AGRICULTURAL LIGNOCELLULOSIC RESIDUES IN GREECE: ESTIMATION AND PROSPECTS FOR RATIONAL UTILIZATION

George I. Mantanis and Paul K. Koukos

FOREST RESEARCH INSTITUTE LABORATORY OF WOOD TECHNOLOGY
VASSILIKA, GR-570 06, THESSALONIKI MACEDONIA, GREECE

ABSTRACT

The subject of agricultural lignocellulosic residues produced in Greece is reviewed in this work. An estimation of the annual overall amounts of the agricultural residues is made, and the rational utilization prospects for these not exploited biomass residues are discussed.

Key words : Agricultural residues, particleboard, fiberboard, charcoal, briquette.

INTRODUCTION

In Greece, large amounts of lignocellulosic residues are produced every year after the end of the agricultural season of the various agricultural species. These residues are either burned down or left over in the ground without any further utilization. In most cases, such residues cause also various disposal problems to the farmers. The agricultural residues are a part of the annual biomass production, and mainly include the straws of wheat, barley, oats, rye, the stalks of maize, cotton, tobacco, and the husks or shells of walnuts, almonds, rice, etc.

According to the Ministry of Agriculture of Greece, the annual production of the most important agricultural species was about that of Table 1 (Greece's Ministry of Agriculture 1992). The total amounts of the agricultural products exceed the 5.5 million tons. Based on similar works done in the past (IIT 1981), it was estimated that the annual overall quantities of agricultural lignocellulosic residues produced in Greece are these indicated in Table 1. Notable is the fact that the overall amounts of these biomass residues exceed every year the mark of 10.0 million tons.

Table 1 Annual production of main agricultural species and estimated quantities of agricultural lignocellulosic residues in Greece(Greece's Ministry of Agriculture 1992, Koukos 1996)

Agricultural *species*	*Annual production (in tons)*	*Estimated annual quantities of agricultural residues (in tons)*
Wheat	2,211,500	5,971,000
Barley	508,500	762,000
Oats	72,000	108,000
Rye	42,500	64,000
Maize	2,320,000	2,784,000
Rice	89,000	142,000
Cotton	210,000	630,000
Tobacco	150,000	120,000
Sunflower	30,000	24,000
TOTAL	5,633,500	10,605,000

The chemical compositior of the agricultural species consists largely of cellulose and lignin (Table 2). There are also enough amounts of silica (Si), and little quantities of inorganic salts and oxides of calcium (Ca), sodium (Na), magnesium (Mg) and potassium (K) which are widely known as "inorganic compounds".

Table 2 Chemical composition of various lignocellulosic fibers(Fadl et al. 1978, Tappi 1983, Youngquist et al. 1993)

Lignocellulosic fibers	*Chemical composition (%)*			
	Alpha-cellulose	*Lignin*	*Inorganic compounds*	*Silica*
Wheat straw	38-46	16-21	5-9	3-7
Oats straw	31-37	16-19	6-8	4-7
Rice straw	28-36	12-16	15-20	9-14
Maize stalk	N/A	22-24	5-6	3-5
Rice husk	38-40	22-24	20-22	19-20
Sugar cane	32-44	19-24	2-5	3-7
Kenaf	31-39	14-19	2-5	N/A
Softwoods	40-45	26-34	0-1	0
Hardwoods	38-48	23-30	0-1	0

N/A : not available

Most of the lignocellulosic residues have a low density and that is why they usually occupy a large space. Consequently, their collection and transfer becomes hard, time-consuming, and costly. They usually need to be gathered all together in a closeby area; otherwise, the costs of collection and transfer go high. Until today, a number of utilization techniques have been developed so as to exploit in a rational way these biomass residues. These techniques include the production of particleboards, fiberboards and paper, and also the production of charcoal and briquettes especially in rural areas that are far away from the forests. Key points of the main technologies used till today are presented in this work in order to stimulate and encourage such technology implementations in Greece.

(a) Production of particleboard - fiberboard - paper

The lignocellulosic residues can be used in low proportions (10-15 %) in the production of particleboard, or even in the production of fiberboards following various chemical or mechanical pulping methods. In general, the economical feasibility of such uses is influenced by the cost of production, the availability of raw material, and the physical and chemical properties of the lignocellulosic fibers.

In USA and Canada, the straws of wheat, barley, oats and rye, and the husks of rice have been utilised in mixture with wood fibers in the production of pulp, particleboards and fiberboards; although they were of lower quality (Hesch 1978, Loken et al. 1991, Knowles 1992). In addition, fibers from cotton stalks, which have a high cellulose composition and show many similarities with the hardwoods fibers, have been used to produce pulp with mild organic solvent pulping methods. Such a research project has been implemented in a pilot plant in China (Frazier 1993).

In Asia, especially in countries with large annual production of rice, e.g., India, China, husks of rice have been used to produce cement-boards (Govindarao 1980). China and Japan also have made attempts to utilize indian cane fibers in combination with wood fibers and foamy plastics to produce various kinds of wood-boards (Wang and Joe 1983).

