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Review of Agro Waste Plastic Composites Production

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ABSTRACT

This article reviews the literature reports base on agro waste plastic composites using different fiber as fillers and reinforcements. Various processing methods and conditions; compression molding process, injection molding, and extrusion method are used in the composites productions. Characterization challenges associated with the agro waste plastic composites productions were also examined. Thus, the findings of this research review can be use as a data base for further inquiring into the agro waste plastic composites in a view to enhance the development of the sector.

Keywords: Agro Waste Plastic Composite; Characterization; Production

1. Introduction

Composites are materials composed of two or more different materials with the properties of the resultant material being superior to the properties of individual material that make up the composites. Hence by definition, blend of agro waste and plastic could be composites [1]. Agro-wastes are by-products of agricultural produce, it can be husk, straw, cobs or fiber [2,3]. However, agro waste plastic composites are combination of agro-wastes filled with plastic polymer (virgin or recycled) to obtain a material of superior properties to the single material for multi functional applications [4-6]. The studies of agro-waste and natural fibers composites have attracted due consideration from academicians and industrialists for their excellent properties such as; improve mechanical strength, water and oxygen barrier, dimensional stability, thermal; wear resistance, chemical etc. [7,8]. In practical applications, low cost agro waste fiber reinforced thermoplastic composites are gaining significant roles in building and automobile industries, and other consumer applications [9,10]. More so, the inherent quality outputs of waste plastic composites such as low cost, renewability, biodegradability, low specific gravity, availability, high strength and non-abrasiveness proffer the use of agro waste plastic composites in variety of practical applications [11-15]. Underutilized agro-waste are most importantly rich resources of lignocelluloses materials, some typical example are millet, rice, wheat, corn straw, cocoa husk, corncobs and fiber [16-18]. Even though its seems simple to define agro-waste as an aggregate for plastic composites, the problems of decomposition in the ground, difficulty in digestion and low nutritional value for animals necessitate alternative utilization of agro-waste husks [19,20]. Though there are limited numbers of research studies on some of the agro-waste like millet husk and rice husk reinforced plastic composites [21,22]. Considering the generality of lignocelluloses fibers in the reinforced plastic composites, major setback in using these fibers are the relatively poor compatibility with hydrophobic thermoplastics, which often lead to poor mechanical properties [10,23]. However, agro-waste as a filler and reinforcement in thermoplastics are popular [24-27]. The search for agro-waste compare to inorganic materials such as glass filler, carbon filler, clay etc. do not have listed advantages [28]. Thus, these inorganic most likely produce residues with toxic byproducts during manufacturing process [12]. Generally, natural fiber polymer composites such as wood plastic composite seem to be the incompatibility between hydrophilic and hydrophobic thermoplastic matrix [3,29-31]. Hence, apart from the low cost of agro-waste there is particular interest nowadays to environment and biodegradability properties of materials to actualize the scale up production of agro waste plastic composites by the formation and synthesis of these filler fibers, various methods are required which involve mixing of filler husks at different filler loading per weight [11,20,32].

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2. General Concepts

In compiling data for this review, the primary methodology use is data gathering and review of published and online document on agro waste material plastic composites conversion technologies. Data from these documents are then organized into this piece of work, which include, key notes of technology information, agro waste conversion process, coupling agents, fillers, and equipment used [33]. Over the last few decades, the whole world has experienced rapid changes and socio-economic transformations. These changes affected and caused severe stress mainly on climate, energy, environment and most facets of globe. Nevertheless, modification in economic and social culture management of the world bring about decrease farm incomes, energy source, environmental safety and high rate of joblessness, leading mass departure of the useful drive and absence of equilibrium for the people of areas.

Certainly, there is demand for social and economic improvement as well as to seek a way of broadening the income generation threshold to cope with the new challenges. Also because of recent need of novel application of materials from thermoplastic resins loaded with fillers in lignocelluloses fibers due to the added benefits that they provide to the materials in terms lightness, low cost, mechanical resistance etc. [2,34,35]. Consequently, this research may lead to emerging business as well as key sector that national, local governments and private organizations should assist. Thus, this encourages as a medium of renaissance for bursting economic and reduces environmental hazards. The development of agro waste plastic composite was followed by the change on people's demands and behavior [5,6]. The demand for environment friendliness gives a possible substitute, discrete and additional genuine agro waste knowledge fulfilling the desires of the qualified as well as much needed "novel" composites [36]. An inspiration following the review research is based on the fact that during the last few decades the growth of composite, agro waste plastic composites industries has been dramatic and could serve as reference material in this sector.

