

## Original Research

# Quality Assessment of Blended NPK Fertilizers Available to Farmers in Enugu State, Nigeria: Evidence for Stronger Jurisdiction

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**ABSTRACT:** A survey was carried out to evaluate market and dealer characteristics that are likely to affect the quality of blended NPK 20:10:10 fertilizer products available to farmers in markets of major farming areas in Enugu State, Nigeria. In addition, the fertilizer bag weights, packaging and storage conditions and nutrient (NPK) contents were audited. Five markets (Orie Adani, Afor Obollo, Ogbete Enugu, Orie Agwu and Ogige Nsukka) were purposively sampled and three common blended NPK fertilizer brands namely: Federal, Ebonyi and Kano were identified. A qualitative visual coding of segregation, presence of filler materials, impurities, granule integrity and caking were made. The results of the nutrient analysis were compared with Manufacturers quoted grades and those Out of Compliance with the National Fertilizer Quality (Control) Act, 2019 (S.B 338) standards tolerance limits (TL) were identified. We found that all the fertilizers tested failed to meet the nutrient quality (20:10:10) claimed by the manufacturers. However, Federal had the highest quality potential grade (15:8:7), followed by Ebonyi (14:8:7), while Kano had the lowest (7:7:8). There was no problem with underweight bags and the likelihood of bags tearing or fertilizer getting wet was low. The average price per 50 kg bag was #27,000.00 for Federal, #21,500.00 for Ebonyi and #7,300.00 for Kano. Given the high cost, retailers resorted to breaking the bulk and selling it in 5 and 2.5 kg bags. Conclusively, there is evidence of diversity in nutrient percentages and dysfunctional markets characterized by little or no regulation.

**Keywords:** NPK fertilizer quality, Enugu State, regulation, market characteristics

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## INTRODUCTION

Fertilizer use is an ongoing farming practice, with major influence on environment, climate change, crop yields, farm earnings and subsequently, food security. According to report released by International Fertilizer Development Centre in collaboration with Fertilizer Technical Working Groups (FTWGs), apparent fertilizer consumption in Nigeria ranges from 892,794 metric tons in 2010 to 1,859,306 in 2021 but declined to 1,298,505 metric tons in 2022. The increase may have resulted from increased demand for specific fertilizers matched to soil type, farming systems and crop needs, coupled with improved local blending of the input under the Presidential Fertilizer

Initiative of the Federal Government. This practice helps optimize the use of the applied nutrients and protects the environment through balanced nutrition. In response to the high demand, there is a multiplication of fertilizer types whose quality cannot be guaranteed (Saweda *et al.*, 2010).

According to Canadian Fertilizer Institute (2013) criteria of blended fertilizer quality include uniformity, nutrient content consistent with the guarantee, free-flowing characteristics, and a minimum of individual material segregation. Low fertilizer quality can also arise from adulteration, poor storage and inappropriate handling

procedures. Adulteration can change the appearance and potency of the product and if mixed with chemicals in sufficient quantity affect crop growth and development (Visker *et al.*, 1996). Moreover, quality deterioration could manifest at different points in the supply chain.

Liverpool-Tasie *et al.* (2010) conducted a survey using the perceptions of fertilizer experts (state desk officers and ADP staff) and producers (manufacturers and blending plants) to assess the nature, structure, source and dynamics of fertilizer quality challenges and regulatory systems across states in Nigeria. They identified inferior products manufactured abroad and imported into the country, adulteration, chemical content different from that advertised, underweight bags, poor packing material, misbranded and fake fertilizers, and poorly labeled fertilizers which are largely associated with fertilizer products in the open market. The results also indicated that regulatory system for fertilizer quality in Nigeria is not clearly defined and actual execution and enforcement are limited.

Bold *et al.* (2015) found that fertilizer purchased in local markets in Uganda had 30% of nutrient missing in them and such low-quality results in negative average returns as high quality led to over 50% average returns for smallholder farmers. However, Michelson *et al.* (2021) in a survey of all fertilizer sellers in Morogoro Region, Tanzania, tested 633 samples of their fertilizer, found that although, their fertilizers met nutrient standards but there was evidence of a quality inference problem in the market. Twenty five percent (25%) of fertilizer deteriorated in observable ways and farmers relied on these observable attributes to (incorrectly) assess unobservable nutrient quality. They also noted that this misperception may likely reduces technology adoption beyond the effect of nutrient quality being unobservable. While, Khor and Zeller (2015) analyzed the effect of fertilizer quality on its use intensity to distinguish between perceived quality and true quality. Results show that perception of higher quality reduces fertilizer application rates.

In Nigeria, blended fertilizers are purchased in accordance with their brand names with perceived differences in quality in respective of same labelled content inscription. There is a price signal in these brands with perceived differences in quality. However, Mailath and Samuelson (2001) noted that low average and heterogeneity in fertilizer quality is not correlated with price. This suggests that the ability to infer quality by price may be severely limited.

