ISSN 2250-3153

Assessing the Effects of Packaging Materials on the Moisture Content and Surface Finish of Packaged Furniture Products

Rogerson Anokye

PhD Research Scholar, Department of Wood Science and Technology, Faculty of Forestry, Universiti Putra Malaysia.

Abstract- The study investigated the effects of packaging materials on moisture content and surface finish of furniture products. Unfinished, semi-finished, and finished furniture parts were packaged for two, four and six weeks using five different packaging materials. Four hundred and fifty (450) strips were prepared from Iroko (Millicia excelsia). Five different packaging materials were selected for the three levels of furniture parts after which a change in moisture contents and colour were determined. The mean moisture content (%) changes determined on unfinished furniture parts with plastic, cardboard, metallic, plastic plus cardboard (PC) and plastic plus cardboard and metallic (PCM) showed a rise in MC with plastic and cardboard showing highest(2.26%) and lowest(0.37%) respectively while in semi-finished furniture parts, PC and metallic recorded the highest and least of 1.72% and 0.65% respectively. However, cardboard recorded 0.12% upon the initial moisture content whiles metallic and cardboard packaging recorded highest and the least rise in MC of 2.21% and 0.14% respectively for finished furniture parts. There was insignificant difference in the surface finish. It was concluded that cardboard is the superior packaging material with the lowest MC increase throughout the three time levels.

Index Terms- Packaging; furniture; plastic; cardboard; metallic materials.

I. Introduction

1.1 The furniture industry in Ghana

In recent times, there has been a rapid development in the processing of furniture in Ghana as a result of increase development in technology. A typical example is the American technology for processing small diameter logs from both natural forests and plantations with wood mizer mills (Okai**,** 2002) that is gaining popularity in the country. In Ashanti and Brong Ahafo Regions, wood mizer mills have been purchased and installed in most companies. These companies stand the chance of turning lumber into finished products such as furniture for domestic and export markets.

In addition, the use of computer-aided design of furniture is catching up with most furniture producing companies in the country. According to the International Tropical Timber Organization (ITTO) there are about 600 small to medium scale furniture producers in the country with the bulk in Kumasi (ITTO, 2004). Most of these companies received their training from the numerous Technical Institutions, Polytechnics, Intermediate Technology Transfer Units and the informal apprenticeship training centres in the country.

Regrettably, there has been a considerable decline in the export of timber products including furniture. In the 1970s there was a sharp decline in the output of furniture exports which was attributed to the general poor state of the economy in the 1970s and early 1980s, obsolescence and continuous breakdown of logging and processing equipment, poor packaging, the over-valued exchange rate, inadequate transport and poor state of rail and harbour facilities, (Baidoe,1987).

Since 1989, the export performance of furniture industry has not been encouraging. Furniture export statistics for 1990 indicates that Ghana earned USD 37,288,400.00 showing 1.86% increase on the 1989 furniture export earning of USD 3,554,270.00 (Appiah, 1990).

Despite a 27.96% drop in volume in 1991 (from 2754 m^3 in 1990 to 1984 m^3 in 1991) furniture export in 1999 increased to about 2720 m^3 which earned the country $7,143,810.00. The international furniture trade is valued at $67 billion and is expected to grow in future because of the encouraging retail market prospects from the USA and Europe, the two largest furniture markets (Ratnasingam, 1998). Unfortunately, the export volume of furniture in 2000 was decreased as against the past performance. The export volume dropped by 8.13% from 2720m^3 in 1999 to 2499m^3 in 2000.

Data available from the Timber Industry Development Division of the Forestry Commission (TIDD) indicates that contracts for a volume of 2,475 pieces of furniture parts were processed and approved for export during the fourth quarter of 2009. There was a sharp increase in furniture parts export as a result of two major parts shipments for the Togolese market undertaken by Portal Limited, a Takoradi based timber firm. The TIDD report indicates that Mim Scanstyle Ltd, once the major furniture parts exporter, submitted almost no contracts for export approval during the same period (TIDD, 2009).

The poor export performance of the furniture industry since 1989 to the present shows that the industry is still facing serious problems. Among the numerous problems identified was difficulty in packaging the furniture. Currently, the few companies that export furniture do so in their knocked-down form. Even with this, there are many problems associated with moisture changes, which lead to discolouration, bruising and staining of the furniture products. Other problems like scratches and sometimes breakages are also real.

Furniture is inherently predisposed to damage during transit and delivery. Damaged goods are unacceptable to consumers and the producer must therefore either scrap the items or undertake costly and time-consuming repairs which leads to high looses to the industry.