Although little has been done the on some cereal husk waste composite, the condition require achievement of suitable use for these residues in the creation of new materials with practical relevance. This aims at scale up the production processes, which will enable agro wastes husks plastic composites design into different products with the maximum achievable properties [37]. Traditional development of agro waste can bring enormous benefits to the economic, society and environment of an area. However, at the same time there is a realization that certain part of the economic have been left behind in development. Given considerable resources into the agro waste plastic composite in the mode of build and natural environment they are gradually seem as areas for economic improvement. This, at the same time, would also contribute to some extent resolving the difficulties associated with over accumulation of waste e.g. formation of habitants for dangerous fauna, and threat to diseases [31].

2.1. Agro Waste Plastic Composites Formation

Inorganic composite materials in recent time have gain wide applications in many higher end industries such as sporting facilities, medical, aerospace, turbines and indoor decorations. However, applications of agro waste plastic composites across industries have been somehow limited. The reason for this can be due to cost issues relating to existing methods of composite production as well as the cost of techniques in relation to composition and formulation. Presently, agro waste plastic composites are prepared base on differences in formulations, filler loading, polymer plastic (virgin or recycled), addtive aggregate, processability techniques, fiber type and required characterizations [12]. These may be used individually or in combination with each other so as to achieve desired structure of agro waste plastic composites. An understanding of available composites fabrications processes and how they are apply to different composites is a necessary requirement for proper selection of composites design for engineering. As mentioned, the characteristic of composites depends on the nature of the reinforcement, the ratio of resin to reinforcement, and the mode of fabrication. Below are some reinforcement polymers in plastic composites formations [38].

1) Polyethylene Terephthalate (PETE).
2) High Density Polyethylene (HDPE).
3) PolyvinylChloride (V).
4) Low Density Polyethylene (LDPE).
5) Polypropylene (PP).
6) Polystyrene (PS).

Another major issue in plastic composites formation is temperature variations in each processing technology, particle sizes, and environment as can be seen in **Table 1**.

2.2. Recycling of Plastics Wastes

Globally, 140 billion metric tons of agro waste is generated every year from agriculture. This volume of agro waste can be converted to an enormous amount of valuable resources; composites, energy, and raw materials equivalent to approximately 50 billion tons of fuel [42]. As raw materials for composites formulations and other usable items, agro wastes have potentials for large scale industries and community level enterprises. Agro waste from residual stalk, straw, leaves, husk, hull, nut or seed shells, and waste wood are widely available, renewable, and virtually free, agro waste are an important resource

Table 1. Compositions, techniques, and formulations of some polymer plastic.

Polymer Matrix	Density g/cm^3	Mesh	Coupling Agent (wt %)	Technique	Formulation	phr	Melt Flow Index G/Min	Reference
PP	0.96		Maleic anhydride	Co-twin screw extruder	RH50-PE50	1	3 g/10	[12]
HDPE 5502	0.954	60	Maleic anhydride	Single screw extruder	RH35-PE65	3.1	0.2 g/10	[39]
HDPE	0.965	100	Maleic anhydride	Twin screw extruder	RH40-PE60	1.5	23 g/10	[40]
PVC		150	Hexamoll		RH20-PVC80	2		[41]

for waste—wealth plastic composites [43]. A major concern about the use of plastics for packaging and disposable items is the environmental effects of the materials lasting for centuries in the landfills or other place of disposal [44]. Recycling is being promoted worldwide as the way to address plastic items [38]. Many municipalities are establishing recycling programmes to battling with this problem at hand [35]. There are two significant reasons for the poor plastics recycling record: 1). some plastics are thermosetting and cannot be recycled (they cannot be remelted), 2). There are many grades of thermoplastic materials, and they cannot be mixed when they are remelted. Society for plastic industries (SPI) established guidelines to code plastic containers so that they can be easily sorted for recycling [45].

