UTILIZATION OF THE SOYA HUSK IN TECHNO-AGGLOMERATES

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RESUMO

A preservação tornou-se uma prática fundamental em todo mundo, dando continuidade a esta ideologia é que buscamos contribuir na pesquisa de um material alternativo que usasse recursos rapidamente renováveis para a produção de chapas aglomeradas.

Numa análise estratégica dos possíveis materiais que pudessem ser utilizados para a produção de aglomerados, optamos pela casca do grão de soja, por ser um material de baixo custo, abundante em todo mundo e composto basicamente de fibra e celulose, conferindo ao material baixa densidade e permitindo a fabricação de chapas aglomeradas com densidades variadas.

Para obtenção das chapas aglomeradas procedemos da seguinte forma:

- Utilizamos diferentes granulometrias da casca do grão de soja e casca "in natura" (integral).

- Adicionamos cola tanino-formaldeído para agregar e impermeabilizar as partículas, e cola de tanino adicionada à emulsão de parafina sem o uso do formaldeído.

- Efetuamos uma prensagem e conseqüente polimerização, onde obtivemos chapas de qualidade, sendo estas submetidas a testes de avaliação, onde verificamos e constatamos a aplicabilidade e eficiência da casca do grão de soja para a fabricação de chapas aglomeradas.

Em todo mundo as pesquisas para desenvolvimento de novos agregados são voltados principalmente par os materiais sintéticos ou para a exploração massiva de recursos naturais não renováveis, enquanto que o emprego de materiais como a casca do grão de soja, abundantes e apropriados, podem tornar-se uma grande tendência para minimizar a poluição, o desmatamento e os preços dos produtos finais.

Desta forma, esta nova tecnologia torna viável a implantação de agroindústrias produtoras de aglomerados, pois a casca do grão de soja deriva de uma cultura amplamente implantada, o que propicia a aplicação atual do conceito de emissão zero ou aproveitamento integral da matéria prima com baixo custo e alta rentabilidade.

ABSTRACT

The preservation of the environment became a fundamental practice nowadays all over the planet. Giving continuity to this ideology we researched an alternative material that uses quickly renewable natural resources for the production of agglomerate sheeting.

In a strategic analysis of the possible materials that could be used for the production of agglomerate, we decided for the soybean husks, for being a material of low cost, abundant and composed basically of fiber and cellulose. It confers a low density to the material and permits the agglomerate

sheeting fabrication with varied densities. To obtain the agglomerate sheeting we took the following steps:

- we used different soybean particle sizes besides the raw husk size;
- we added tannin-formaldehyde glue to connect and waterproof the particles;
- we carried out a compression and polymerization where we obtained quality sheeting, these being submitted to evaluation tests where we confirmed the applicability and efficiency of the soybean husk for agglomerate sheeting manufacturing.

In the whole world the research for new aggregate development has turned principally to synthetic materials or to the massive exploitation of non-renewable natural resources, while the use of the materials like soya husk, abundant and appropriate, can have a great tendency to minimize pollution, deforestation and final price products.

This new technology turns the implantation of agglomerate producing industries viable, because the soya husk is derived from an amply implanted culture, which hold the concept of Zero Emission or whole usage of the prime material to the current application with low cost and high profitability.

INTRODUCTION

The history of humanity was always marked by the search for growth in the production of goods, which generated the continuous development of technology. However, as scientific and technological knowledge developed, the ancient preservation of nature was being lost also.

This withdrawal from nature brought imbalance and losses to all humankind and consequently to the entire earthly biosphere. Today, when we take into account the violent process of payback by nature, through phenomenon of imbalance and catastrophes that threaten life in all aspects, we see that environmental preservation has become a critical question of global competence.

One of the most dramatic manifestations of environmental degradation, in the entire world, is the activity of the lumber industry, which intensely exploits and devastates natural and replanted forests, in search of prime material to attend to the ever-increasing human consumption. "Of approximately 8 million hectares of forests that existed in the world eight thousand years ago, only 3,044 billion are left ", says the report divulged by the Costa Rica Foundation. This entity informs that tropical forests are destroyed at a rate of 17 million hectares per year.