Diagana *et al.* (2018) noted that supply of high-quality fertilizers in a timely manner and at affordable prices to knowledgeable farmers through professionalized private supply chains constitute a key outcome of a harmonized regulatory framework. Anecdotal evidence in Nigeria shows that there is weak regulatory framework and

limited enforcement of fertilizer standards. Therefore, fertilizer quality is a widespread concern, since nutrient contents of fertilizers are not observable and small-scale farmers rarely examine their quality before purchase or use, but rather trust the information supplied by the producers. In such situations farmers are defenseless against the vices of the producers and marketers of substandard products. These millions of smallholder farmers working to improve their livelihoods in an environment characterized by dwindling government support and increased competition between players within the fertilizer value chain need to be protected. These concerns are founded in hearsay (Fairbairn *et al.* 2017). as there is no empirical evidence of the quality status of fertilizers sold in open markets in Nigeria. As part of efforts to respond to this challenge, there is need to provide evidence-based factsheets on existence, magnitude and aspects of substandard fertilizers in Nigeria especially with the enactment of the newly established National Fertilizer Quality (Control) Act 2019 (S.B 338). Paying attention to quality at the retail level will help improve customer satisfaction and better inventory control (Canadian Fertilizer Institute, 2013), as well as ensure better crop use of applied nutrients which helps protect our environment.

This study specifically, examined current fertilizer market conditions and quality analysis of three most commonly used brands of blended NPK 20:10:10 fertilizers sold in Enugu State Nigeria, in order to highlight areas of concern and stimulate actionable regulatory enforcement of the National Fertilizer Control Act 2019. It will improve market transparency, informed decision making by farmers and policy makers and a more prosperous agricultural sector.

## METHODOLOGY

### Sampling of fertilizer markets and dealer

We collected information about location of major agricultural areas in Enugu state from Enugu State Agricultural Development Program from which five were sampled. Then, a major market in each location was purposively selected and characterized. The markets were Orié Adani in Uzo-uwani L.G.A., Afor Obollo in Udenú L.G.A, Ogbete in Enugu North L.G.A, Orié Agwu in Agwu L.G.A and Ogige Nsukka in Nsukka L.G.A. After identification and characterization of the markets, an inventory of fertilizer dealers in each market was conducted, and three were randomly selected.

### Identification and sampling of fertilizer brands

Research assistants visited the sampled dealers and recorded the characteristics of markets and the dealers in

a pretested questionnaire.

The following information were collected:

- Characteristics of the market (Town, type of market, concentration of dealers, periodicity of the market).
- Characteristics of the dealer (fertilizer ownership, knowledge about fertilizers, training in fertilizer, possession of license, type of customer, business status and size).
- Characteristics of storage (ventilation, temperature, product handling equipment, use of pallets).
- Characteristics of NPK 20:10:10 fertilizer products (Available brands, quantity in hands, bag type, bag weight, evidence of quality problems).

### Characterization of sampled fertilizers

Three most popular brands were chosen and their samples collected for further analysis. They are locally known as Federal, Ebonyi and Kano.

### Chemical analysis of fertilizers

Total nitrogen (N) content of each brand was determined by Kjeldahl method; available phosphorus ( $P_2O_5$ ) by Bray-1 method and exchangeable K by 1 M  $NH_4OA$ ; all performed in accordance with the Association of Analytical Chemists (AOAC) (2000) recognized protocol.

### Physical analysis of fertilizers

A qualitative evaluation of the following physical properties of each fertilizer brand was carried out.

**Segregation** (unequal distribution of the blend components) was evaluated using a categorical scale of none, low, medium and high.

### Granule integrity

Granule integrity was estimated by quantifying fineness and dustiness.

Samples of the fertilizers were collected, observed and a degree of fineness assigned to it using a scale: none, low, medium or high. While, dustiness was estimated by the amount of dust deposited at the bottom of a plastic bag after shaking and rated qualitatively as none, low, medium or high.

### Moisture Content

Moisture content was determined by qualitative evaluation by feeling and assessment of the fluidity of the fertilizer samples and rated as adequate, medium or high.

### Caking

Presence or absence of large aggregates were qualitatively checked by observation and feeling the fertilizer bags and rated as none, low, medium or high.

### Impurities and fillers

Presence or absence of non-fertilizer materials were determined by observation and categorized as Yes or No.

### Nutrient content compliance

The number of each fertilizer brand that met the standards set in the National Fertilizer Quality (Control) Bill 2019 (S.B 338) standards tolerance limits (TL) for NPK fertilizers were counted.

### Statistical analysis

All quantitative data collected were subjected to descriptive statistical analysis.