There are great numbers of thermoplastics, but almost 90% of the volume of thermoplastics manufactured is made up of only six: polyethylene (high and low density), polystyrene, polyvinyl chloride, polypropylene, and polyethylene terephthalate [38,46]. Studies of agro waste plastic composites productions outlet seems rather limited. Thus, the much desire in an area of relevance for this is most likely due to advancement in agro waste in developed countries, probably because they are seen as being more important facilities and machineries than under developed and developing countries that have abundant agro wastes [47]. Most of present scientific establishment are focused on the methods which are in scale up stages than optimization of production. Several studies links via appraisal outcomes related to reason for agro waste research application, strategies chosen in addition to result from agro wastes research carryout in support of researcher opinions [48]. Studies directed through several authors [49] exposed thus, some earlier establish application structures existed could not be appropriate for scale up production and did not fit the most agro wastes. [30] Concluded that agro wastes plastic composites were lagging behind in term of production for commercial purposes to virgin inorganic materials.

However, since matrix and reinforcements are primary constituents of an agro waste plastic composite material, it is worth to note that there are other additives which are used to modify the properties of the polymeric resin which make up the matrix. Thus, additives such as viscosity, modifier, fillers, reagents, pigments and others are basic components of plastic composites. Fillers are materials which may be added to the resin to vary the properties and/or extend the volume of the matrix [50]. In addition, some additives are use as accelerators, which control the rate at which curing can occur.

2.3. Agro-Waste Production Methods

2.3.1. Extrusion Process

It is a process in which large volume of constitutes are produce, raw materials such as thermoplastic granules, pellets or powder are placed into a hopper and feed into barrel of a screw extruder. The barrel is equipped with helical screw that blends the mixture and conveys them down the barrel toward the die. The internal frictions from the mechanical action of the screw heat the mixture and liquefy them. However, the screw has three distinct section for performance of such actions; feed section, melt section and pumping section [51,52].

2.3.2. Injection Molding

In this process the constitutes are feed into the heated cylinder, and the melt is forced into the mould either by a hydraulic plunger or by the rotating screw system of an extruder [51-53].

2.3.3. Injection Blow Molding

It is a modified extrusion and injection molding process. Depending on the materials, the blow ratio may be as high as 7:1. Blowing is usually done with a hot air blast at pressure ranging from 350 - 700 KPa. In some operation, extrusion is continuous, and the moulds move with the tubing [52,53].

2.3.4. Compression Molding

This process involves a pre-shape charge material, premeasured volume of powder, or viscous mixture of liquid-resin and filler measures is place directly into a heated mould cavity that typically is around 200˚C but can be much higher. Forming is done under pressure from a plunge or from half of the die, thus, the process is somewhat similar to closed die forging of material. The process is usually used in thermosetting plastics with the

original material being in a partially polymerized state [52,53].

2.3.5. Co-Extrusion Process

Involves simultaneous extrusion of two or more constitutes through a single die. The product cross-section thus, contains different constitutes each with its own characteristic and function. It is commonly performed in shapes such as flat sheets, films and tubes, and is used especially in food packaging where different layer of polymer constitutes have different function [52,53].

2.3.6. Thermoforming Process

It is the process of forming thermoplastic sheets or films over a mould by means of the application of heat and pressure [53].

2.4. Agro Waste Plastic Composites Processing Methods

1) Classifying the agro waste materials to separate fiber materials from non fiber materials.

2) Selecting the classified fiber materials according to a desire property.

3) Forming agro waste composite by integrating selected fiber/husk with a plastic material.

2.5. Processing and Manufacture of Agro Waste Plastic Composites: Problems and Challenges

Agro waste plastic composites materials hold the potential to redefine the field of traditional composites materials both in terms of performance and potential applications [30]. There is little doubt that the agro waste plastic composites have tremendous markets through their outstanding properties. But developing processing manufacturing technologies in terms of quantity and value for commercialization will be one of the biggest challenges [54]. For example, dispersion of agro wastes particles or compatibility with matrix materials is the important issue [55]. Quick increase in volume and categories of agro waste, as a result of intensive agriculture in the wake of population growth and improve living standards, is becoming a burgeoning problem as rotten waste agro waste emits methane and leach ate, and open burning by farmers to clear their lands generate carbon dioxide and local pollutants [1,33,56,57]. However, improve management of waste from agricultural wastes is contributing toward reducing the effects of climate change, water and soil contamination, and air pollution [58]. Furthermore, this waste is of high value with respect to material and energy recovery. In an effort to harness these potentials, researchers had inquired into it extensively [59,60]. There are certain strengths that agro waste plastics composites companies possess relative to virgin inorganic materials. [13,60] gave some of the differences that exist between virgin inorganic materials plastic composites companies and agro recycled wastes resting on attributes namely; organization, action, procedure, as well as human [61]. Exhibiting appraisal of it recommended articles, several alterations in addition to developments be make hence its outcome assessment base on merits then demerits from key attributes. In terms of structure, processes and people, the virgin inorganic materials composites companies are a beneficial situation in case of accepting a novel modification of idea, in as much as proprietor/administrator gain assurance to, the management for the change method, together with a complete understanding of the process [55]. Financial in addition to scientific means problems are the key constraints tormenting agro wastes plastic composites businesses and researches were cited by [1]. Thus, it has been observed through [62] that suggested dual constraints vested on agro waste composites production. They were the incompetence then expertise, as well as insufficient fund and personnel needed in this specific area. The aforementioned two key constraints may subsequently resulted to more, namely lower research and preparation financial plan, which additionally restrict development for scale up production acceptance.

