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PHYTOGENICOLOGY: AN EMERGING FIELD OF STUDY FOR PRODUCTIVITY AND SUSTAINABLE ENVIRONMENT IN MONOGASTRIC ANIMAL PRODUCTION

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ABSTRACT

In this commentary a case for scholarly study of bioactive plants (Phytogenicology) used in monogastric animal feeds is made. Plants and their extracts have for decades been used by man in food and medicine. Spices such as black pepper and thyme have been used to improve acceptability of human foods. These plant materials contain certain substances that make them potent and beneficial in some aspects of human nutrition and health. Their potency has made them to be regarded as phytogenics exhibiting antimicrobial and antioxidant properties. Human being share certain things in common physiologically, biochemically and nutritionally with monogastrics and having similar gut system. The success story of phytogenics in human nutrition has led to the current surge in their use in monogastric nutrition. Incorporating Phytogenicology as part of the curriculum in the study of animal production is important to unveil their growth promoting potential, possible implications and their sustainable use.

Keywords: bioactive plants, monogastric animal, phytogenicology, spices.

INTRODUCTION

Phytogenicology which can also be regarded as Phytogenical Science is a word coiled by the authors and which means the study of spices, plants parts, and plant extracts in relation to their application in farm animal nutrition and nutrition-related health challenges. This entails the study and use of extracted bioactive molecules in plants or plant parts in processed form to solving nutrition and nutrition-related health challenges in farm animals. These biologically active products which are regarded as phytogenics, botanicals or phytobiotics, include herbs, roots, barks, woody parts, flowers, seeds, fruits and pods of plants that are medicinal, and some are

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pungent in nature such as spices (Windisch *et al*., 2008). There have been strong interests recently in use of these products in animal feeds especially the monogastric types (swine and poultry). However, this need to be sustained through integrated approach ranging from:

* Scientific study to determine their active ingredients
* Determining their properties and the behavior of the active molecules at certain conditions (temperature, interaction with feed components etc.)
* Determination of toxic substances in them and their toxic levels in feeds.
* Massive feeding trials using different animals including pets in determining their effect on farm animal productivity.
* Determining the possibility of using them in cubing some nutrition challenges in animal nutrition and health.
* Cultivation of such plants in commercial quantities.
* Good processing and packaging of the products for commercial purposes.

The tropical ecosystem of Africa, Asia, South and Central America is blessed with massive natural green biomass which could be explored. Use of medicinal plants and spices in human health and nutrition has been recognized and is advancing in many countries. In developing countries such as in Africa, the knowledge and interest is increasing. In Nigeria for instance, herbalists or traditional medicine experts (phytotherapists) use herbs, roots and tree barks to manage human infections caused by bacteria, fungi, helminthes and protozoa - the same organisms confronting swine and poultry. In human also, digestive disorder and conditioning of the digestive system of nursing mothers are managed using some of these products like spices such as *Xylopia aethiopica* (Omodamiro, 2012) and plant extracts (Sharifi et al., 2013).

Information and knowledge derived from human experience could be a necessary tool in developing a framework for studying, developing and utilizing these products in feeding of farm animals, especially swine and poultry which have similar gut architecture and digestion pattern as human. This can be achieved through collaborative efforts involving different experts in agriculture such as the animal nutritionists, animal physiologists, veterinary pathologists, biochemists, agronomists, traditional phytotherapists and knowledge from pharmacognosy. Apart from their biochemical make up, knowledge of their microbiological, serological, histopathological, endocrinological, immunological enzymological, metabolic and reproductive effects are important. Best agronomic practice for their cultivation, their processing, storage and

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packaging should also be scholarly studied. Their use in monogastric nutrition is growing because of certain performance challenges such as lipid oxidation, gut microflora, digesta fermentation, flatulence and reduced nutrient digestion and absorption in the face of global withdrawal of dietary antibiotics in farm animals.

The objective of this work is to intensify efforts in the search for alternative bioactive plant materials to replace antibiotics in animal nutrition by making Phytogenicology (the study of these plants and their products) a core area of the search and not only by feeding trials.

