1. Introduction

Protein energy malnutrition (PEM) is a clinical disease condition that results from inadequate and/or under-utilization of food protein. The problem of cheap sources of high quality proteinous foods for the over-populated developing nations like Nigeria is still a lingering issue till date. It appears to be recalcitrant due to the high level of ignorance and poverty. Reference [1] asserted that the food situation in Nigeria is generally regarded as not too un-favourable in that certain foods are grown locally to provide for the population, however, self-sufficiency in food production only will not sufficiently address the problem of hunger or the calorie gap unless accompanied by adequate knowledge.

Globally in 2016, [2] estimated that there were 155 million children under the age of five who were stunted (too short for their age), 52 million wasted (too light for their height) and 41 million overweight (too heavy for their height); while, stunting prevalence was highest (34%) in the WHO African Region and the WHO South-East Asia Region. These statistics are improvement on those obtained earlier by the World Health Organization [3], whereby it was estimated that 182 million or 1 out of 3 children under the age of five years in developing countries (mostly in sub-Saharan Africa) are malnourished. Specifically in Nigeria, [4] indicated that out of the 180million Nigerian population estimate, 37% are children under-5 that were stunted, and that there occurs 1 million under-5 deaths/year (of which 45% was due to malnutrition); while 13% of young Nigerians <15y/o were at risk of being malnourished (that is, 10,087,996 children). In addition, [5] stated that PEM was associated with as much as 50-60% of under-five mortality in poor countries and a myriad of morbidities.

Meanwhile, various attempts by local and international government and humanitarian organizations only succeeded in making little or less than appreciable impact on the status of
malnutrition in Nigeria. Over the years such efforts as improving the living standards of Nigerians, empowering and educating mothers on appropriate feeding practices, and attempting to address the scourge of poverty have been grossly inadequate in tackling this menace. This necessitates further strategies that can make cheap quality protein energy accessible to the poor Nigerians. One of such measures is the use of fermented leguminous condiments that can be used as cheap protein additive in the diet of children suffering from PEM, as is currently being adopted at a nutritional rehabilitation center at Osun state of Nigeria.

Hence, this paper examines the current trend in the nutritional rehabilitation practices for managing pediatric protein energy malnutrition, as applied to the case of Nigeria in sub-Saharan Africa.

2. Protein Energy Malnutrition (PEM)

The World Health Organization (WHO) defined malnutrition as ‘the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions’. The term protein-energy malnutrition (PEM) applies to a group of related disorders that include marasmus, kwashiorkor (figure 1), and intermediate states of marasmus-kwashiorkor. The term marasmus is derived from the Greek word marasmus, which means withering or wasting. Marasmus involves inadequate intake of protein and calories and is characterized by emaciation. The term kwashiorkor is taken from the Ga language of Ghana and means the sickness of the weaning, and the term was first used in 1933 to refer to an inadequate protein intake with reasonable caloric intake [6].

Protein energy malnutrition is often characterized by poor weight gain, slowing of linear growth, behavioral changes (irritability, apathy, decreased social responsiveness, anxiety, and attention deficits. Besides macronutrient deficiency, deficiencies in iron, iodine, vitamin A, and zinc are the main manifestations of malnutrition in developing countries [7]. Deficiencies of micronutrients, including vitamins, minerals, and trace elements have various clinical signs such as for Iron (fatigue, anemia, decreased cognitive function, headache, glossitis, and nail changes), Iodine (goiter, developmental delay, and mental retardation), vitamin D (poor growth, rickets, and hypocalcemia), vitamin A (night blindness, xerophthalmia, poor growth, and hair changes), folate (glossitis, anemia), and neural tube defects (in fetuses of women without folate supplementation), and zinc (anemia, dwarfism, hepatosplenomegaly, hyperpigmentation and hypogonadism, acrodermatitis enteropathica, diminished immune response, poor wound healing). Edema is characteristic of kwashiorkor but is absent in marasmus [6].

Meanwhile, malnutrition was one of the leading causes of childhood morbidity and mortality in many developing countries [8] [9]. Figure 2 shows the approximate distribution of the major contributors to child mortality. Malnutrition is implicated in more than 50% of deaths of under-5 children [10].
2.1. Management of PEM

The most important preventive strategy is to reduce poverty and improve nutritional education and public health measures [13]. There are three phases to the management of severe malnutrition and these are initial treatment, rehabilitation and follow-up phase. As stated, treatment of the initial life-threatening conditions, such as severe dehydration and infection is the first step in managing PEM, followed as rapidly as possible by correction of weight deficit that always occurs in severe PEM [14]. Correction of the weight deficit is indicated to be a very important aspect of the treatment of malnutrition. The formation of new tissue is said to require protein, but large quantities of protein are not necessary. Reference [14] indicated that it is not enough simply to feed a standard infant milk formula; and for really effective treatment, a high-energy feed must be given.

