Creative Application of Mustard Straw and Stalk

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Rapeseed mustard have always stood high among other oilseeds be it interms of its oil quality or its seed meal rich in bioactive compounds. The agro-waste after mustard harvest is left for decay in field or it is burnt without serving any purpose which instead creates environmental pollution. It was estimated that approximately 22 mt of mustard straw and stalk (annually) is available in India (Tripathi et al. 2008). According to Pal et al. (2013) Indian mustard straw and stalk constitutes about 70% of total plant minus the seeds. According to studies by Maiti et al. (2007) mustard straw and stalk has higher content of cellulose (48.5%) and hemicellulose (29.6%) in comparison to agro-waste residue of rice straw (cellulose 28.5%, hemicellulose 24%), wheat bran (cellulose 30%, hemicellulose 27.2%) which can act as cheap source for production of lignocellulolytic enzymes and alternative use to generate bioethanol. Fossil fuels globally are still the major source of energy with consequences for their effect on climate change. Alternative uses has always been in focus like the use of biofuel-biodiesel and bioethanol. Lignigication of straw residues have received wide attention for used in food industries. In oilseed crops the xylo-oligosaccharide contains more acetal and uronic acid substituents in comparison to other cereal crop, which adds to the advantage in food industry (Pronyk and Mazza 2012). Mustard straw and stalk being rich in cellulose and hemicellulose content serve as carbon source by the fungus for production of enzymes such as glucosidase, xylanase and xylosidase in submerged fermentation (Pal et al. 2013). Agricultural crop wastes, for example, provide a low-cost feedstock for the biological synthesis of fuels and chemicals, as well as economic, environmental, and strategic benefits (van Wyk, 2001). In India, mustard stalk and straw (MSS), devoid of seed, account for approximately 70% of the total plant and are considered agricultural waste. MSS is also not used as cattle feed and is either left in the field to decay naturally or is burned without serving any purpose other than adding to environmental pollution.

Mustard being a member of brasicasea family has unique identity with the presence of glucosinolate. The phytochemical role has been recognized as anti-insecticidal and anti-herbivore activity. Pyrolysis of mustard straw has been found as bio-oil for insecticidal activity (Suqi et al. (2014). The conversion of mustard straw through thermochemical means is known as pyrolysis.

Another alternative for recylcling of organic waste is composting, this is widely accepted practice in India for agriculture use. The utilization of mustard straw agro- waste for alternate use will not only serve as a source of income but also reduce environmental pollution.

Mustard straw as discussed earlier, has high content of cellulosic compounds and less of protein content rendering it unpalatable and indigestible for the ruminants. Various chemical methods have been used to improve the nutritive value of mustard straw. One of the biological methods is fermentation of mustard straw with white rot fungi. Through this process it renders the straw fiber more accessible to rumen enzymes for subsequent digestion. The extent of mustard straw quality fermented with white rot fungi is regulated by relative degradation of lignin and carbohydrates besides the protein production (Misra et al.2006). The performance was found to be favourable in terms of dry matter, crude protein content and digestibility of mustard straw. This shows the ample uses of dry mustard straw for various functions instead of allowing it to decay in the field.

Wood industry is facing tough competition to meet the demands of the population. Many studies have demonstrated the alternative use of wood by substituting it with waste of annual plants for wood-based board industry and paper industry (Dukarska et al. 2015). Study by Dukarska et al (2015) showed comparable chemical composition to that of wood with its added advantage is the shape of the straw particles (slender and flatness) similar to the particles from the wood particle core layer.

Table 1. Alternative uses of or recycling of mustard straw and stalk residue

SL. No.		Brief description	References
1.	Composting	Composting is one of the common ways to recycle organic waste. The humus in this waste is of great value for maintaining soil fertility.	Raj and Antil (2011)
2.	Lignocellulosic bio- refinery	Lignocellulosic biomass serves as the most abundant material in the world. Lignocellulosic biorefinery coverts lignocellulosic biomass to production of energy and chemical needs	Zhang et al. (2007)
3	Prebiotic compounds	Lignification of mustard straw leads to Xylo oligosaccharide with high substituents of acetyl and uronic acid adding value for use in food applications as prebiotics.	Pronyk and Mazza 2012
4	Lignocellulolytic enzymes	Mustard straw and stalk (MSS) are a novel source of lignocellulolytic enzymes and a saccharification substrate. MSS is a suitable candidate as a low-cost agro-residue for the manufacture of lignocellulolytic enzymes by T. clypeatus, and it may also be used to make bioethanol.	Pal et al. (2013)
5	Carbohydrate source	Because of its high sugar content serve as source for extraction of carbohydrates for use in food industry.	Pronyk and Mazza(2012)
6	Pyrolyzed bio-oil	Mustard pyrolyzed-oil as an alternative use for chemical insecticide	Suqi et al. (2014)
7	Protein rich animal feed	Mustard residues fermented with various fungi may be converted to protein-enriched food	Misra et al. (2006)
8	Particle board industry	The boards made up of even 100% mustard straw particles met the requirements of EN312 standard for boards intended for general use in dry conditions. Reduction of use of mustard straw to 75% allowed for the production of P2 boards-boards used for interior design like furniture in dry conditions.	Dukarska et al. (2015)

Conclusion

The recycling of agro-waste is the need for the hour through ecofriendly, viable and socially accepted technologies to prevent the large-scale accumulation of these waste in order to overcome pollution and disposal problem.

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