## RESULTS AND DISCUSSION

### Market and dealer characteristics that may affect fertilizer qualities in Enugu State

Based on information obtained from Enugu State Agricultural Development Program, five fertilizer markets were purposively selected due to their location in the major agricultural areas of the state. The markets were Orié Adani in Uzo uwani L.G.A., Afor Obollo in Udenu L.G.A, Ogbete in Enugu North L.G.A, OriéAgwu in Agwu L.G.A and Ogige Nsukka in Nsukka L.G.A. While Ogbete Enugu and Ogige Nsukka are located in urban area and operate daily, the rest are in rural areas and operates periodically (Table 1). The study strictly covered what obtained in these markets. Other fertilizer distribution channels in the state were not studied. Three common blended NPK 20:10:10 fertilizer brands were identified at the various markets. They are Golden Fertilizer produced by Golden Fertilizers Company Ltd Lagos, locally known as Federal, Golden Fertilizers produced by Ebonyi Fertilizer and Chemical Company Limited, locally known as Ebonyi and Golden Fertilizer produced by A. A. Global Fertilizers Kano locally known as Kano. Fertilizer distribution outlets in Enugu State markets were 100% privately owned and comprised more of retailers (92%), less of Wholesalers (8%) and no Importer. None of the fertilizer sellers had License to sell while; only 0.7% and 18 % of them were trained and had knowledge about fertilizer, respectively. This is contrary to the provisions of the National Fertilizer Use Act (2019) Section 1 (2) which

**Table 1.** Characteristics of Blended NPK Fertilizer Markets and Dealers in Enugu State.

| Market location | Market type | Periodicity | Distributor |              | Ownership (%) |   |           |               |     | Status (%) |         |         | Trained (%) | LSF (%) | KAB (%) | Buyer Type |  |  |
|-----------------|-------------|-------------|-------------|--------------|---------------|---|-----------|---------------|-----|------------|---------|---------|-------------|---------|---------|------------|--|--|
|                 |             |             | Count       | Density      | Private       |   | Importers | Whole sellers |     | Retailers  | SSF (%) | LSF (%) |             |         |         | FOD (%)    |  |  |
|                 |             |             |             |              | Govt.         |   |           |               |     |            |         |         |             |         |         |            |  |  |
| Adani           | Rural       | Periodic    | 30          | Scattered    | 100           | 0 | 0         | 13            | 87  | 0          | 0       | 20      | 60          | 35      | 5       |            |  |  |
| Obolloafor      | Rural       | Periodic    | 33          | Scattered    | 100           | 0 | 0         | 6             | 94  | 3          | 0       | 6       | 90          | 10      | 0       |            |  |  |
| Enugu           | Urban       | Permanent   | 42          | Concentrated | 100           | 0 | 0         | 12            | 88  | 0          | 0       | 21      | 55          | 35      | 5       |            |  |  |
| Awgu            | Rural       | Periodic    | 17          | Scattered    | 100           | 0 | 0         | 6             | 94  | 0          | 0       | 12      | 90          | 10      | 0       |            |  |  |
| Nsukka          | Urban       | Permanent   | 28          | Concentrated | 100           | 0 | 0         | 0             | 100 | 0          | 0       | 29      | 85          | 15      | 0       |            |  |  |
| State           | Rural       | 3 Periodic  | 3 80        | Scattered    | 3 100         | 0 | 0         | 8             | 92  | 0.7        | 0       | 18      | 77          | 21      | 2       |            |  |  |
| Summary         | Urban       | 2 Permanent | 2 70        | Concentrated | 2             |   |           |               |     |            |         |         |             |         |         |            |  |  |

KAB: Knowledge about Fertilizer, LSF: Licensed to sell Fertilizers; SSF: Small-scale Farmers, LSF: Large-scale Farmers, FOD: Farmer's Organizations Dealers

**Table 2:** Blended NPK Fertilizer Storage and Handling in Enugu State.

| Market location | Storage / Display Type (%) |      |            | Ventilation (%) |          | Temperature (%) |      | Relative Humidity (%) |      |          | Handling (%) |            | Pallets (%) |     |      |
|-----------------|----------------------------|------|------------|-----------------|----------|-----------------|------|-----------------------|------|----------|--------------|------------|-------------|-----|------|
|                 | Ware house                 | Shop | Open Space | Sat.            | Non-Sat. | Low             | High | Low                   | High | Adequate | Manual       | Mechanized | Good        | Bad | None |
| Adani           | 6.7                        | 33.3 | 60         | 60              | 40       | 0               | 100  | 3.3                   | 63.4 | 33.3     | 100          | 0          | 13.3        | 0   | 86.7 |
| Obolloafor      | 3.0                        | 24.2 | 72.8       | 27.3            | 72.7     | 0               | 100  | 3.0                   | 90.9 | 6.1      | 100          | 0          | 0           | 0   | 100  |
| Enugu           | 9.5                        | 50   | 40.5       | 45.2            | 54.8     | 0               | 100  | 7.1                   | 45.3 | 47.6     | 100          | 0          | 14.3        | 7.1 | 78.6 |
| Awgu            | 0                          | 47.1 | 52.9       | 52.9            | 47.1     | 0               | 100  | 11.8                  | 64.7 | 23.5     | 100          | 0          | 0           | 0   | 100  |
| Nsukka          | 0                          | 71.4 | 28.6       | 53.6            | 46.4     | 0               | 100  | 10.7                  | 35.7 | 53.6     | 100          | 0          | 3.6         | 0   | 96.4 |
| State Summary   | 4.7                        | 44.7 | 50.6       | 46.7            | 53.3     | 0               | 100  | 5.3                   | 60.7 | 34       | 100          | 0          | 7.3         | 2   | 90.7 |