In this project, we researched the use of the soya husk, a quickly renewable natural resource, for production of agglomerate sheets in the production of walls, ceilings, furniture, and parquet. Using tannin-formaldehyde glue to attach and waterproof the particles of the material, and with subsequent compression, we obtained the agglomerate sheets of soybean husks, multifunctional material, whose technological process of industrial production and adequacy we researched in this work.

With this work we try to strengthen the line of research of alternative materials that try to take advantage of agricultural by-products in the agglomerate industry. The soybean husk is a fibrous by-product resulting from the agricultural production activity of the soybean, vastly spread all over the world. Its use until now has been restrained to the feeding of cattle.

The industrial manufacturing of products with soybean husk can become an excellent alternative to minimize deforestation, the prices of final products and to increase the agricultural profitability of the producers of soybean, with the sale of the husk to the industry.

THEORETICAL FOUNDATION

The constant innovation in the production of compressed agglomerates for application in diverse areas in which they are demanded is a worldwide researched branch. What is searched for is cheap agglomerate sheeting resistant to the adversities of use.

The first tries to fabricate agglomerate lumber, instead of compensated lumber, came from techniques from the United States that untied natural wood into fibers and compressed them again into a homogenous mixture, with the help of an agglomerate. In Europe, the method was developed by the Swiss Fahrni (father), and the German Himmelheber Fahrni (son) created the first three-layered sheet in a practical form, and was produced industrially. Himmelheber performed the first experiment, with the development of agglomerate with a urea-formaldehyde base, and interpreted them following the analysis of its technical execution, economic worth and the usage of the agglomerate production.

One of the first suggestions about the fabrication of "artificial wood" was presented in the magazine *"The Increased Value of Wood Crafts"**, edited in 1887. The product would be obtained through the utilization of sawdust and blood albumin glue, with the help of pressure and temperature. In 1905, an experimental factory was installed, thought of by Watson, in the system then called ***flakeboard***. But only in 1933 did the North Americans install the first factory in the world to produce agglomerate sheeting with a thickness of 3.2 mm. In 1936, Pfohl registered the first patent with almost exact indications about the fabrication of sheets made from splinters cut to a pre-determined size, with the addition of agglomerant. But this system did not go forward. In 1938, a factory using the Pfohl system was installed. And in Germany the production of phenolic agglomerated wood was started. In this country, the first rudimentary grinded sheets were fabricated, with industrial bases, using sawdust and leftovers of the compensate industry.

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*Gunter Pauli, UNU (University of United Nations), Japan "Zero Hora" Journal, Porto Alegre city, Friday, December 1996, pg.53.

In 1943, the fabrication of sheetings suffered considerable stagnation with World War II, due to in great part the difficulties in obtaining agglomerants and lumber. But in 1949, with the development of the production of synthetic adhesive resins, the agglomerate sheeting production was reactivated, because of interest of the makers of machines that began to offer particle cutters, driers, sieve, special hydraulic compressors etc, to the market. Beginning in 1958, the worldwide production of agglomerate wood sheeting is increasing in an impressive manner until today. New production techniques and new products are being developed.

Edwards Potter, Irving Potter and Robert Myron (1974) created a process to produce boards from a mixture of wooden-cellulose particles, ground and agglutinated, applying heat and pressure simultaneously to the mixture. In this process the material is dried and then mixed with some adhesive agglutinant and consolidated with heat. The proportions should be predetermined and placed in a mould that will suffer the action of the heat and pressure. The mould to be used should be moveable and to have easy maintenance.

These boards can be used as measured wood or railroad ties, or to be cut into small pieces and used as planks. The method for preparation of the boards is simple. They are joined with prime material and an agglutinant, place in a mould with defined thickness, where fasteners are adapted to retain the thickness of the sheeting after the pressure is applied. Afterward they are taken to an oven for a prolonged time and subsequently cooled at room temperature, thus allowing the removal of the final product of the board of joined particles.

The inventor of the process of molded body manufacturing, especially plates of fibrous material, was Mixolit Kuns Ferzeugung Gesellschaft. In this manufacturing was used a humid process that specially joined scraps of wood, shavings, and even dust derived from the polishing.

Afterwards, they were mixed under pressure and dried in an appropriate place. The pressure was made to drain the material, through openings and canals. The drying is done in appropriate places, at a temperature of 100° C to 300° C. The final humidity should be 3%, after leaving the dryer.