2.1 Nutritional Challenges and Current Solutions Adopted to mitigate them.

Performances of farm animals both in health and productivity needs to be enhanced through proper utilization of nutrients contained in the feed. Improper utilization of nutrients due to inadequate digestion and absorption could undermine the health status and productivity of farm animals Choct (2009). Digestion and absorption of nutrients by the intestine are key processes leading to nutrient utilization. These important processes could be undermined or hampered due to the following reasons:

According to Olomu and Oboh (1995) monogastric farm animals (swine and poultry) cannot adequately digest fibre to release nutrients embedded in them which occur in matrix form. Fibre has mineral binding capacity and could bind iron and zinc. Another problem fibre could impose is fermentation which will result to loss of energy and passing out of watery faeces (Kroismayr 2008) resulting to poor nutrient utilization (Hetland *et al*., 2003). The problem of fibre in monogastric animals is reduced by inclusion of feed grade enzymes (such as hemicellulase and cellulase) in the feed.

The presence of non starch polysaccharides - NSP (e.g. xylans and β-glucans) in some feedstuffs especially rye, barley and wheat makes feeds produced with them to form gel in the gut (Choct *et al.*, 1996; Lee *et al.,* 2004). Gelation of digesta in the gut reduces nutrient absorption, increases digesta viscosity (rate of digesta flow) and encourages fermentation in the intestine (Hetland *et al*., 2004). Inclusion of enzymes (such as xylanase and glucanase) is acceptable practice that could prevent gelation and reduce their negative effect (Choct *et al.*, 1996).

Antinutritional factors pose serious problems to feed utilization by swine and poultry. Phosphorus an important physiological and metabolic mineral (it is part of adonesin triphosphate – ATP, an energy yielding organic compound) is bound in cereal grains especially sorghum in form of phytic acid or phytate (Odetallah, 2016). Phytate is the main source of phosphorus storage in plants and is present in many plant-based feed ingredients Odetallah (2016). Cereal grains form 40 – 60% of diets for monogastric animals. Only about 20% of phosphorus in phytic

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acid in cereal grains is available to monogastric animals (Olomu, 2011). Addition of phytase (an enzyme that breaks down phytic acid) in the feed is the current practice to reduce the negative effect of phytic acid. Negative effects of other antinutritional factors such as trypsin inhibitor, heamaglutinins, saponins, tannins, canavalins, oxalates and hydrogen cyanide are been mitigated currently by processing such as boiling, drying, frying and toasting (Vaijiyakumari *et al*., 1996)

Rancidity (lipid oxidation) of feeds and feedstuffs has negative consequences on nutrient content of feeds and on health of animals (Botsoglou *et al*., 2004). The level of vitamins in feeds and feedstuffs could be undermined by lipid oxidation. Release of free radicals and peroxides when fat and oils are oxidized is a major challenge in animal feeding (Botsoglou *et al*., 2005). Addition of industry manufactured antioxidants such as butylated hydroxyl toluene (BHT) and ethoxyquine has been good nutrition practice. Ascorbic acid (vitamin C) and tocopherol (vitamin E) which are natural antioxidants found in fruits such as citrus and vegetable oils respectively are used to reduce fat oxidation or its negative effect on animals (Florou-Paneri *et al*., 2006)

The digestive system harbours a great deal of pathogens such as gram negative bacteria (*Salmonella, E. coli, Campylobacter* etc.*), protozoa* (*Emeria spp*), fungi and viruses which interfere with the ability of the gut to digest and absorb feed effectively (Namkang *et al*., 2004). Its nutrient distribution mechanisms (the villi height and the villi number, the crypt and the crypt depth, Na+ - K+ pump) could be further disrupted. Antimicrobial drugs are usually added to minimize this which plant extracts could be used.

Unlike in ruminant animals, fermentation in swine and poultry compromises feed utilization. Apart from energy loss and discomfort which fermentation could cause, fermentation of starch, protein and fat produces products such as ammonia, amines, amides and methane which are toxic to monogastric animals.

Young pigs and poultry are hampered by low secretion of certain endogenous fluids such as hydrochloric acid which is important for effective protein digestion in the stomach of swine or *proventriculus* of poultry such as chicken. This could be mitigated by mixing organic acids in feed or drinking water of these animals (Canibe *et al*., 2008). Plant materials which have acidic properties like lime juice has been reported to reduce the pH of foods (Novella, 2014).