Traditionally, the primary function of packaging is to contain and protect the product (Kotler, 1984). Of late, attracting attention, describing the product and making the sale also form part of the functions of packaging. Improving packaging is often limited by a perceived increase in packaging material purchase costs.

The purpose of this study was to investigate the effects of five packaging materials on the moisture content and the surface finish of the packaged furniture and to make recommendations on the most appropriate materials and method for packaging furniture.

Information gathered from interviews and questionnaires administered to the furniture companies that export furniture revealed that they are faced with problems associated with packaging such as moisture changes and discolouration of the surface finish. In this respect, the study when undertaken successfully will help to achieve this ultimate goal by way of prescribing improved methods and materials for packaging furniture by the industries.

The research will also lead to the reduction of the number of damages experienced by furniture exporters in order to reduce the amount of compensations paid on defected goods and thereby maximizing their profit. Moreover, the study will help bring about sustainable utilization of our limited forest resources.

1.2 Furniture produced in Ghana

Page (1973) states that the bulk of furniture produced by all sector in the import-substituting sector of the industry consists of wooden and upholstered furnishings, designed for domestic and commercial use. According to Prempeh (1993), furniture is fully assembled, finished and upholstered before sale on the local market; for the large firms in the export market like Scanstyle Mim Limited produces knocked down furniture and the range consist of garden chairs of all kinds, indoor chairs and occasional furniture. Knocked down furniture is furniture that may easily be folded or taken apart and packed flat for transport. It is also called demountable or packaged furniture (Gloag, 1969).

Knocked down processing allows for better-packed and less breakage in transit. It also promotes compact storage in the warehouse, making handling very easy and increasing the strength of the joint. Unfortunately, the nature of knocked down processing allows firms to avoid the use of heavily protected locally produced inputs such as primary paints, lacquers and fabrics

1.3 Packaging of furniture

Human beings have always protected food and drink in containers, using skins, leaves, and gourds, and then baskets, pottery, and, as early as 1500 BC (Covell, 2002). According to Willinston (1988), proprietary products such as panels and furniture parts for the shoulder trade were also packed in individual cartons. The trend of packaging and branding will continue in the foreseeable future.

Packaging is all the activities of designing and producing the container or wrapper for a product (Kotler, 1984). It can also be described as the technology used to contain, protect, and preserve products throughout their distribution, storage and handling, and at the same time to identify them, provide instructions for their use, and promote them (Covell,2002).

Packaging may include the product's primary package or container, secondary package and the tertiary or shipping package. Recently, labelling and printed information appearing on the package is also part of packaging. Packaging must maintain the condition of its contents. It must exclude all the undesirable conditions to prevent it from becoming unfit for use during the period designated as its shelf life. The pack must also prevent the product leaking, especially if there is a corrosive or poisonous chemical inside. The pack must identify the contents and their amount by print and pictures, and, if necessary, provide instructions on use, as well as any hazard warnings. The latter is essential when the pack contains pharmaceuticals or chemicals, either domestic or industrial.

1.3 Materials for packaging furniture

A wide range of materials ranging from "tamperproof" to "waterproof" devices is in use as packaging materials. Common ones in use are cellophane (plastic film), polyethylene, plywood, solid wood, shredded paper, wood wool, cellulose wadding, corrugated cardboard, foam, polystyrene (Styrofoam), natural and synthetic papers, plastic and metallic containers. Some of these materials act as accessories to the main pack.

Sawn wood or lumber has a wide range of different end uses. The various end uses are from construction to repairs, packaging, furniture, mining, shipping, sleeper etc (Amoako, 1993). Wood intended for furniture production must be kiln dried to a very low moisture content of about 8 to 12 % (Rietz 1957). A few of the more important reasons according to him are that seasoning reduces gross weight and thereby reducing shipping and handling costs, imparts dimensional stability, increases most strength properties, increases fastener holding power and thereby joint strength, increases electrical resistance, improves paintability and glueability, and finally, improves the thermal properties of wood. In addition to these advantages, drying wood below the fiber saturation point renders it impervious to biological degradation so long as it is not re-wetted. Attack by wood destroying fungi, in particular, is prevented.