Sat. = Satisfactory,

stipulates that “A person shall not carry any business (a) a manufacturer, blender or importer of fertilizer, (b) a distributor of fertilizer in Nigeria without obtaining from the prescribed Authority a permit or Certificate of registration”. The implication is that their activities are not regulated. The finding was in tandem with that of Liverpool-Tasie et al. (2010) which states that regulatory system for fertilizer quality in Nigeria is not clearly defined and actual execution and enforcement are limited. Seventy seven percent of fertilizer buyers in the State are small scale farmers and Farmer Organizations constitute only 2%.

**Storage and handling of blended NPK fertilizers in Enugu State**

In Enugu State, fertilizers are stored in ware houses and shops but displayed in shops and

Open spaces for sale. The result of the survey indicates that about 51% of fertilizer dealers in the state display their products for sale in open spaces and Motor parks within the markets, while only about 5% are stored in ware houses (Table 2). This comprised, mostly of retail dealers who sell their products in small paint buckets (5kg) and large tin Tomato cups (2.5Kg). This practice of selling fertilizers in open spaces expose them to unfavorable temperature and relative humidity which may increase volatilization of nitrogen components of the fertilizer, induce high moisture content and subsequent caking. This has wide implication on the quality of the fertilizer as it leads to deterioration of the product. The quantity involved in open space display was small compared with the entire quantity, but however not negligible because they serve larger number of poor farmers. Fifty three percent of the shops

and ware houses had satisfactory ventilation while those displayed in open spaces had no problem with ventilation. There was generally high temperature in the Ware houses, Shops and Open spaces. Critical relative humidity (CRH) of fertilizer is a property useful as an indicator of RH level at which moisture pickup will commence with its attendant undesirable results such as caking or physical breakdown (Clayton, 1984). It has considerable significance when assessing the effect of moisture on fertilizer quality during handling and storage of fertilizers. However, different fertilizer materials vary considerably both in the rate of moisture pickup and in their ability to tolerate the absorbed moisture. Adequate Critical relative humidity (55%) was found in only 34 % of shops and ware houses studied. The problem was more pronounced at Obollo afor market. The fertilizers were generally handled manually and

**Table 3.** Characteristics of Blended NPK Fertilizer Products in Enugu State

| Market location | Available Fertilizer Brand | QS   | AQS   | Bag Type |        |        | Average Price per Selling Measure (#) |              |                              | Evidence of:  |                       |              |
|-----------------|----------------------------|------|-------|----------|--------|--------|---------------------------------------|--------------|------------------------------|---------------|-----------------------|--------------|
|                 |                            |      |       | IPL (%)  | OL (%) | OW (%) | Bag (50Kg) #                          | Bucket (5Kg) | Large Tin Tomato Cup (2.5Kg) | Mismanagement | Manufacturing Problem | Adulteration |
| Adani           | Federal                    | 306  | 4972  | 100      | 0      | 0      | 27000                                 | 2850         | -                            | Yes           | No                    | No           |
|                 | Ebonyi                     | 64   | 1658  | 100      | 0      | 0      | 21000                                 | 2200         | 1200                         | Yes           | No                    | No           |
|                 | Kano                       | 28   | 782   | 100      | 0      | 0      | 7000                                  | 900          | 500                          | Yes           | No                    | Y            |
| Obolloafor      | Federal                    | 160  | 1080  | 100      | 0      | 0      | 26500                                 | 2900         | -                            | Yes           | No                    | No           |
|                 | Ebonyi                     | 70   | 642   | 100      | 0      | 0      | 21000                                 | 2150         | 1200                         | Yes           | No                    | No           |
|                 | Kano                       | 56   | 869   | 100      | 0      | 0      | 7500                                  | 850          | 450                          | Yes           | No                    | Yes          |
| Enugu           | Federal                    | 327  | 3580  | 100      | 0      | 0      | 26500                                 | 2800         | -                            | Yes           | No                    | No           |
|                 | Ebonyi                     | 130  | 2120  | 100      | 0      | 0      | 21500                                 | 2300         | 1250                         | Yes           | No                    | No           |
|                 | Kano                       | 35   | 468   | 100      | 0      | 0      | 6800                                  | 800          | 450                          | Yes           | No                    | Yes          |
| Awgu            | Federal                    | 275  | 2462  | 100      | 0      | 0      | 28000                                 | 3000         | -                            | Yes           | No                    | No           |
|                 | Ebonyi                     | 92   | 3690  | 100      | 0      | 0      | 22000                                 | 2400         | 1200                         | Yes           | No                    | No           |
|                 | Kano                       | 42   | 743   | 100      | 0      | 0      | 8000                                  | 950          | 500                          | Yes           | No                    | Yes          |
| Nsukka          | Federal                    | 176  | 1886  | 100      | 0      | 0      | 27000                                 | 2900         | -                            | Yes           | No                    | No           |
|                 | Ebonyi                     | 133  | 942   | 100      | 0      | 0      | 22000                                 | 2350         | 1250                         | Yes           | No                    | No           |
|                 | Kano                       | 37   | 267   | 100      | 0      | 0      | 7200                                  | 950          | 500                          | Yes           | No                    | Yes          |
| State Summary   | Federal                    | 1244 | 13980 | 100      | 0      | 0      | 27000                                 | 2890         | -                            | Yes           | No                    | No           |
|                 | Ebonyi                     | 484  | 9052  | 100      | 0      | 0      | 21500                                 | 2280         | 1220                         | Yes           | No                    | No           |
|                 | Kano                       | 198  | 3129  | 100      | 0      | 0      | 7300                                  | 890          | 480                          | Yes           | No                    | Yes          |