METHODOLOGY

This research deals with an experimental research, with a well-defined objective of obtaining soy husk agglomerate sheets, using tannin resin. For dealing with an unpublished research and an unexplored field, it was necessary to establish first a research action strategy, described below.

Chart 1 makes evident how the strategy of the soybean husk fraction separation was elaborated.

Chart 1 –Sieves used and sequence

Husk in its natural state	→			100%
Sieve 1.5 mm	→	retained	→	Y% ?
Sieve 1.0 mm	→	retained	→	X% ?
Sieve 1.0 mm	→	passed through the cloth	→	Z% ?

Chart 2 makes evident how the methodological strategy was elaborated for the experimental part that evaluates the effect of the soybean husk granulation in the resistance of the agglomerates obtained in the perpendicular traction tests.

Chart 2 – Distribution of experimental tests, formulation and their meanings

Fabrication of the samples for Perpendicular Traction tests
Make an average of 10 samples for each formulation
Granulation of the soybean husk

Formulations	D1	I	X	Y	Z	B
D1IB	Density 1g/cm^3	Entire Husk				*See resin formula –chart 3
D1XB	Density 1g/cm^3		Husk >1mm and < 1.5mm			
D1YB	Density 1g/cm^3			Husk > 1.5mm		
D1ZB	Density 1g/cm^3				Husk < 1mm	

***B** – Resin formula: 13% of resinous tannin solids over the soy husk total and, following formulation B below:

Chart 3 –Composition percentage of formulation B referring to D1

Formulation B glue	**Percentage (%)**
-Powdered tannin resin:	37,49
- Water	50,14
- Formol	6,09
-Paraffin emulsion at 25%	6,28

Chart 4 makes evident how the methodological strategy was elaborated for the experimental part that evaluates the effect of the final density of the agglomerates in relation to the resistance of those observed in the perpendicular traction tests.

Chart 4 – Effect of the agglomerate density.

Formulations	D1	D9	D8	I	B
D1IB	Density 1g/cm^3			Entire husk	*See resin formula (chart 3)
D9IB		Density 0.9g/cm^3			*
D8IB			Density 0.8g/cm^3		*

The tests that lead to the results, were done in triplicate for the proposed development in chart 1, so that the values obtained were an average.

The results of the proposed tests in charts 2 and 4 were the result of an average of 10 samples for each formulation.

In the sequential development, chart 2 allows the identification of the best soybean husk particle size for agglomerate structuring, and from chart 4 the best density was identified, that which best contributes to the resistance to perpendicular traction.

The formulations tested in the second stage (after planning charts 1, 2 and 4) in the soy husk agglomerate structuring:

Chart 5 – Total formulations* with a resin cover on the surface of the agglomerates.

E ⇒ Agglomerate sheet with cover on the surface
1 ⇒ Density 1g/cm^3
I ⇒Entire soy husk
A ⇒ 15% of the tannin resin solids */(2% on the surface –13% in the crumbs)

In all the procedures for preparation of the resins the following methodology was adopted: add water to the tannin powder to the hydration and adding afterwards the paraffin emulsion and formaldehyde, when these are components of the formula.

The research group also decided to adopt, as criteria of the methodological strategy, the following procedures:

All the agglomerate materials were tested for resistance to perpendicular traction. The three agglomerate materials with the best results in perpendicular traction according to the International DIN standard for perpendicular traction were tested for swelling tests in cold water and resistance to flexibility.

Triplicates were made for each material in the tests of swelling by immersion in cold water. An average of 4 samples of each material was tested for the flexibility tests.

ANALYSIS OF THE RESULTS

Initially, it was verified that the soy husk in its natural state could be separated into fractions of different granulations that amount to the whole. To make the separation, we used sieves that appear illustrated in the procedure chapter.

Chart 6 presents the results obtained in terms of percentage of the fractions of the soybean husk separated with the help of sieves.

Chart 6 –Percentage of the principal separate fractions of the soy husk.