Mild or moderate PEM can be treated by providing a balanced diet. Liquid oral food supplements (such as lactose-free one) can be used when solid food cannot be adequately ingested. Reference [15] asserted that diarrhea often complicates oral feeding because starvation makes the GI tract more likely to move bacteria into Peyer patches, facilitating infectious diarrhea. If diarrhea persists (suggesting lactose intolerance), yogurt-based rather than milk-based formulas are given because people with lactose intolerance can tolerate yogurt. Patients should also be given a multivitamin supplement.

As stated earlier, the first step in the treatment of severe protein-energy malnutrition (PEM) is to correct fluid and electrolyte abnormalities and to treat any infections. The usual electrolyte imbalances are hypokalemia, hypocalcemia, hypophosphatemia and hypomagnesemia [16]. Macronutrient replenion is often commenced within 48 hours under the supervision of nutrition specialists. Oral zinc supplements were also indicated to be effective.

During the second stage of treating protein-energy malnutrition by supplying macronutrients in dietary therapy, milk-based formulas are the treatment of choice. At the beginning of dietary treatment, patients could be fed ad libitum. After 1 week, intake rates could approach 175 kcal/kg and 4 g/kg of protein for children [15] and 60 kcal/kg and 2 g/kg of protein for adults. A daily multivitamin could also be added.

More so, other treatments may be needed to correct specific deficiencies, which may become evident as weight increases. It is recommended that in order to avoid deficiencies, patients can take micronutrients at about twice the recommended daily allowance (RDA) until recovery is complete. Also, energy distribution among macronutrients could be about 16% protein, 50% fat, and 34% carbohydrate [13]. An example of such combination is skimmed powdered milk from cow (110g), sucrose (100g), vegetable oil (70g), and water (900ml). Many other formulas can be used (for instance, whole fresh milk plus corn oil and malto-dextrin). Milk powders used in formulas are diluted with water.

In addition, supplements are to be given with the formulas: Magnesium 0.4 mEq/kg/day IM could be given for 7 days; B-complex vitamins at twice the RDA are to be given parenterally for the first 3 days, usually in addition to vitamin A, phosphorus, zinc, manganese, copper, iodine, fluoride, molybdenum, and selenium; IM iron supplementation may be necessary since absorption of oral iron is poor in children with PEM [13]. Afterwards, parents are to be taught about nutritional requirements and available food options to fulfill their children’s requirement.

Meanwhile, in developing nations like Nigeria, affordability of standard factory-made dietary formulas is often a great challenge to the care-givers. As such, combinations of various economical locally available staple foods are made to conform to the general and child-specific nutritional requirements of the patients. These combinations are then taught to the care-givers to apply regularly at home. Such combinations usually include fermented leguminous condiments that are rich in the much-needed protein energy.

2.2. Use of Nigerian Fermented Condiments in Diet of PEM Patients

Nigerian traditional diets consist of large quantities of staple foods that provide calories but are poor in other nutrients. Soups are the main sources of proteins and minerals, and one way to improve the diet has been to improve the nutrient content of soups [17]. Seeds of legumes may contribute up to 80% of dietary protein and may be the only source of protein for some groups. Their cooked forms are eaten as meals and are commonly used in fermented form as condiments to enhance the flavors of foods [18] [19]. With high contents of protein, leguminous condiments can serve as a good complement and substitute for fish or meat in soups. Examples of food condiments include dawadawa (African locust bean), ogiri (fluted pumpkin or castor seeds), ugbu (African oil bean), ukwa (African breadfruit), daddawa (soy-bean) and etekteke (oil palm nut).

It is known that fermentation increases nutritional values of foods, as it can produce important nutrients and eliminate anti-nutrients. For instance, [20] asserted that in natural or pure mixed-culture fermentations of plant foods by microorganisms, anti-nutritional components (e.g. phytate in whole wheat breads) can be reduced by up to 50%; toxic components, such as lectins in tempe and other fermented foods made from beans, can be reduced up to 95%. It was reported in [21] that the most significant aspect of melon seed fermentation is increase in its soluble nutrients, while of particular importance is the free amino acids liberated, thereby increasing the digestibility and utility of the melon seeds. Reference [22] studied the effect of fermentation on the nutrient content of locust beans and reported that protein and fat increased when fermented whereas the quantity of carbohydrates decreased. Increased levels of the amino acids were also reported except for arginine, leucine and phenylalanine. Similar results were reported for other seed legumes [23] [24]. Alanine, lysine and glutamic acid were the predominant amino acids, with arginine and proline occurring in small amounts [25] [18]. The improved nutritive values
Food condiments made from vegetable proteins may be a good source of certain B vitamins, but are deficient in ascorbic acid and some fat-soluble vitamins, which are lost during fermentation. Reference [26] has shown that fermentation significantly increased the content of thiamine, riboflavin and niacin in the African oil bean. Similar changes were observed during the fermentation of melon seed and fluted pumpkin seed [27] [28]. Reference [29] observed increases in calcium, phosphorus and potassium when African yam bean was fermented for condiment production. This is in contrast to previous results of [28], which reported decrease in calcium, copper and phosphorus but increased iron and zinc in fluted pumpkin. It is evident that fermented food condiments is a good source of nutrients and could be used to produce complementary food supplements.

