
L  92.40 a -0.71 b +4.68
- - - - - - - - - - - -
P00            7M 5D  0:21
 (n=  5)       7M 5D  0:22
MAX
L  92.51 a -0.65 b +4.83
MIN
L  92.32 a -0.79 b +4.66
MEAN
L  92.42 a -0.71 b +4.73
SD
L   0.08 a  0.05 b  0.06
```

360 revolutions

```
P00            7M 5D  0:32
001
L  92.32 a -0.74 b +4.75
002
L  92.18 a -0.78 b +4.79
003
L  92.11 a -0.69 b +4.69
004
L  92.08 a -0.66 b +4.69
005
L  92.03 a -0.72 b +4.69
- - - - - - - - - - - -
P00            7M 5D  0:32
 (n=  5)       7M 5D  0:32
MAX
L  92.32 a -0.66 b +4.79
MIN
L  92.03 a -0.78 b +4.69
MEAN
L  92.14 a -0.72 b +4.72
SD
L   0.11 a  0.04 b  0.04
```

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