	Code		%
Husk in its natural state	I%	→	100.00
Sieve 1.5mm (retained)	Y%	→	14.28
Sieve 1.0mm (retained)	X%	→	11.88
Sieve 1.0mm (passed)	Z%	→	73.84

Figure 1 presents the influence of the density variation upon the soy husk agglomerate structures, such that the points that represent each density were obtained from an average of 10 tests in equal conditions for each density tested. In the figure, it is evident that the increase in the final density of the agglomerates induces a significant increment in the resistance to perpendicular traction, such that D1 = density $1.0 g/cm^3$, D9 = density $0.9 g/cm^3$ and D8 = density $0.8 g/cm^3$; such that I = entire soy husk and B = 13% of resinous tannin solids over the dry husk mass.

Figure 1 – Influence of density of agglomerate sheets produced with soy husk in its natural state, with a single layer, upon the resistance to perpendicular traction.

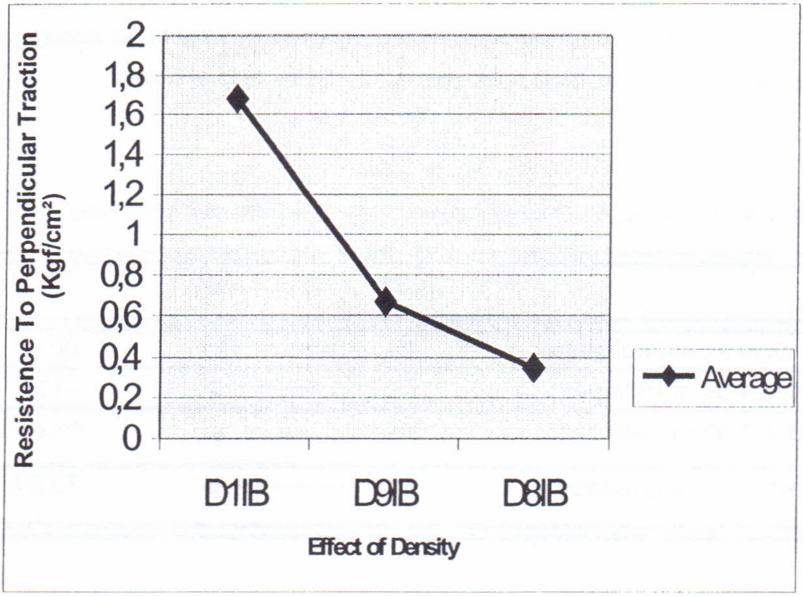

Figure 2 that presents the influence of the variation of soya husk particle size on the structure of the agglomerates, such that the points represent each tested size. They were obtained from an average of 10 tests in equal conditions for each tested granulation. In the figure, it is evident a betterment of soya husk in its natural state, when compared to other granulations caused by the separation of the stated husk by sifting; in relation to the resistance to perpendicular traction, such that I = entire soy husk, X =

husk < 1.0mm; such that D1 = density $1g/cm^3$ and B = 13% of resinous tannin solids over the dry husk mass.

Figure 2 – Influence of different soya husk particle size used in agglomerate sheet structuring with a single layer upon the resistance to perpendicular traction.

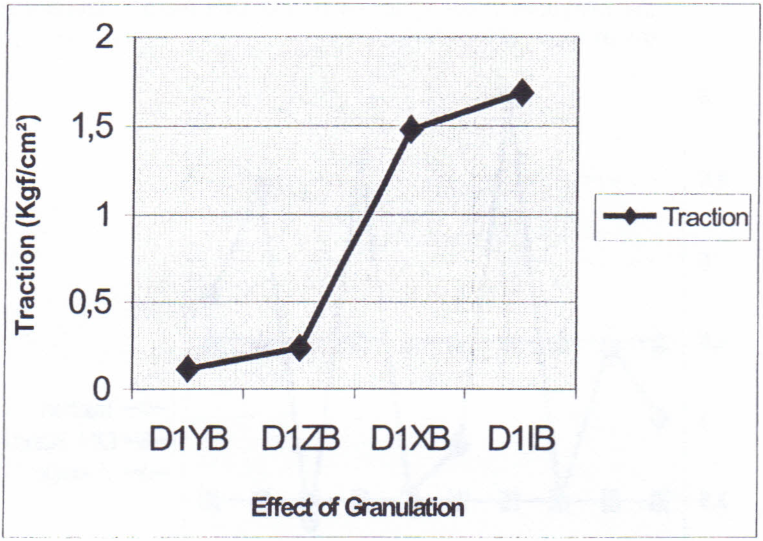

Figure 3 illustrates a detailed comparison of the behavior of each of the 10 samples of soy husk agglomerates tested of the W1IB formulation, making evident that all the values of resistance to perpendicular traction are situated above the minimum specified by the DIN standard, including the average shown, so that the uniformity of the adhesion force obtained in this formula is confirmed.