QS: Quantity in Stock (50KgBags); AQS: Average Quantity Sold in a Year # Bags, Bag Types: IPL : Inner Polytene lining, OL: Outer Laminated, OW: woven

### Characteristics of blended NPK fertilizer products in Enugu State

The study identified three popular brands of blended NPK 20:10:10 fertilizer sold in the State namely Federal, Ebonyi and Kano. At the time of data collection, a total of 1244, 484 and 198 bags (50kg) of Federal, Ebonyi and Kano, respectively were found in the markets. The dealers reported that they sold annually, an average of 13,980, 9,052 and 3,129 bags of Federal, Ebonyi and Kano brands of NPK 20:10:10 fertilizers, respectively. The study indicates that buyers have greater patronage for Federal than Ebonyi and Kano in spite of its higher price as shown in (Table 3). All the brands were bagged using Inner Polytene lining. However, the gauge of the lining was not determined. This is significant as the polyethylene layer is not completely waterproof,

as is often assumed but has some permeability to water vapor. As indicated in (Table 3), the prices of the fertilizer brands ranged from #27,000.00 per 50kg bag of Federal to #7,300 for Kano, with few markets to market variations. Farmers were willing to pay extra #14,200.00 and #19,700.00 per same 50kg bag of Ebonyi and Federal, respectively. There is a great concern for this wide price differential as there is no empirical evidence of a correlation between the fertilizer prices and their quality. There is an erroneous believe that higher prices indicate higher quality, which is not so as reported by Bold *et al.* (2015). They observed a substantial variation in quality across fertilizer samples but prices were homogenous. It is remarkable to note that, in view of the high cost of the fertilizers, most of the peasant farmers were unable to buy the fertilizers at the 50 Kg package. The retailers decided to break bulk by selling in

small uneconomical paint buckets (5Kg) and large Tin tomato cups (2.5kg). The small paint bucket sold for #2280 for Ebonyi and #890 for Kano. The practice is prone to adulteration and deterioration of fertilizer quality as the bags are opened exposing the fertilizers to unfavorable weather conditions. It was only Kano and Ebonyi that they sold in these measures. The presumed higher quality, Federal was not sold in these measures because according to the retailers it was not profitable to do so, as it is very costly and difficult to adulterate. They often mixed Kano with Urea to look like Federal. This practice may shift the ratio of the fertilizer to an unknown value as the mixture was done arbitrarily. There was no evidence of manufacturing problems but mismanagement was observed in all the fertilizer brands. Adulteration was only observed in Kano. This may be as a result of its lower cost and breaking of bulk.

