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Staple Food Fortification for Malnourished Children and Pregnant Women in Northern Ghana

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***Abstract*—Most people in rural Africa and other developing countries take in food that is not sufficiently rich in nutrient. The reason for this deficiency is because of poverty, specifically lack of money to buy proper dietary food or ignorant in consuming the right nutritional food is of concerned. This phenomenon had led to many health problems such as anemia, night blindness, high maternal mortality rate, brain damage and the rest.**

Many people in Northern Ghana are deficient in micro-nutrient intake, particularly children and pregnant women. The quickest and cost effective way is through the fortification process. The White maize flour which is the staple food for people living in Northern Ghana can be increased by missing with a premix (Super cereal Plus). The fortification process was carried with a low cost technology of Hand Operated Mixer Machine. A 0.0175:50 kg premix-white maize flour was estimated to be the standard nutrition needed by malnourished children and pregnant women. Homogeneous of the food fortification was achieved with the Hand Operated Mixer Machine, however, attention must be given on modification of the machine, particularly for ease of operation and at a lower cost.

***Keywords*— Food Fortification, Malnourish children and pregnant women, Premix, White maize flour**

I. INTRODUCTION

Ghana is a West African nation on the Gulf of Guinea. There are marked climate, agro-ecological and economic disparities between the south, which has two rainy seasons, and the arid north, which has only one. In the north, climate change is contributing to increasingly erratic rainfall, and thus to desertification. As a result, in this region chronic poverty and food insecurity are widespread. Thirty percent of children living this region under the age of five are stunted or chronically malnourished, affecting their growth and educational development. In the Upper East Region, nearly thirty percent of people do not have adequate access to food, compared to a national average of five percent.

Fortification of food aid for vulnerable groups, in 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 batches of maize flour. The ratio of 0.017.5:50 kg premix-white maize flour was mixed together to provide the necessary minerals and vitamins needed by the malnourished children and pregnant women. It was also estimated that approximately 15 to 20 kg of maize flour can be consumed within a limited time to ensure that the micronutrients are preserved in the food. The objective of this publication is to fortify the staple food using using low cost technology of manually Hand Operated Mixer Machine.

A. Background of the Northern Region of Ghana

Northern Ghana (Fig. 1) comprises the three northernmost administrative regions of Ghana: the Upper West Region, Upper East Region and Northern Region. These lie roughly north of the Lower Black Volta River, which together with its tributaries the White and Red Voltas and the Oti and Daka rivers, drain the area that comprises Northern Ghana. Northern Ghana shares international boundaries with the Burkina Faso to the North, Togo to the east and Cote D'Ivoire to the lower southwest. To the south Northern Ghana shares regional boundaries with the Brong Ahafo Region and the Volta Region.

Much of Northern Ghana falls within the savannah vegetation belt. Rainfall is modest in many parts of the area and allows for the cultivation of cereal crops and legumes. Agriculture and agro-based industries still remain the main stay of the peoples of this zone. Varieties of millet and sorghum as well as rice are cultivated. Northern Ghana is much drier than southern areas of Ghana, due to its proximity to the Sahel, and the Sahara. The vegetation consists predominantly of grassland, especially savanna with clusters of drought-resistant trees such as baobabs or acacias. The hot Harmattan wind from the Sahara normally blows between December and the beginning of February. The temperatures can vary between 14 °C (59 °F) at night and 40 °C (104 °F) during the day.

Northern Ghana has a lot of natural resources which include, tourist attraction sites, typical traditional dances, bee keeping and wonderful cultural activities. However, the available natural resources are not tapped and used to develop people in the Region.