According to [20], fermentation can also act as preservation for foods, since it uses up food energy and creates conditions unsuitable for spoilage microorganisms. For instance, in pickling, the acid produced by the dominant organism inhibits the growth of all other microorganisms. There are examples of poisonous plants like cassava (containing cyanide/prussic acid) that are converted to edible products by fermenting. Reduction in anti-nutritional and toxic components in plant foods by fermentation was observed in a research which showed that cereals, legumes, and tubers that are used for the production of fermented foods may contain significant amounts of anti-nutritional or toxic components and inhibitors of enzymes [20]. These substances reduce the nutritional value of foods by interfering with the mineral bioavailability and digestibility of proteins and carbohydrates.

### 2.3. Current Trend in Managing PEM in Nigeria

After stabilization of the vital organs, replenishing the body calorie/protein requirement is said [13] [14] [16] to be the next stage in the management of PEM. In the developing nations like Nigeria, the bulk of dietary protein for a vast majority of its populace is obtained from plant products, as animal sources (eggs, cheese, milk, meat and fish) are not often affordable to the people of low income earners. Good plant sources of protein include legumes, nuts and seeds like soybean, cowpea, groundnut, bambara nut, pigeon pea, beans [30], fermented locust beans and melon seeds [31]; while others include corn, rice, guinea corn, millet, vegetables and fruits. However, plant sources are low quality or incomplete proteins as many of them either lack one or more of the essential amino acids, or proper balance of amino acids. Incomplete proteins can, thus, be combined to provide all the essential amino acids to obtain the maximum nutritive value. Such combination diets generally yield a high-quality protein meal, providing sufficient amounts and proper balance of the essential amino acids needed by the body to function.

Since fermentation process concentrates and improves the quality of protein in the foods, fermented condiments that are made from seeds like locust beans, melon, soybeans and oil bean seeds could serve as a great cheap sources of high quality protein for protein-deficient patients in particular, and the general populace that cannot easily afford animal proteins that are the usual sources of good protein to the rich. There is however, the possibility of rejection of such condiment-containing food by some patients, as a result of the strong flavour that is characteristic of such fermented condiments.

Some field surveys conducted recently across the geographical regions of Nigeria by these authors (unpublished) indicated that liquid-based gruel prepared from a combination of locally available cereals, soybeans and groundnut is the usual diet for the nutritional rehabilitation of the patients of protein deficiency, while the solid-based meals include a combination of boiled starchy fruits (such as under-ripe plantain) and local soup with fermented leguminous condiments as protein supplier. These solid-based foods are usually served to older children that have the appetite for solid foods.

The surveys also highlighted a fact that the prevalence of PEM in the Northern Nigeria is generally higher than that of the Southern and Western Nigeria. This was evident from the number of reported new cases in each region over the same period of study. In all cases, however, seasonality cum availability of food seems to determine the occurrence and frequency of malnutrition in children. In other words, there is usually very few or no reported cases during food harvest period such as at the time of writing this review, when there is a boom in food accessibility. This trend continues till all harvested foods (of mostly subsistent farming households) have been exhausted.

Typically, the sampled treatment centres in the north-west and north-east regions of Nigeria usually commence nutritional rehabilitation by serving infant milk-based formula to infants that 0-6months old, and liquid-based gruel to children of 6 months to 4 years. Such gruel is made from the combinations stated above in the ratio 6:3:1 of cereal (usually millet), soybeans and groundnut. These food sources are much more easily affordable and accessible to the usually-economically disadvanged parents of those PEM children, than the factory-processed formulas. Also, the neutrality in smell and taste of such combination make it easily acceptable to the children, who are usually averse to feeding as a result of their illness.

Similarly, the south-west nutritional rehabilitation centre that was surveyed often use gruel made from cereal/soybeans combination as its liquid-based treatment diet for especially younger children, while formulating its solid-based diet from easily digested starchy staple like boiled plantain that is usually served with a local soup that is supplemented with fermented leguminous condiments for their protein content. In addition, soybeans-based snack and drinks are often made to be given to the patients for taste variety, to avoid monotony. Such snack includes soybeans cheese, while an example of the drinks includes soy-milk.

In addition, to the general food combination practices of the treatment centers in the Northern and Western Nigeria, the Southern region usually includes much of crayfish and
palm-oil (both of which is more easily available and cheaper in this region), groundnut, fermented condiments and other ingredients.