Figure 3 –Results of the 10 tests of resistance to perpendicular traction of the formulation W1IB agglomerates, drawing a comparison to the minimum value specified by the DIN 68761 standard and the average of the stated tests.

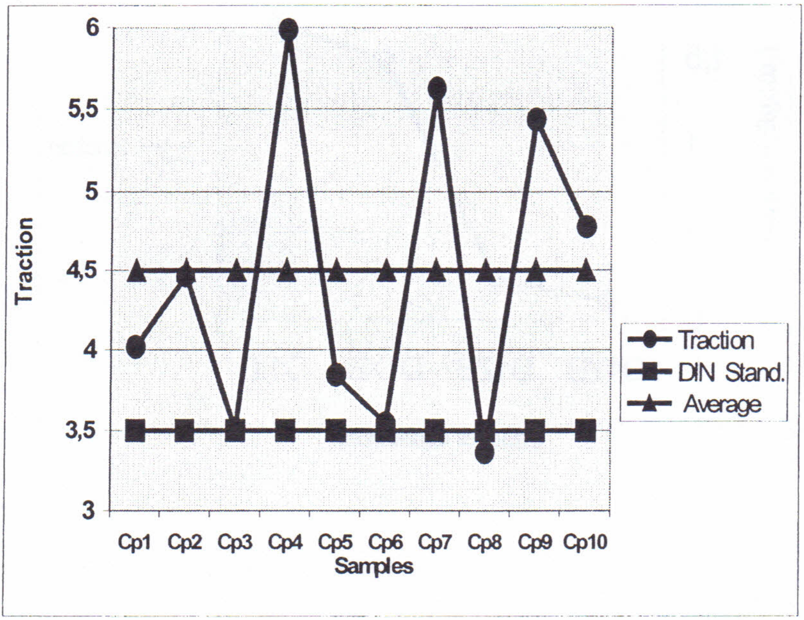

Figure 4 makes evident respectively the swelling percentage of the samples of the formulations S1IB, E1IA and W1IB, such that the values presented represent an average of 3 tests in equal conditions for each formulation, in a period of 2 hours in which it becomes evident that the soy husk agglomerates structured according to the formulations S1IB and W1IB swell less than the maximum allowed, thus satisfying the DIN standard, such that the agglomerates structured according to the E1IA formulation present a swelling percentage slightly higher than the maximum allowed for a period of 2 hours immersed in cold water.

Figure 4 – Average percentage of increase in thickness of the formulation samples S1IB, E1IA and W1IB, after 2 hours immersed in cold water.