There is high level of animal manure produced in farms, disposal of which leads to contamination of the environment through manure lagoons, which pollutes streams, rivers and even underground water. Livestock produces 37% of global methane production, 65% of nitrogen oxide and 64% of ammonia. Therefore, animal production is a big culprit in greenhouse effect, couple with offensive faecal odour emanating from animal manures which has direct negative impact on human habitat (Chukwu *et al*., 2006). It is a known fact that if animals utilize

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more of the nutrients there will be less faecal output released to the environment. Strategy to reduce faecal output through adequate nutrient utilization has been the application of enzymes and use of highly digestible feed ingredients to formulate feeds (Jonghloed *et al*., 1993). Nutritionists have used these methods to reduce phosphorus and nitrogen output and deposit in the environment which usually are washed down to underground water, into streams and rivers by rain water. Plant extracts and spices could play a key role in reduction of faecal output and faecal odour.

Mycotoxins which are toxins or secondary metabolites produced by fungi contaminate feeds and feedstuffs. Known mycotoxins such as aflatoxin, T2- Toxin, ochratoxin and fuminisin cause deleterious effects on animal's welfare especially young ones. In chicks for instance, reduced feed intake, paralysis, stunted growth and enlarged organs have been reported. Generally, one of the most important effects of mycotoxins is the impact on feed conversion ratio and growth due to lower nutrient absorption with or without feed intake reduction Laurain (2016). Lower nutrient absorption has been associated wiyh the infliction of lessions on the gastro intestinal tract resulting to reduced number of villi and height of the villi (Richard, 2016). Yeast extracts (esterified glucomanan - EGM) and plant extract mannan-oligosaccharides (MOS) in different forms are now widely used anti-mycotoxins to reduce the effect of mycotoxins.

2.2 Current Challenge

Judging from the above mentioned challenges in monogastric animal nutrition, which enzymes, antibiotics and good processing of feedstuffs have been used to reduce to some extent, the official withdrawal of antibiotics from animal feeds has opened up another chapter in the "challenge" debacle. Antibiotics are known to modulate the gastro intestinal tract (GIT) of swine and poultry. Their withdrawal has been reported to lead to proliferation of microorganisms in the GIT with the attendant nutrient fermentation, poor nutrient absorption and poor productivity (Dibner, 2004). The GIT must be in good health condition to be able to process feed, even when enzyme is added. The question could be; will the GIT be in good condition to respond appropriately in antibiotic-free state. Considering the fact that enzymes will only break down feed, a product with multi - dimensional efficacy is required which will modulate and prepares the gut for effective absorption of nutrients. Phytogenics could achieve this feat. This assertion could be supported by the following facts about phytogenic materials.

* They have complex and mixed molecules that are bioactively important such as phenols, organic acids, essential oils, lycopene, flavonoids, sulphorephene, tocopherol, carotene which act as antioxidants and antibiotics.

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* They are naturally renewable. Their natural sources (plants) could be cultivated on farms at commercial level.

* Their active ingredients such as essential oils and organic acids are well metabolized by the liver and report of negative residual effect is scarce.

* They are environment friendly because environmental toxicity has not been established for their use in feeds. Hence environmental contamination which is for instance associated with phosphorus and protein is not likely. This could positively attract commendation from environmentalists who have been pushing for sustainable environment in animal production.

* Bacteria resistance resulting from their inclusion in feeds has not been reported.

* Aromatic phytogenic materials such as spices have sensory qualities, and add flavour to feeds which improve palatability (feed acceptance by animals).

* With the campaign for organic agriculture which is in the increase, these products are good window to achieving that.

* Their recognition in animal nutrition, could lead to increase in employment in tropical environments, through cultivation of such plants, processing, packaging and marketing.

3.1 The Potency of Phytogenics

Naturally, bioactive plants and their products are embedded with numerous organic compounds ranging from carotenoids, flavonoids, organic acids, phenols and essential oils. All these compounds have different and similar properties and mode of action. This means that when they are added to feed, challenges such as fat oxidation, nutrient fermentation in the gut, flatulence, poor digestion and absorption can be mitigated. Synergy between the bioactive compounds could lead to better results of improved growth, feed efficiency and general productivity which have been reported by Windisch *et al*. (2008). This synergy could also be improved when more than one phytogenics are combined, each contributing its different bioactive compounds, thereby generating positive interactions.