However, agro wastes composites have limited data collection systems and that poise other challenges, while data could be vanished in the process, else it hang around with researcher and administrators [42]. Thus, it stresses importance of techniques in verifying classes for information that have being gathered afterward its methods that can exercise achievement. Extent to which difficulty using this kind of techniques essentially takes into account and so the easiest edition to the already established virgin inorganic composites plastic companies be desired.

Preparation as well as learning could be the key ingredient in production programme of the agro wastes composites sector [49]. Preferably, for undersized sector operating with a small number of personnel, can perform effectively and render simple preparations as well as instructing the workers, in addition to period required in enforcing preparations in minor stage could invariably lesser to major stage of the sector. Nevertheless, agro wastes plastic composites industries that acknowledge importance of preparation, lack strong style as to the need as well as short of means, experience, nor provisions to deal with efficiently the plans to assist workers. Another problem is the inability of government and private sector in sharing enough finance to carryout preparations. Lack of strategies in achieving agro wastes recycled plastic composites could prove to be difficult. [33,

42,56,63] related on the constraints encountered by waste management sector in an effort to improve a best customs. Certain predicaments are as follows:

- Opposition for transformation;
- Absence of knowledge in excellence supervision;
- Shortage of funds;
- A prominence for interim reasons; and
- Lack of plans as well as general aims.

However [34], in their literature findings pertaining constraints comprehension in the modification, short of experience and professional, difficulties in data retrieval in addition to location are some key problems experience via waste conversion industries. Hence, these researchers acknowledge unproductive interaction, personnel be short of ability, lacking the importance to anticipation as well as absence of plan. Consequently, the best experience for most constraints encounters which could afford progress in an effort to successfully actualize the structure with regard to agro waste sector.

3. Reasons for Adopting Improvement and Scale up Production

Researchers have embarked on agro waste plastic composites for different reasons. [8,47,64,65] acknowledge different reasons stated from various authors that were deliberated. These are:

1) Upgrading development of agro waste composites, hence become simpler in assuring companies and government for financing commercialization participate effectively by means to gain smooth process.

2) Waste management organizations trust essential law governing free in addition safe environment for people to thrive and personnel encouragement that shows administrative approach through proper use of waste-wealth system approach.

3) Altering people hopes still in respect of establishment that embark on agro wastes is progressively gaining acceptance.

4) Creating employment and have pride in agriculture.

5) To improve poor sanitation performance from harmful faunas that harbour diseases.

While the aforementioned justifications differed, it is showing identical bearing for improving usability and scale up production to create safe environment, job and proffer future for agro waste as raw materials. Successful agro waste composites productions occupied strategic stress from outcome of technology changes, financing latest facilities, techniques and to gain inspired researcher group that possess administrative expertise [64]. Thus, lean toward few suitable employees in terms scale production for commercial purposes. Similarly, problems of compositions, filler loading and compatibility are still inherent [66]. See **Table 2** for example of composition.

4. Lessons from Agro Waste Composites Production Outfit

Various researchers debate in diverse methodology in agro wastes composites acceptance to apply for both recycled and virgin plastics because of its essential qualities in addition to some compositional diversity [67,68]. Presumably the discrete procedure that suits the agro wastes composites background has to be planned. Many researchers [7,56,63,65,69,70] have a variety of views about wastes composites production and implementation in scale up manner and some researchers' in an effort to combine as well as to blend relevant realities.