In Europe (Belgium and France), the woody parts of flax after following a fiber separation method were used as raw material in an industrial scale production of particleboards. In Germany and Poland, similarly, the woody stems of hemp were separated and mixed with wood fibers to produce various particleboard products (Hesch 1968, Newman 1970, Injutin et al. 1983).

In USA, recent research programmes have been concentrated on the rational utilization of kenaf and jute fibers to produce pulp and fiberboards (Rowell 1992, Sellers et al. 1993). Especially interesting is the ongoing research of the University of Wisconsin that - in cooperation with the Government of India - attempts to utilize jute and kenaf fibers with mild acetic acid, biomechanical and mechanical pulping processes for the production of paper (Sabharwal et al. 1994, 1995).

Other research (Grigoriou 1993, 1994, 1996) has showed that wood particles used in the middle layer of particleboards can be replaced by either olive-cernel or particles from almond shells in amounts of 10 and 20 %, respectively. Particleboards made from such agricultural residues were of somewhat poorer quality compared to those of wood; however, small amounts of these residues (up to 20 %) had no significant impact on the boards quality. In addition, such residues (almonds, olive cernels, nuts) in a powder form have been used as additives in adhesives, especially in the production of plywood, so as to improve some of the adhesive properties (Sellers 1985).

In conclusion, most of the agricultural residues produced can and should be used in the production of particleboards - fiberboards in low proportions (10-20 %), and always in mixture with wood. It seems that the properties of the final products are not significantly influenced by the low proportion presence of such residues. Such implementations are well encouraged, especially in Greece where only a small part of the agricultural residues is utilised in an industrial scale. In such attempts, however, the main disadvantages of low availability in raw material throughout the year, long period of storage, susceptibility to fungi and insects and high costs of transfer should be carefully considered in order to be solved and overcome.

(b) Production of charcoal and briquettes

One of the alternative rational uses of the agricultural residues is the production of charcoal. Specifically, in rural areas - especially in the developing countries - it is feasible to produce charcoal with a simple carbonization process using as raw material the available agricultural residues. In India (IIT 1981), a carbonization technique has been used with success. Under controlled conditions of temperature and pressure, a charcoal product called "Paru" has being produced. Rice husks, wheat straws, coffe husks, groundnut shells, coconut shells and coirdust have being mainly used as raw material. The yield of this carbonization process is around 30-40 %. Overall, it largely depends upon the quality of raw material, the moisture content (M.C.) and the composition of raw material in carbon and inorganic compounds. In fact, every kind of agricultural residues can be utilised by this technique (IIT 1981, TDRI 1983, Hulscher et al. 1992). However, it is preferable when the moisture content of the raw material is kept below 10-12 % after following a drying process. A charcoal product made from rice husks (IIT 1981) and having a M.C. < 10 % and an inorganic compounds composition of 20 % showed to have good quality and a calorific value of about 4,000-4,200 Kcal/Kg. Similar carbonization techniques have also been developed in other South and East Asia countries (TDRI 1983, Hulscher et al. 1992). In general, such a utilization method can be divided into three kinds of carbonization units: household, industrial and export. Major factor in the overall process is the position of the carbonization unit (site of plant), that is, it is better to be as closer as possible to the source of raw material so as to keep the transfer costs very low.

Agricultural residues could also be utilised in the production of briquettes (TDRI 1983). Such briquettes can be used as a substitute source of fuel besides fire-wood and compressed wood. The overall process is quite simple and consists of three main steps: drying, pulverization, and compression (see Fig. 1). Some kinds of binders may be used when necessary. Briquettes can be in the form of a log or pellet. Their dry density is usually greater than 0.70 g/cc.

Feedstock

↓

leaning & removal of sand

↓

Drying

↓

Pulverization

↓

Compression

↓

FINAL PRODUCT

↓

Storage

Figure 1. Flow diagramm of the production process of briquettes from agricultural lignocellulosic residues (TDRI 1983).

Most promising raw materials in the production of briquettes are: cotton stalks, groundnut shells, rice husks, bagasse piths and coir dust as far as it concerns the production of briquettes in the South and East Asia region. In other regions, any of the available agricultural residues can be used as raw material. Briquettes could also be carbonized or not carbonized. Usually, their M.C. has to be kept below 10-12 %. Advantages of this utilization include the following (TDRI 1983, Mantanis 1996) :

- uniform size of product
- increase of calorific value per unit volume
- insignificant losses in thermal energy
- eed for less room of storage

For the economical success of such a utilization, problems related to the availability of raw material as a resourse, marketing for briquettes, and acceptability of potential users should be carefully considered (Hulscher et al. 1992).