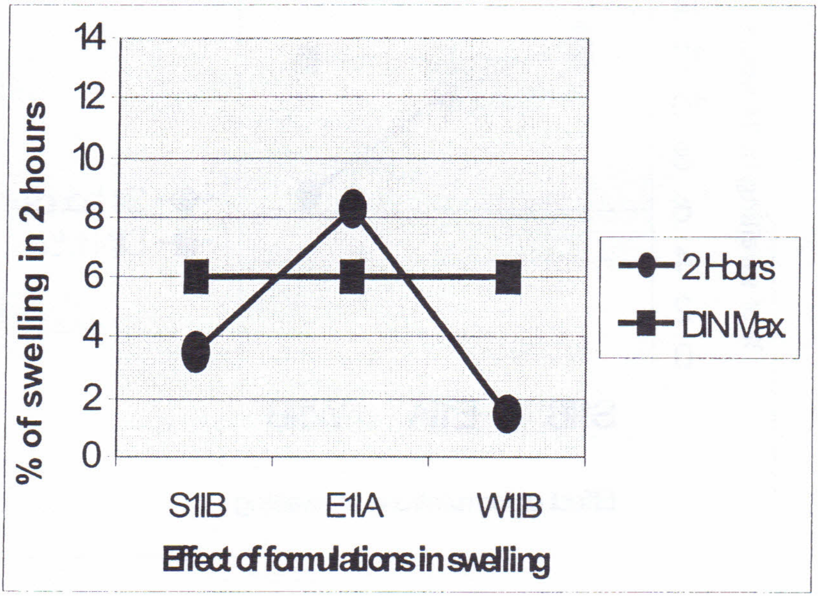

Figure 5 makes evident respectively the swelling percentage of the samples of the formulations S1IB, E1IA and W1IB, such that the values represent an average of 3 tests in equal conditions for each formulation, in a period of 24 hours in which it becomes evident that the soy husk agglomerates structured according to the formulations E1IA and W1IB swell less than the maximum allowed, thus satisfying the DIN standard, such that the agglomerates structured according to the formulation S1IB present an average percentage of increase in thickness of the samples slightly greater than the maximum allowed for a period of 24 hours immersed in cold water.

Figure 5 – Average percentage of increase in thickness of the formulation samples S1IB, E1IA and W1IB, after 24 hours immersed in cold water.

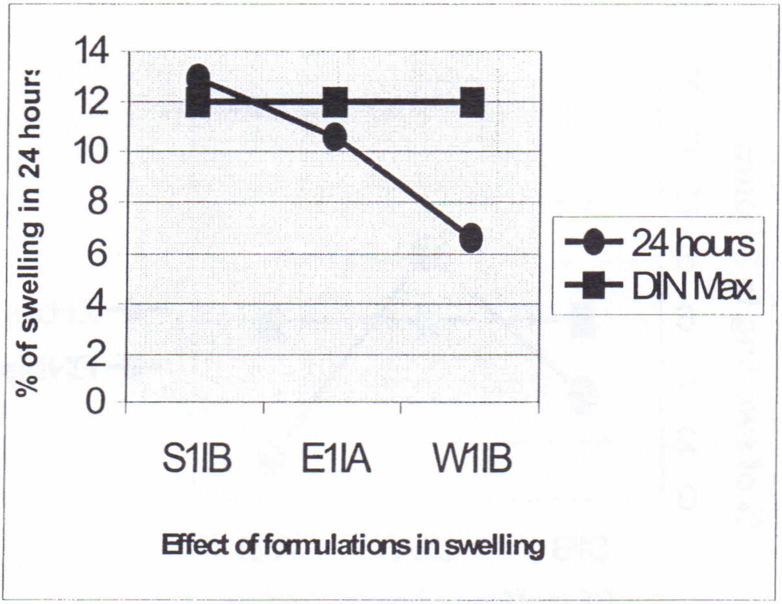

Figure 6 presents the linear correlation existing between the resistance of the soy husk agglomerate materials to perpendicular traction and swelling by immersion in cold water, made evident that the greatnesses are inversely proportional: as long as the resistance of the agglomerate to perpendicular traction increases, the swelling of the agglomerate decreases.

Figure 6 – Inverse linear correlation between the increase in resistance to perpendicular traction (kgf/cm^2) of soy husk agglomerate materials and the decrease in swelling. percentage in a period of 2 hours of immersion.