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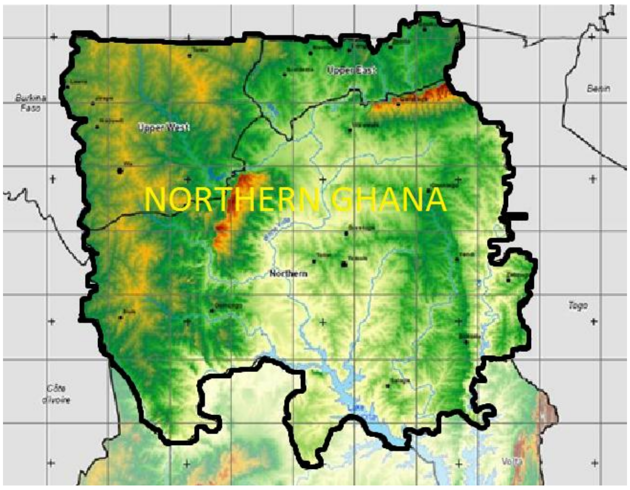

Fig. 1: Northern Ghana (Northern, Upper East and Upper West)

B. Demographic Profile

Northern Ghana has a low density, and along with the official language of English most inhabitants (52%) speak a language of the Oti–Volta subfamily in the Niger–Congo languages.

Historically, Northern part of Ghana has been noted for its traditionally and rich culture that has been evidenced by masses of visitors and tourists. The population as of 2010 by Ghana Statistical Service (GSS) of the Regions was 4216658.689, representing a total of 17.1% of Ghana's population.

II. MATERIALS AND METHODS

The main methods used for this project was to determine the homogenous mix of premix and white maize flour using a hand operated mixer machine. With the 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 was established.

Application of the mixing steps was gradually followed to provide successful fortification process. Where the prepared premix was mixed together with the white maize flour in a manually hand operated mixer machine. The primary data for analysis was obtained using the colour metre.

III. RESULT AND DISCUSSION

Food fortification has been defined as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups (FAO/WHO 1994). The 1992 ICN conference held in Rome emphasised the importance of food based activities in their plan of action geared at addressing the issue of micronutrient malnutrition (FAO/WHO, 1992) facing developing countries in the world. Food fortification is one of the relevant modes of action. Advantages of food fortification relative to other modes of intervention have been widely noted and a result of these is that fortification programmes can be implemented and yield results within a short period (Austin et al., 1981; Arroyave, 1987; INACG, 1990; Mannar, 1991; Nestel, 1993). The focus of the international community has so far been on the three most prevalent deficiencies: vitamin A, iodine and iron. There considerable steps in the implementation of a food fortification programme in developing countries is to identified the need for nutritional intervention on behalf of a population or a sub-group thereof and the required levels of fortification, identification of a suitable carrier, select appropriate fortificants, determine the technologies to be used in the fortification process and put in place the mechanism of ensuring of that the nutritional objectives of the programme are met.

A. Identification of Nutritional Need

Nutrition Surveillance System (NSS) surveys conducted by the Ghana Health Service (GHS) with support from UNICEF between June and November, 2013 indicated that malnutrition cases were increasing among children under five in Northern Ghana. According to Mrs Gloria Nyam Gyang, the Multiple Indicator Cluster Survey (MICS) conducted in 2011 also indicated that, of the total population of children under five years in the Northern Region, 136,902 (37.4 per cent) were stunted, 83,584 were underweight and 29,650 (8.1 per cent) were wasted.

The phenomena to this malnutrition is due to the fact that cereal grain which is mostly consume by the people is mill before consumption. During the milling process a substantial proportion of the nutrients are lost from the refined product. The fortification/enrichment of cereal grains is one valid reason is to restore to refined products, nutrients which have been removed during the milling process (Clarke, 1995).

Malnutrition is a major public health and development concern in poor communities. (Van de Poel, 2007). People at the poor religions are venerable to be malnutrition of which Northern Ghana is not an exception.

B. Required Level of Fortification

Deficiencies in iron, iodine, vitamin A and zinc are still major public health problems in developing countries (Dexter 1995). Malnourishment is a major health problem in developing countries (Muller and Krawinkel, 2005). This is bally concerned as it affect pregnant women and young children, leaving them with diseases such as anemia, kwashiorkor, marasmus, brain damage and other. To combat this catastrophe, a complimentary food (fortification food) is the best and quickest method to embrace. 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 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.