Most of the small and medium scale furniture manufacturing industries all over the country use air seasoned lumber. The green lumber is neatly stacked with stickers separating one layer from another. In some cases, they are left at the mercy of the weather. Some companies even use processed timber with high moisture content and in fact, some finished products in the form of furniture, doors and windows are being processed from the green lumber. However, green timber may contain a sizeable amount of water. Seasoning is a costly and time consuming process and would not be employed unless there were valid reasons why it is required. So far, only the large scale furniture companies like SCANSTYLE Mim Ltd and DUPAUL employ the use of kiln in drying the timber for furniture construction

Cardboard is one of the widely used packaging materials in the world. According to Pröyry (2003), the exportation of paper and paperboard from the North America and Europe to the other parts of the world is high and it will continue to increase till the year 2015. Unfortunately paper based (board) packaging components are subject to deterioration and reduced performance through ingress of moisture. For this reason, board components are ideally stored in heated and temperature stable areas away from warehouse doors which remain open for significant periods of time. Corrugated and board sheet material should be stored flat if kept for prolonged periods (FIET, 2001).

Plastic packaging materials come in the form of cellophane, foam, polystyrene and polyethylene. These can be thermoplastic or thermosetting. The thermoplastic such as the polyethylene is the most common. They are described as linear polymers, straight chained -though may branch occasionally and crystalline. This is why they soften if the plastic is heated (Metcalfe *et al*, 1966). But some like the polystyrene are amorphous which makes it not having a sharp melting point. According to Ashby and Jones (1998), polyethylene and the polystyrene are the common plastics in use in the packaging industry. Plastics have a mechanical property of being less stiff, lower density, lower strength and with less hardness. These properties may deteriorate rapidly with quite small increase in temperature (Bolton 1988). According to FIET (2001), plastic packaging materials and components are less affected by ambient environment, temperature and humidity fluctuations, but they should be dry before use.

The basic metallic materials used in the packaging industry are aluminium and steel. Metallic container is advantageous in exportation of furniture as it is locked against pilfering and sealed against the weather, usual packing requirements are relaxed, and the freight is billed as a volume shipment. Interchange of material is expedited, and containers can be used for storage; some terminals are fitted with electrical outlets for maintaining refrigerated containers. Damage claims on container cargo have been found to be much lower, and pilfering has been almost eliminated (Covell, 2002).

Plywood is normally used as packaging material because its behavior can be predicted with reasonable accuracy by calculations used in structural theory and normal engineering practices. The performance of plywood is similar to that of solid wood of the same species generally, but it is subjected to the following modifications: The permissible working stress parallel to the grain is often higher in plywood than solid wood of the same species; transit load in both parallel and perpendicular directions; has greater dimensional stability and rigidity than solid wood and it is advantageous in terms of strength to weight ratio and resistance to split and impact.

1.4 The Hazards of Distribution

The key to selecting packaging, which protects product, is to understand the hazards within the distribution environment. Ideally packaging should match the hazards inherent in handling and distribution of the product such that it is adequately protected, whilst avoiding excessive use of packaging which increases purchase and distribution costs. The deep understanding of the hazards allows informed selection of packaging materials and packaging formats, reducing the use of unnecessary packaging and reducing product damage rates. Distribution hazards are typically categorized as shock by drop or impact and vibration.

1.5 Forms of damage

Breakage is a common form of damage to furniture legs, cornices, doors, glass panels, and chair arms. Breakage is mostly caused by impacts either by shock or by drop; if products are consistently damaged in this way during transport and storage, more cushioning should be applied to the vulnerable component or alternative product delivery options considered.

Bruising is also the result of impact, probably a less severe impact than would cause component breakage. Bruising is generally the result of inadequate cushioned coverage, particularly along the edges, around the corners, and over the flat panel surfaces of the furniture unit.

Scratching occurs when a packaged piece of furniture comes into contact with a sharp edge or point. This may be a protruding bolt inside a vehicle, a door handle in the warehouse or factory, or the handle of another piece of furniture, which is inadequately protected. Scratching is also caused within knocked-down furniture by dust and dirt, loose fittings, screws, handles or other components which are allowed to move about within the pack during transport and handling. Scratching can also happen when a package is being opened by customers or their agents. Corrugated cases are often sealed by pressure-sensitive tape, and anyone trying to open these cases is tempted to use a knife or other sharp blade to slit the tape, unaware that a vulnerable finished surface lies just beneath. A piece of stout board underneath the taped joint can help.

Abrasion is a particular problem in packages containing knocked-down furniture. It occurs whenever finished timber comes into contact with an unsuitable packaging material or with another abrasive component within the same package. It may also be caused by sudden shocks, vibrations, effects of changes in moisture content and temperature.

1.6 Discolouration

Natural wood surfaces, both solid and veneers, are liable to change colour when exposed to natural light. The stronger the light, the greater the colour change. (Kellogg and Meyer, 1982).This may not be a problem if the whole unit or panel is exposed, because when the article is in use it will age naturally. However, if only part of the unit is exposed, the colour variations between the exposed and unexposed portions may prove unacceptable to the purchaser, despite the fact that in time the colour differences will disappear.