A brief period of time remuneration may result to lasting profit [33,71]. Smaller companies that embark on agro wastes research and development could not offer heavy finances for complete period on training and instructing solo. Agro waste composites industries ought to, for small size, looking at the development plan which could scale down fee, add revenue, lessen discard, and reduce malfunctions, through better capability in term of achievement thus, can be accomplish in short period [80].

Excessive stress for wastes management should be suppressed [42]. New agro wastes composites production outfit have no capability to hired expertise that can train personnel through rigorous testing by rules as well as trainings. However, these will assist professional in short period to enhance quality improvement, training and learning, by institutions of higher learning, research institutes, and allocating learning means by opponent business like outfits via linkage can be easier choice [72]. Linkage ensures possibility to gain knowledge to solve constraints as can be observed in **Table 3**.

5. Discussion

The line of reasoning which were submitted by various writers indicates that some power as well as limitation related to production of agro wastes plastic composites. Meanwhile, there are also constraints with application

Table 2. Composition of the studied formulations.

Polyethylene (wt %)	Rice husk flour (wt %)	Coupling agent (Phr)
90	10	2
80	20	2
70	30	2
60	40	2
50	50	2
40	60	2
30	70	2

Table 3. Examples of agro waste.

Type	Examples	References
Wheat	Straw, Husk	[17]
Rice	Husk, Hull, Straw and Stalk	[40]
Sorghum	Husk, Straws, Cobs, Stover, Leaves	[72]
Millet	Husk, Straws, Cobs, Stover, Leaves	[73]
Coconut	Fronds, Husk, Shells	[74]
Coffee	Hull, Husk, Ground	[75]
Cotton	Stalks	[76]
Peanut	Shells	[77]
Sugarcane	Bagasse	[78]
Nuts	Hull, Shells	[54,79]

best and customized processes in such segments. Achievements, emphasize on the writing cannot suggest actually an authenticity confronted by agro wastes composites production by agreeing on excellence creativity. In several circumstances, it has confirmed the advancement mostly via experts that have usually accepted huge international methods. The agro wastes composites research and production sectors understanding of continuous improvement techniques came through data acquired from experts and professionals whose practical knowledge in these set up may be limited considering multifaceted types of agro wastes plastics composite in operation and the true problems confronting them.

What are the key constraints confronting these sectors? This literature exposed the two main difficulties usually bedeviling majority of agro wastes plastics composites production. Firstly, it has to do with finances and secondly, it concerns broad means of problem, which can be generalized to period, personnel, professional as well as expertise. Maximum scale production method may include lot of advancement scheme in a row at the same time; afterward need preparation of everybody in agro waste sector ideas, instruments, management, and then harmony and so on. Entirely these need some substantial financing. Is it affordable by actors in sector? As soon as it approaches executing progress plans which most likely require novel instruments in addition to technology, it could once more need some brand of monetary pledge. Apparently, production companies may not be able settle for such method due to the poor result on their means accessibility.

Agro wastes composites production must be presented with a scale up and continuous improvement method which is appealing to them in which cannot assure for enhancing all nor get solution to all constraints nonetheless somewhat it necessity can be acknowledge within less period, in regarding to enduring feasibility. Meanwhile new knowledge, problem solving techniques and profit are some of the key reason of entire commercials, major and minor summarily it cannot be say that ensuring ideas to get upon may possess influence on end result, that is addition of revenue, trade as well as decrease in price of manufacture. However, together training agro wastes composites proponents to acquire enduring focus on all procedure require. Instant profit could be accomplished via classifying agro waste make in particular setup, in term of period, cash, procedure, delay and snags, scraps, rework, vigour and so on. In addition to making the system effective it should embark on constant improving structure then efficient application agenda plan notably essential for undersize firms and research industries in wastes plastics composites sectors. Considering this, simply then an extra development could be realized through a progress method, constant cultural change and acquiring knowledge for production processes.

6. Conclusion

This review study presented different methods and procedures for the production of plastic composites from agro waste materials which have received considerable attention in the recent time. Furthermore, it provided a summary of production challenges, characterization of various agro waste fibers and polymer matrix. Consequently, it gave changes in activity, stability, renewability, recoverability and selectivity in particular in some of these production methods. Financial constraints, manpower and technology challenges facing this sector were equally outlined hence trying to proffer suggestions on the way forward. Drawing from the discussions and ideas presented, the whole notion of agro waste plastic composites in small and large companies could basically reappraise production atmosphere, intensive research and commitment.

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