According to Ghana Health Service (GHS) a proportion of 0.017.5:50 kg premix-white maize flour was to be mix together to provide the necessary minerals and vitamins needed by malnourished children and pregnant women.

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C. Identification of Carrier

The selection of adequate micronutrient mixture is key for fortification processes. It is important to select a mixture of micronutrients, especially regarding iron, that is well absorbed and at the same time does not change the organoleptic characteristics of the fortified maize flour. The bioavailability of nutrients remaining after the processes of corn milling is not discuss in this publication

Research indicates that cereal food is mostly consumed by the developing countries, on average, cereals provide 52% of caloric intake globally with Africans representing 60-75% (Bauernfeind and DeRitter, 1991). It further stated that, developing countries consumed 95% of cereals as a dietary staple which also provide approximately 47% of the per capita protein intake.

Fortification of maize flour with fortificant is a cost-effective, food-based approach that should be regarded as part of a broader, integrated initiative to prevent micronutrient malnutrition, complementing other efforts to improve micronutrient status. Maize flour or dry maize products with 13% of moisture are very stable and can be fortified with a powdered premix (fortificant) composed of appropriate vitamins and minerals. All these key factors make maize flour the ideal for food fortification

D. Selection of Premix

The report from World Health Organization and Food and Agriculture Organization (WHO/FAO, 2006) indicates that vitamin A, iodine and iron are the most prevalent deficiencies in the developing country. Ghana Health Service (GHS) in collaboration with World Food Program (WFP) accepted the 'Super Cereal Plus' as having the right micro-nutrient to be used to alleviate the pandemic that malnutrition bring to Children and pregnant women.

The selection of the premix was based on the fact that the following factors are meet;

1) Most of the people in the northern Ghana live as large household and consumed maize flour in large quantity (Sunny Kim and Wilma Freire, 2003).
2) White maize flour is the staple food for the consumers. E.g. Tuozaaf, popularly known as TZ.
3) Maize floor is centrally processed by a household and therefore quality can be controlled by the family members (Lindsay Allen, *et al*, 2006).
4) Ease of mixing of premix (fortificant) and maize flour with low cost technology.
5) Ability to consume food within a short period of time to ensure micronutrients are not lost.

E. Technology Used In Fortification Process

The technology to be used for the fortification process must allow the premix and maize flour to be relatively mixed with ease and at a lower cost. The food fortification must be homogenous and safe for consumption.

F. Description of Mixer Machine

The Hand Operated Mixer Machine (Fig. 2) has a 'U' chamber (Stainless steel) which house the mixing product during the fortification process. The machine is supported by a central shaft that fits into the flange pillow bearings mounted on the 'L' angular supports. When the hand wheel is rotated, the permanently attached paddles on the central shaft equally rotates mixing the product in the 'U' chamber. The paddles are properly position on the central shaft to ensure close contact with the inner walls of the 'U' chamber. This arrangement provide homogeneous mix of the food fortification.

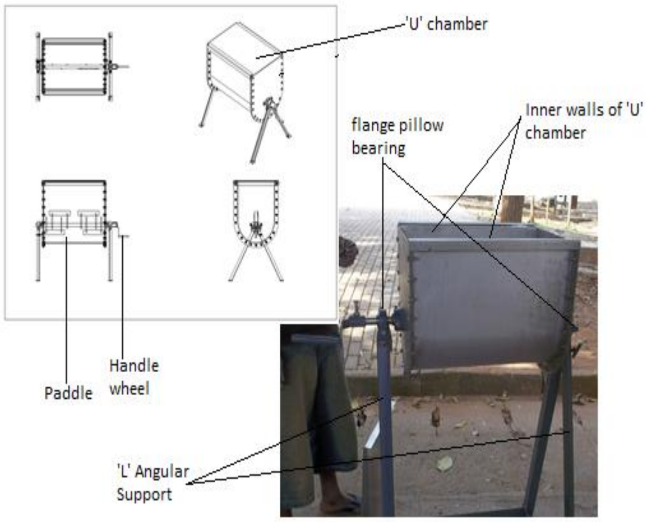

Fig. 2: Hand Operated Mixer Machine

1) Item Used in Premix Preparation

The following materials and equipment were used in the fortification process.