Carotenoids are natural occurring organic compounds produced by plants. They are essential in human food and management of human health. Among numerous carotenoids that occur, zeaxanthin, β-carotene, α-carotene, lutein and β-cryptoxanthin are the most abundant. They are produced in yellow maize, citrus fruits and green leafy vegetables. Many carotenoids have essential roles having antioxidant properties to protect cells and tissues from stress caused by

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lipid oxidation. They have been reported to enhance immune function and reduction of cancer in human (Rao and Rao 2007). Carotenoids especially β-carotene are precursors of vitamin A, an essential vitamin for proper vision and reproduction.

Flavonoids are biochemical compounds which have a polyphenol structure and are responsible for the flavor in many fruits and vegetables (Ross and Kasum 2002). Flavonoids are considered to be plant secondary metabolites and have many possible health-promoting effects when consumed (Wang *et al*., 2011). One of the most common classes of flavonoids found in plants like citrus fruits are flavonones, in particular naringin and hesperidin which impart the bitter flavor to grapefruit (Garg *et al*., 2001; Ross and Kasum 2002). Naringin is hydrolyzed to naringenin by gut bacteria before absorption (Shulman *et al.,* 2011), which is a common precursor to many other classes of flavonoids (Wang *et al*., 2011). Naringenin is thought to have several health-related benefits and biological effects, which include acting as an antioxidant (Shulman *et al*., 2011). Hesperidin was reported to increase high density lipoprotein (HDL) and decreased low density lipoprotein (LDL), triglycerides and plasma lipids when administered to rats (Benavente-Garcia and Castillo, 2008). Essential oils and organic acids have been reported to have antimicrobial properties and phenols are antiseptic in nature. These are used as feed sanitizers, keeping feeds free from microbes and could increase storage quality of feeds.

4.1 Essential Investigations that are Necessary

Though phytogenics have been recognized to have the potential to improve productivity in animal agriculture it is important that their mode of actions and their likely dietary implications be studied. In this regard, their study should also be centered on their;

- Microbiological effect in the feed and in the gastro intestinal tract.
- Serological effect, determining their impacts on the blood cells, serum protein and liver enzymes.
- Histopathological effect noting their impact on internal organs such as the liver and kidney.
- Endocrinological effect, understanding how they affect the release of hormones such as insulin, thyroxin, glucagon, sex hormones, reproductive hormones and their activities.
- Immunological effect studying their stake on immune system in the area of mucus secretion and production and activation of antibodies especially immunoglobulin (IgA).

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- Enzymological effect knowing their place in secretion, activation and activities of enzymes of digestion (pepsin, trypsin, chemotrypsin, amylase, sucrase, lipase etc.).
- Metabolic effect, determining whether they have significant role in biosynthesis (e.g. protein accretion) and breakdown of organic compounds (e.g. energy generation) in the body such as having similar role as cofactors and coenzymes.
- Gut anatomy influencing the number of villi, height of villi, crypt depth and gut length.
- Reproductive effect noting their impact on oogenesis, ovulation, feotus implantation, spermatogenesis, semen quality (volume, colour, viscosity), erection, sperm count and sperm morphology.
- Muscular effect, inquiring whether they act as stimulants.
- Uterine effect studying their effect on feotal development and their relationship with oxytocin and vasopressin.
- Mammary effect unveiling their effect on milk synthesis and milk letdown. Their relationship with oxytocin.
- Product quality effect investigating their impact on egg quality (shell colour, shell thickness, yolk colour, albumen height), nutritive value and organoleptic property of meat, milk quality (taste, colour, nutritive value).
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5.1 Conclusion

Phytogenic substances have shown great potentials in tackling some of the problems posed by anti-nutritive factors in some feedstuffs and the challenges of official withdrawal of antibiotic feed additives in feeds for farm animals. These substances have bioactive compounds in complex forms which exert synergic action in animals. Their great advantage is that they abound naturally in our ecosystems especially in tropical green environment, they can be cultivated which could lead to sustainable productivity of farm animals. Their comprehensive study and inclusion in curriculum of Animal Science is vital to critically and fully harness their potentials.

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