**Table 4. Mean Physical Attributes of Blended NPK Fertilizers Sold in Enugu State.**

| Market location | Available Fertilizer Brand | Bag Weight (50 Kg) |      |      |      | Segregation |      |      |     | Filler (%) |     | Impurities (%) |     | Granule Integrity |      |      |     |     |      |      |     |    |
|-----------------|----------------------------|--------------------|------|------|------|-------------|------|------|-----|------------|-----|----------------|-----|-------------------|------|------|-----|-----|------|------|-----|----|
|                 |                            | Mean               | SD   | Min. | Max. | No          | Med. | High | Low | Yes        | No  | Yes            | No  | Fine Dust         | High | Med. | Low | No  | High | Med. | Low |    |
| Adani           | Federal                    | 50.37              | 0.86 | 49.6 | 51.3 | 80          | 0    | 0    | 20  | 0          | 100 | 0              | 100 | 0                 | 80   | 20   | 0   | 80  | 0    | 0    | 0   | 20 |
|                 | Ebonyi                     | 50.90              | 1.31 | 50.0 | 52.4 | 20          | 40   | 30   | 10  | 0          | 100 | 0              | 100 | 0                 | 0    | 40   | 60  | 100 | 0    | 0    | 0   | 0  |
|                 | Kano                       | 53.50              | 2.56 | 51.6 | 56.4 | 60          | 10   | 0    | 30  | 100        | 0   | 0              | 100 | 0                 | 0    | 20   | 80  | 20  | 0    | 80   | 0   | 0  |
| ObolloAfor      | Federal                    | 49.97              | 0.15 | 49.8 | 50.1 | 80          | 10   | 0    | 10  | 100        | 0   | 0              | 100 | 0                 | 80   | 20   | 0   | 0   | 0    | 20   | 80  | 0  |
|                 | Ebonyi                     | 50.10              | 0.01 | 50.0 | 50.2 | 40          | 10   | 10   | 40  | 100        | 0   | 0              | 100 | 0                 | 0    | 60   | 40  | 40  | 0    | 0    | 0   | 60 |
|                 | Kano                       | 51.90              | 1.91 | 49.7 | 53.2 | 70          | 0    | 0    | 30  | 100        | 0   | 0              | 100 | 0                 | 0    | 20   | 80  | 0   | 0    | 80   | 20  | 0  |
| Enugu           | Federal                    | 50.00              | 00   | 50.0 | 50.0 | 60          | 10   | 0    | 30  | 0          | 100 | 0              | 100 | 0                 | 80   | 20   | 0   | 100 | 0    | 0    | 0   | 0  |
|                 | Ebonyi                     | 50.03              | 0.25 | 49.8 | 50.3 | 0           | 60   | 0    | 40  | 0          | 100 | 0              | 100 | 0                 | 0    | 80   | 20  | 80  | 0    | 0    | 0   | 20 |
|                 | Kano                       | 52.20              | 2.09 | 50.8 | 54.6 | 0           | 0    | 80   | 20  | 100        | 0   | 0              | 100 | 0                 | 20   | 20   | 60  | 60  | 0    | 0    | 0   | 40 |
| Awgu            | Federal                    | 50.10              | 0.01 | 50.0 | 50.2 | 80          | 0    | 0    | 20  | 0          | 100 | 0              | 100 | 0                 | 60   | 40   | 0   | 80  | 0    | 0    | 0   | 20 |
|                 | Ebonyi                     | 50.07              | 0.40 | 49.7 | 50.5 | 60          | 10   | 0    | 30  | 0          | 100 | 0              | 100 | 0                 | 20   | 20   | 60  | 100 | 0    | 0    | 0   | 0  |
|                 | Kano                       | 52.23              | 2.93 | 50.3 | 55.6 | 70          | 20   | 0    | 10  | 100        | 0   | 0              | 100 | 0                 | 40   | 20   | 40  | 20  | 0    | 0    | 0   | 80 |
| Nsukka          | Federal                    | 50.03              | 0.05 | 50.0 | 50.1 | 90          | 0    | 0    | 10  | 0          | 100 | 0              | 100 | 0                 | 60   | 40   | 0   | 100 | 0    | 0    | 0   | 0  |
|                 | Ebonyi                     | 50.23              | 0.15 | 50.1 | 50.4 | 0           | 20   | 60   | 20  | 0          | 100 | 0              | 100 | 0                 | 40   | 20   | 40  | 100 | 0    | 0    | 0   | 0  |
|                 | Kano                       | 50.60              | 0.66 | 50.0 | 51.3 | 0           | 40   | 40   | 20  | 100        | 0   | 0              | 100 | 0                 | 60   | 20   | 20  | 0   | 0    | 80   | 20  | 0  |
| State Summary   | Federal                    | 50.09              | 0.37 | 49.6 | 51.3 | 68          | 14   | 0    | 18  | 0          | 100 | 0              | 100 | 0                 | 72   | 28   | 0   | 72  | 0    | 4    | 24  | 0  |
|                 | Ebonyi                     | 50.27              | 0.63 | 49.7 | 52.4 | 24          | 28   | 20   | 28  | 0          | 100 | 0              | 100 | 0                 | 12   | 44   | 44  | 84  | 0    | 0    | 16  | 0  |
|                 | Kano                       | 52.09              | 2.07 | 49.7 | 56.4 | 40          | 14   | 24   | 22  | 100        | 0   | 0              | 100 | 0                 | 24   | 20   | 56  | 20  | 0    | 48   | 32  | 0  |