1. Chroma Meter (CR-310)
2. Minolta printer
3. Scale
4. Gallenkamp oven dryer
5. Blender
6. Trays
7. Egg yoke yellow powder
8. White maize flour
9. Super cereal Plus (premix)
10. Transparent disc container
11. Colour powder

Chroma Meters are compact, lightweight, portable tristimulus colorimeters for measuring reflected color and color difference in a wide range in determining maturity level of raw product in process food. The whole system is fully portable and can be used wherever the measurement subject is, indoors or outdoors, for on-the-spot color control. It has a measuring area of 50 mm diameter that measures substances and textured surfaces. A xenon arc lamp is used to illuminate the surface during the measurement.

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The Minolta printer displaces the digital reading of the result and print. The machine can stored up to 300 different measurements. The measurements are stored as absolute colour and colour difference.

Technical specifications

- Light Sourc: Xenon are lamp
- Measuringarea: Ø 50 mm
- Measuring system: wide-area illumination / 0 ° angle
- Dimensions CR-310 (W) x (D) x (H): 91 x 60 x 229 mm
- Dimensions DP-301 (W) x (D) x (H): 220 x 200 x 50 mm

2) Premix Preparation

For proper assessment of homogeneous mix of the food fortification using the Chroma Meter, one of the foods for the fortification must have a different based-colour. With this experiment the based-colour of the premix was changed to enable the colour meter ascertain the mixing effect of the food fortification using the Chroma Meter.

A 5.5g egg yoke was mixed together with colour powder and water. A 84.5g of white maize flour (substitute for Super Cereal Plus) was later added and mixed (Fig. 3). Water was supply at a required quantity to facilitate the mixing process. The colour powder added to the premix was to give it a conspicuous colour for the Chroma Meter to easily measure the mixing content of the food fortification.

Premix was dried in the Gallenkamp dryer for 30 minutes at a temperature of 60^{o}. The dry premix was later milled with the blender to give it that powdered characteristic.

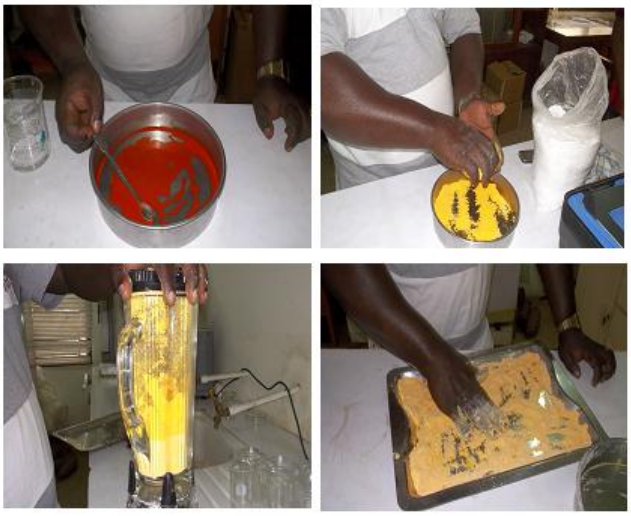


Fig. 3. Preparing the premix (Powdered colour premix)

3) Food Fortification

Under Ghana Health Service (GHS) recommendation on food fortification, a ratio of 0.0175:50 kg of premix-white maize flour was accepted. A 15 kg of maize was also determine to be an average maize flour consumed before the micro-nutrient are lost. Therefore the premix to be mixed with 15 kg white maize flour was estimated to be 5.25 g by calculation.