On the other hand, the treatment of protein deficient children in the Boko-Haram ravaged north-eastern States of Nigeria has a different dimension to it. Due to the displacement of people by terrorism in the region, a vast majority of the populace reside at IDP camps in uncomfortable and difficult situations. Thus, children born and/or living in such conditions often suffer various degree of malnutrition. It was found that there is an average of 15-20 new cases per week; while statistics from UNICEF estimated 400,000 under-five children that could suffer from acute malnutrition in north-eastern Nigeria [32]. Subsequently, for their rehabilitation, UNICEF often make available formulated diet that is known as ready-to-use therapeutic foods (RTF), otherwise called ‘miracle foods’ as a result of their effectiveness in rapidly correcting severe acute malnutrition. RTF is an energy-dense, micronutrient-enhanced paste made from a homogenous mix of rich foods, such as peanuts, oil, sugar, milk powder, and supplements of vitamin and mineral [33].

On the part of Nigerian government, various efforts to reduce and manage malnutrition gave rise to many policies and strategies that dated back to the 90s, but are constantly being reviewed and updated. According to the Federal Government of Nigeria, FGN [34], National Committee on Food and Nutrition (NCFN) was established in 1990 as an institutional arrangement to (amongst others) articulate a comprehensive policy and actions that could effectively reduce malnutrition considerably or eradicate it in Nigeria. Thereafter, NCFN formulated a policy in 1995, to set specific targets that included 30% reduction of malnutrition among children under-five by 2010, and 50% reduction of micronutrient deficiencies (especially of vitamin A, iodine, and iron) by 2010. This effort included vitamin A fortification of some marketed staple foods (such as 70% sugar, 100% wheat flour and 55% vegetable oil), so that children would naturally consume vitamin A in their food. The policy also included fortification of wheat flour with iron, thereby helping to protect children’s physical and mental health.

Further, the Home-Grown School Feeding program was also launched in September 2005 to provide a nutritionally-adequate meal during the school day in order to ensure at least one whole meal for the children, thereby encouraging school attendance and academic attainment. In addition, Nigeria established over 495 community management of acute malnutrition (CMAM) sites across northern Nigeria; and nutrition summits are held to drive the scaling-up of: promoting optimal infant feeding practices, controlling micronutrient deficiency and anemia through vitamin and mineral supplementation, food fortification and dietary diversification, and eliminating iodine deficiency through a salt iodization program in Nigeria [34]. Recognition was also given to the roles that other sectors play in improving food security.

Hence, all these efforts outlined above are among the various attempts by different groups (care-givers, health facilities, humanitarian agencies and government bodies) to significantly reduce and eradicate the menace of malnutrition in Nigeria, in order to achieve the set objectives of the FGN such as: to reduce the number of under-five children who are stunted by 20% by 2018, or reduce low birth-weight by 15% by 2018, and to increase exclusive breastfeeding rates in the first six months to at least 50% by 2018 [34].

3. Conclusion and Recommendation

Protein energy malnutrition (PEM) is a disease condition that results from inadequate and/or under-utilization of food protein. The problem of cheap sources of high quality proteinous foods for the over-populated developing nations like Nigeria is still a lingering issue till date. Some field surveys conducted recently in Nigeria by these authors indicated that for the management of pediatric PEM, liquid-based gruel prepared from a combination of locally available cereals, soybeans and groundnut is the usual diet for the nutritional rehabilitation of the patients of protein deficiency, while the solid-based meals include a combination of boiled easily-digested starchy foods and local soup with fermented leguminous condiments as protein supplier.

Fermented food condiments are prepared by traditional methods of uncontrolled solid substrate fermentation resulting in extensive hydrolysis of the protein and carbohydrate components. Apart from increasing the shelf-life and reduction in the anti-nutritional factors, fermentation markedly improves the digestibility, nutritive value and flavour of the raw foods used as substrates. Such protein-rich fermented foods have a good potential of supplying cheap high quality protein to the diet for managing pediatric PEM.

Meanwhile, there have been continuous efforts by various concerned groups such as international and local agencies in significantly eradicating the scourge of malnutrition in Sub-Sahara Africa, including Nigeria. These efforts include formulation of appropriate policies for all malnutrition-affected regions, and provision of free ready-to-use therapeutic foods (RTF) in the north-east of Nigeria where Boko-Haram activities predispose children to high prevalence of the disease.

It is, however, recommended that consolidated efforts be made by all relevant governmental bodies in the 36 states of the federation in order to adequately arrest and manage the disease as early as possible, in order to reduce to the barest minimum the number of death that could result. Also encouragement and more enlightenment should be given to care-givers (especially women) on proper food combination and utilization of the various locally food commodities (including fermented food condiments), so as to obtain the maximum nutritional benefits from such.

References