REFERENCES

1. Chow P. (1974). Dry formed composite board from selected agricultural residues. World Consultation on Wood Based Panels. FAO, New Delhi, India.
2. Fadl N. A. et al. (1978). Hardening of cotton stalks hardboard. Indian Pulp & Paper 33: 3-4.
3. Fadl N. A. et al. (1990). Effect of defibration and hardening on the properties of rice straw hardboard. For. P. New. 2: 4-7.
4. Fahmy Y. A. & N. A. Fadl (1974). Study of the production of hardwood from some indigenous (Egyptian) agricultural residues. Egypt. J. Chem. 17: 293-301.
5. Frazier L. (1993). Schenck GmbH. Private communication.
6. Govindarao V. M. (1980). Utilization of rice husk - a preliminary analysis. J. Sci. Ind. Res. 39: 495-515.
7. GREECE'S MINISTRY OF AGRICULTURE (1992). Agriculture Production. Annual Report. Athens, Greece.
8. Grigoriou A. (1993). Utilization of almond shell residues as raw material in the production of particleboards. Technika Chronika 12: 7-24 (in Greek).
9. Grigoriou A. & A. Passialis (1994). Verwendung von Astlolz der Obstbaum-plantgen fuer die Herstellung von Spanplatten. Holz. als Roh-und Werkstoff 52: 126-130.
10. Grigoriou A. (1996). Utilization of agricultural lignocellulosic residues as raw material in the production of wood-boards. Geotechnika Sci. Mat. 7 (4): 4-12 (in Greek).
11. Hesch R. (1968). Einjahrespflanzen als Rohstoffe fuer die Spanplattenindustrie. Holz als Roh-und Werkstoff 26: 129-140.
12. Hesch R. (1978). Straw is a viable material for the particleboard industry. Plywood & Panel 19 (7): 26-27.
13. Hesch R. (1979). Stroh als Rohstoff fuer Platten. Holz-Zentralblatt 3 (13): 22, 196.
14. Hulscher W. S. et al. (1992). Briquetting in South and East Asia : State of the Art Assessment. Ann. Rept. Technology & Development Group, The Univ. of Twente, and Densi Tech BV, The Netherlands.
15. INDIAN INSTITUTE OF TECHNOLOGY (1981). Utilization of agricultural, forest and industrial wastes. Dept. of Chem. Eng. New Delhi, India.
16. Injutin V. I. et al. (1983). Composition for producing structural products. Otkrytiya, Ixobret. Prom. Obraztsy, Znaki 21: 63.
17. Knowles L. (1992). A better alternative. Timberline Tribune 1: 6, USA.
18. Koukos P. K. (1996). Utilization alternatives of the agricultural production residues. Geotechniki Enimerosi 89: 38-40 (in Greek).
19. Loken S. et al. (1991). Guide to resource efficient building cements. Annual report. CRBT. Missula, MT, USA.
20. Mantanis G. I. (1996). Pilot plant for the production of briquettes from wood sawmill residues, forest lumbering residues and agricultural residues. Project proposal. Forest Research Institute, Thessaloniki, Greece (unpublished).

21. Neumann C. (1970). Ueber die Moeglichkeiten der Herstellung und Verwendung von Spanplatten in Entwicklungslaendern. Dissertation im Fachbereich Biologie der Universitaet Hamburg. P. 57-74.

22. Philippou J. L. (1981). Conversion of biomass into energy and chemicals by thermolytic methods. In : Components of productivity of Mediterranean-climate regions. Basic and applied aspects. Eds. Margaris & Mooney. Dr W. Junk Publishers. The Hague/London.

23. Rowell R. M. (1990). Materials Science of Lignocellulosics. Proc. Res. Soc. Symp. Vol. 197: 3-9. San Francisco, USA.

24. Rowell R. M. (1992). Composites from kenaf fiber. Final Report. FPL Project ARS 77939. USDA For. Serv. For. Prod. Lab., Madison, Wisconsin, USA.

25. Sabharwal H. et al. (1994). Biomechanical pulping of kenaf. Tappi J. 77 (12): 105-112.

26. Sabharwal H. et al. (1995). Refiner mechanical and biomechanical pulping of jute. Holzf. 49 (1995): 537-544.

27. Sellers T. (1985). Plywood and Adhesive Technology, Pp. 471-493. Marcel Dekker Inc., New York & Basel.

28. Sellers T. et al. (1993). Kenaf core as a board raw material. For. Prod. J. 43: 69.

29. Smith W. W. (1976). History and description of current (bagasse fiberboard) operations of Tablopan (de Venezuela). Tappi CA Rept. 67: 87-91.

30. Stamm A. J. (1964). Wood and Cellulose Science. Ronald Press. New York, USA.

31. Tappi (1983). Properties of fibrous raw materials. Pulp and Paper Manufacture, Vol. 1. New York, USA.

32. TROPICAL DEVELOPMENT & RESEARCH INSTITUTE (1983). A profile of the briquetting of agricultural and forest residues. Report No. G181: 1-12. London, UK.

33. Wang S. Y. & I. S. JOE (1983). Studies on the properties of bamboo composite panels. For. Prod. Ind. 2: 17-31.

34. Youngquist J. A. et al. (1993). Agricultural fibers in composition panels. Proc. 27th Int. Part./Comp. Mat. Symp. pp. 133-152, Pullman, WA, USA.