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

The maize flour of 15 kg and a premix 5.25 g were both poured into the Hand Operated Mixer machine (Fig. 4). After securing the cover lid on the ‘U’ chamber, the hand lever was turn to start the fortification process.

Fig. 4: White maize flour and premix (Powdered colour premix)

4) Taking Reading of Food Fortification

The based-colour of both white maize flour and premix were recorded using the Chroma Meter (Fig. 5). After every 60 revolutions turns of the hand lever, random sample of the food fortification is collected and record to ascertain the mixing level. Five samples were taken at different points using the transparent disc container. The collected samples are placed on the laboratory table and the based-colour recorded with the Chroma Meter and printed by Minolta printer. These fortification process, recording of food fortification based-colour and printing the readings were repeated for six (360 revolutions) consecutive times (see Appendix A).

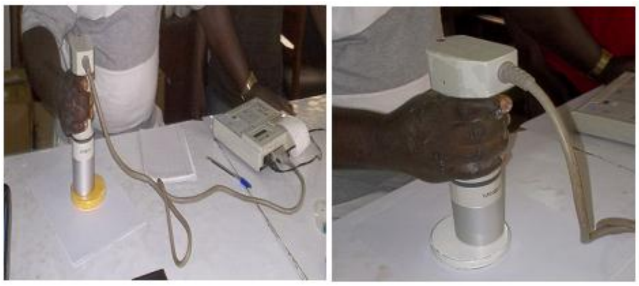


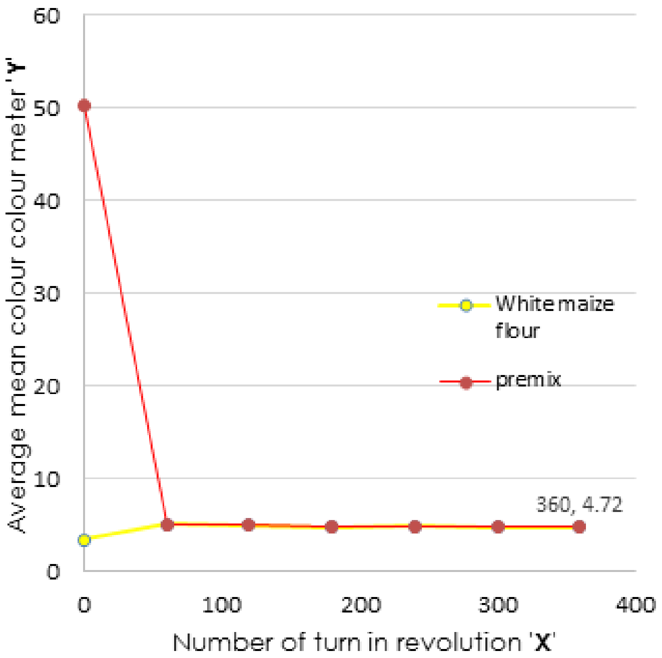
Fig 5. Taking initial colour of premix sample and white maize flour

Table I 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 Hand Lever, an average random of the first mean colour reading was recorded as 5.04 (Graph I). 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 homogeneous mix food fortification.

TABLE I. 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 I. NUMBER OF TURN AGAINST AVERAGE MEAN COLOUR READING OF FOOD FORTIFICATION



IV. CONCLUSION

The specific objective of fortifying staple food for malnourished children and pregnant women in Northern Ghana was successful. Though there was muscular work in the fortification process, the strength exhausted was within the means of 'average person'. The analysis of data indicates that homogeneous mixing with lower cost technology such as Hand Operation Mixer Machine with the help of Chroma Meter is possible.

ACKNOWLEDGMENT

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[16] Region is one of the regions in Ghana where the most typical tradition and rich culture are found (26/4/2016, 2.07 pm)

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APPENDIX A: 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+50.50
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 -0.70 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 -0.70 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
```