SD = Standard Deviation, Min. = Minimum, Max. = Maximum, Med. = Medium

**Physical attributes of blended npk fertilizers sold in Enugu State**

As shown in (Table 4), all the fertilizer brands had a higher bag weight than the standard prescribed 50 Kg. However, Kano brand had a higher standard difference of 2.07. A qualitative visual coding of segregation, presence of filler materials, impurities, granule integrity (presence of fine particles and dust) and caking in relation with the type of bag were also made. Generally, there was an absence of fine dust in all the fertilizers sampled. However, the Federal brand had higher percentage of samples considered to be high or medium in granule integrity. Seventy two percent of their samples had their granule integrity in the high category, while Ebonyi and Kano had theirs only in 12 and 24% respectively. This property may likely influence the rate of degradation of these fertilizer brands especially when retailed in buckets and cups as is the practice in the State.

This is true as noted by Sanabria *et al.* (2013) that nutrient deficiencies may be due to granule segregation. Federal and Ebonyi did not differ in caking, for Kano brand, about 80% percent of the samples showed presence of caking in the categories of medium or low.

**Level of compliance of each fertilizer brand with the newly established national fertilizer quality (Control) Act 2019 (S.B 338)**

The most important quality of a fertilizer material is its nutrient content. Nutrient content analysis of each brand of fertilizer was carried out on samples collected from sealed 50 Kg bags. The result of the nutrient contents analysis and bag weight verification and compliance with Manufacturer’s quoted grades were presented in (Table 5). All the fertilizers brands contained less nitrogen than the Manufacturers quoted grades of 20%. On State average, Federal contained 15.35% nitrogen,

Ebonyi 13.95% and Kano 7.47%. Similarly, the phosphorus content failed short of the quoted values with Kano brand having the highest deviation of 3.14%, Federal and Ebonyi having 2.34 and 2.21%, respectively. Federal brand contained less Potassium (6.84%) than Ebonyi and Kano that contained 7.38 and 7.83% contrary to the manufacturer’s quoted values of 10%.

All the fertilizers available at the markets were all out of compliance (OOC) with National Fertilizer Regulatory Act (2019) (NFRA) standards. Nutrient shortages (OOC) occurred with higher frequency and severity in NPK bulk blends manufactured in Nigeria (Ebonyi and Kano) as compared with Federal which was said to be imported. These nutrient deficiencies observed in the fertilizer brands may have resulted from granule segregation and/or insufficient nutrient inputs at the time of the blending (Sanabria *et al.* 2013, Diagana *et al.* 2018). Segregation means that the blended fertilizer is no longer uniform, or

Table 5. Mean Nutrient (NPK) Contents of blended retail fertilizers sold in Enugu State and their out-of-compliance (OOC) from Manufacturer's Quoted Values.