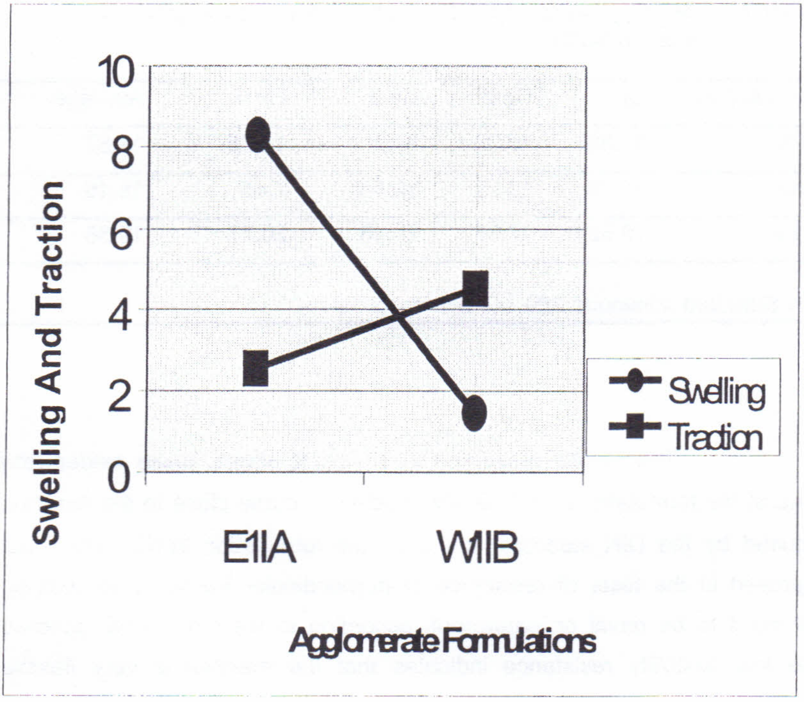

Chart 7 below presents a profile of the flexibility resistance parameter tests (MOR) in Kgf/cm^2 of the soy husk agglomerates, of the 3 best formulations according to the performance obtained beforehand in the resistance to perpendicular traction tests, as proposed in the strategy addressed in the methodology; according to the DIN standard and compared to it.

The results presented below, represent an average of 4 samples tested in equal conditions, and the individual profile of each sample in a universal-testing machine (the same machine used before in the tests of resistance to perpendicular traction).

Chart 7 – Flexibility resistance (MOR) of the soy husk agglomerate sheets, values in Kgf/cm^2.

Formulations	Cp 1	Cp 2	Cp 3	Cp 4	Average
S1IB	14.86	10.32	9.64	12.65	11.87
E1IA	18.25	19.92	18.18	7.45	18.46
W1IB	18.62	17.66	20.48	20.77	19.38

DIN Standard minimum: 180

The results presented in the chart above, make evident that none of the formulations, in flexibility resistance, come close to the minimum required by the DIN standard, not even the formulation W1IB, which was approved in the tests of resistance to perpendicular traction and swelling, proving it to be naval or waterproof, according to the same DIN standard. This low flexibility resistance indicates that the material is very flexible.

However, this can be changed varying the resin formulation but this modification would require long term studies, not anticipated in this research.

The results of flexibility are important for sheets of large size, however the results obtained allow the small soy husk agglomerate sheets in the fabrication of boxes in general, for example more specifically boxes for fruit, parquet, partitions and prefabricated houses; and principally in the fabrication of compensates as a filler. These agglomerates can still be used in the fabrication of furniture if coated with Formica type plates, which confer an extraordinary rigidity.

CONCLUSION

The present work proves the technical and economic possibility of the soybean husk for production of agglomerate boards type "flakeboard".

In the evaluation test of thickness swelling properties after immersion in water for 2 hours and 24 hours, all treatments present results far inferior to the maximum permitted by the DIN standard.

We also verified that, with the increase in formulation density, a significant decrease in swelling percentage in water is obtained. On the other hand, an intermediate husk granulation (3 mm) and high density influence the agglomerate resistance in a representative form. A possible explanation for this fact is that upon reducing the granulation grinding the husk, a greater adherence and compaction of the particles occurs. These characteristics, associated with the increase in density, increase the resistance of the material.

For the F2b treatment, using grinded soya husk with 3 mm granulation and 0.93 g/cm3 density we confirmed that the perpendicular traction and swelling requirements are reached. Therefore, it is concluded that the production experiments of agglomerate sheeting with soya husk and tannin-formaldehyde resin point to an increase in the efficiency using a variable particle granulation between 3mm.

Research that proposes studies of other natural resins, in fabricating soya husk agglomerates could raise the resistance of low-density sheeting. For example, the soya husk can lead to multiple results when used simultaneously with other agricultural or industrial residues in agglomerate fabrication.

It's important to point out that the test carried out for this research only explored the use of tannin resin in agglomerate fabrication. The influence of other resins for soya husk agglomerates still needs to be researched, just like the increase in the grade of resinous solids that may enrich the resistance of the material, within an economic viability.

This research could establish the beginning of a solution for an adequate destination of the soya husk, profitability and efficiency in the industrialization and agglomerate sectors.

ACKNOWLEDGEMENTS

To God for everything he gave, conceding knowledge, HEALTH, CAPACITY and COMPREHENSION.

To SETA S. A. - EXTRATIVA TANINO DE ACÁCIA for the donation of the powdered tannin resin, and for the constant collaboration has given to the development of the resistance to perpendicular traction and soybean husk agglomerate flexibility tests.

To Ceval, for the donation of the soybean husk.

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