| Market location | Available Fertilizer Brand | Mean Observed N | Deviation from MQV (20%) | Nutrient Content OOC* in Nitrogen (%) NFRA (0.73)# | Mean Observed P <sub>2</sub> O <sub>5</sub> | Deviation from MQV (10%) | Nutrient Content OOC* in Phosphate (%) NFRA (0.69)# | Mean Observed K <sub>2</sub> O | Deviation from MQV (10%) | Nutrient Content OOC* in Potash (%) NFRA (0.70) | Mean Observed Bag weight | Deviation from MQV (50 Kg) | Bag Weight | Under |
|-----------------|----------------------------|-----------------|--------------------------|--|---|--------------------------|---|--------------------------------|--------------------------|---|--------------------------|----------------------------|------------|-------|
| Adani           | Federal                    | 15.47           | 4.13                     | Yes  | 8.17  | 1.13                     | Yes   | 7.27                           | 2.73                     | Yes   | 50.37                    | 0.37                       | No         |       |
|                 | Ebonyi                     | 12.83           | 7.17                     | Yes  | 9.23  | 0.77                     | Yes   | 7.27                           | 2.73                     | Yes   | 50.90                    | 0.90                       | No         |       |
|                 | Kano                       | 5.97            | 14.13                    | Yes  | 8.20  | 1.80                     | Yes   | 7.93                           | 2.07                     | Yes   | 53.50                    | 3.50                       | No         |       |
| Obolloafor      | Federal                    | 14.60           | 5.40                     | Yes  | 7.77  | 2.23                     | Yes   | 8.37                           | 1.63                     | Yes   | 49.97                    | - 0.03                     | No         |       |
|                 | Ebonyi                     | 13.00           | 7.00                     | Yes  | 6.23  | 3.77                     | Yes   | 6.70                           | 3.30                     | Yes   | 50.10                    | 0.10                       | No         |       |
|                 | Kano                       | 6.87            | 13.13                    | Yes  | 6.57  | 3.43                     | Yes   | 8.53                           | 1.47                     | Yes   | 51.90                    | 1.90                       | No         |       |
| Enugu           | Federal                    | 14.30           | 5.70                     | Yes  | 7.57  | 2.43                     | Yes   | 6.23                           | 3.77                     | Yes   | 50.00                    | 0.00                       | No         |       |
|                 | Ebonyi                     | 15.90           | 4.10                     | Yes  | 7.00  | 3.00                     | Yes   | 7.63                           | 2.37                     | Yes   | 50.03                    | 0.03                       | No         |       |
|                 | Kano                       | 7.73            | 12.27                    | Yes  | 6.40  | 3.60                     | Yes   | 7.10                           | 2.90                     | Yes   | 52.20                    | 2.20                       | No         |       |
| Awgu            | Federal                    | 16.13           | 3.87                     | Yes  | 7.93  | 2.07                     | Yes   | 5.97                           | 4.03                     | Yes   | 50.10                    | 0.01                       | No         |       |
|                 | Ebonyi                     | 12.57           | 7.43                     | Yes  | 8.40  | 1.60                     | Yes   | 7.50                           | 2.50                     | Yes   | 50.07                    | 0.07                       | No         |       |
|                 | Kano                       | 7.58            | 12.42                    | Yes  | 7.03  | 2.97                     | Yes   | 6.97                           | 3.03                     | Yes   | 52.23                    | 2.23                       | No         |       |
| Nsukka          | Federal                    | 16.27           | 3.73                     | Yes  | 6.87  | 3.13                     | Yes   | 6.37                           | 3.63                     | Yes   | 50.03                    | 0.03                       | No         |       |
|                 | Ebonyi                     | 15.43           | 4.57                     | Yes  | 8.07  | 1.93                     | Yes   | 7.80                           | 2.20                     | Yes   | 50.23                    | 0.23                       | No         |       |
|                 | Kano                       | 9.23            | 10.77                    | Yes  | 6.06  | 3.94                     | Yes   | 8.60                           | 1.40                     | Yes   | 50.60                    | 0.06                       | No         |       |
| State Summary   | Federal                    | 15.35           | 4.65                     | Yes  | 7.66  | 2.34                     | Yes   | 6.84                           | 3.16                     | Yes   | 50.09                    | 0.09                       | No         |       |
|                 | Ebonyi                     | 13.95           | 6.05                     | Yes  | 7.79  | 2.21                     | Yes   | 7.38                           | 2.62                     | Yes   | 50.27                    | 0.27                       | No         |       |
|                 | Kano                       | 7.47            | 12.63                    | Yes  | 6.96  | 3.14                     | Yes   | 7.83                           | 2.17                     | Yes   | 52.09                    | 0.09                       | No         |       |

M.Q.V =Manufacturers Quoted Value .NFRA= National Fertilizer RegulatoryAct, OOC = Out Of Compliance, NFRA (0.73) # =Maximum Tolerance Difference, Underweight = Fertilizer content with short weight which exceeds the 0.6% of the weight claimed on the label.

that smaller particles have separated from the larger ones and have collected in a different place. However, degradation may also have occurred during handling along the distribution chain. Similarly, the wide variation between quoted values and analyzed result may support the assertion by Liverpool-Tasie *et al.* (2010) that most laboratories designated for fertilizer testing are very familiar with soil, plant tissue, and water analyses but lack the specifics about fertilizer testing in addition to relevant equipment and qualified staffing. Our findings are consistent with that of Bold *et al.* (2017), who found highly variable nutrient content and average nitrogen deviations of 30% in urea in Uganda but contrasts with Ashour *et al.* (2017). The implication of this

low-quality fertilizer is that it may reduce the economic returns (profitable) to adoption substantially especially at current price.

### Conclusion

There is evidence of poor quality (nutrient deficiency) in NPK 20:10:10 blended fertilizers sold to farmers in Enugu state. The NPK fertilizers manufactured by Golden Fertilizers Kano presented the most frequent cases of poor quality compared with other brands. The cause of the nutrient deficiencies cannot be explained by this study. Underweight fertilizer bags are not a serious problem. Market situation was unorganized and unregulated while most fertilizer

dealers are unlicensed and have no knowledge or training about fertilizers, all of which can impact fertilizer quality. Current prices of 50 Kg bag of the fertilizer brand are #27,000.00for Federal, #21,500.00 for Ebonyi and #7,300.00 for Kano. In response to the high cost of the fertilizers and poverty of most farmers, retailers resorted to selling in 5 and 2.5 Kg measures which may encourage adulteration. Therefore, the traditional practice of packaging fertilizers only in 50 Kg packs is no longer feasible. Therefore, packaging in smaller units as found in Beverage industries is recommended. Finally, the impact of the recently enacted National Fertilizer Regulatory Control Act (2019) is yet to be felt in the State, It is hope that this study will give them a leeway to proper

enforcement.

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