Climatic conditions have detrimental effects on the surface finish of the packaged furniture products. Moisture, dehydration and temperature damage can take a variety of forms. High temperatures can cause softening of adhesives (Kollman and Côte, 1984) and, of greater importance to the packer, softening of lacquers. It is easy for lacquers to mark if they become soft whilst in contact with even the least abrasive packaging material, and harder packaging materials, such as single-faced or double-faced corrugated fibreboard, may cause severe marking.

Furniture makers have little control over the environment in which their products will be transported or stored, so it is important to make the package as weather resistant as possible. Enclosing the article in a plastic (polyethylene) bag can help. A silica gel packet of appropriate size may be placed in the bag to absorb excess moisture and prevent the formation of condensation if high humidity is likely to be a problem.

II. Methodology

The materials which were used for the study were plastic sheets for waterproofing, corrugated paperboard for shock and vibration proof metallic container for tamper proofing, electronic moisture meter, samples of *Millicia excelsia* (Iroko), sellotape and a marker. The electronic moisturemeter (capacitance type) was used to measure the moisture content of the wood samples.
Kiln dried samples of *Millicia excelsia* (Iroko) were selected for the study. Sellotape was also used to seal the plastic and cardboard packs. The waterproof marker was used to mark all selected samples to ensure easy identification.

The study was carried out at two different sites – Scanstyle Mim Company Limited and Bibiani Logs and Lumber Company (BLLC). Mim was selected because it is one of the biggest mills in the country and also the leading exporter of furniture. BLLC was also selected because of its large concession in *Millicia excelsia* (Iroko) predominant forest district of the country. It also has a modern computerised kiln.

Feasibility studies carried out at the mills also indicated that availability of logs for processing was not a problem and the companies had enough selected species for the study. The two companies were also ready to release information and samples for the study. The Faculty of Renewable Natural Resources' Workshop of Kwame Nkrumah University of Science and technology, Kumasi was used for the execution of the project.

Millicia excelsia (Iroko) was selected for the study because the initial survey of the company revealed that contracts for immediate processing demanded this species and was the leading species in the exportation of furniture in the country. In addition, the logs were available in sufficient quantities to ensure continuous production and it is in abundance in the local mills in the community to ensure easy access to the material.

Kiln dried samples of *Millicia excelsia* (Iroko) were planed and sawn into dimensions of 20 × 20 × 100 mm strips. Four hundred and fifty (450) strips were prepared and sanded. These were divided into three groups: unfinished, semi-finished and finished furniture parts of one hundred and fifty (150) strips each.

The unfinished furniture was made up of smoothly sanded strips without any protective coating. Sanding sealer was applied to the semi-finished furniture and the finished furniture received both sanding sealer and lacquer. After preparation, specimens were marked using waterproof ink to identify them.

Five different packaging materials were selected based on their use by the furniture companies and their availability. These were plastic sheet (P), cardboard (C), metallic container (M), a combination of plastic and cardboard (PC) and a combination of plastic, cardboard and metallic container (PCM).

These materials were thoroughly checked for any punchers and defects. They were later cut to size to suit the volume of samples to be packaged.

After preparing the specimens, the initial moisture content was taken with the capacitance type moisturemeter at room temperature (25°C). The average prevailed temperature and relative humidity at the workshop during the period of the experiment were 27.9°C and 73.6% respectively. Every specimen was tested and photographed with a digital camera to ascertain the initial colour, after which they were immediately packaged.

Each group was made up ten (10) replicates for each packaging method. For instance, a pack containing ten specimens (replicates) of unfinished furniture parts was packaged in plastic sheet. This was repeated for other packages.

The set-ups were then stored for periods of two (2), four (4) and six (6) weeks under the then prevailing weather conditions. These three time levels were selected based on the length of time that products usually remain in the pack. A product for local consumption stays in the pack for a maximum of two weeks before they are unwrapped. The four week time level was also based on the maximum period it takes for shipping a product to the international market. Finally, a product upon reaching their destinations takes a maximum of six weeks before they are unwrapped.

After each period, the specimens were unwrapped and the moisture content quickly taken to determine the moisture content differences. Photographs were also taken at each period with the same digital camera and used to compare with the initial colour to determine any change in colour of the surface finish based on colour constancy.

The means and standard deviations of the data were determined. Descriptive analysis was used to discuss all the results and a comparative analysis was used to describe the differences in colour of the surface finish.

The experimental design used was split plot in complete randomized design (CRD). The data was subjected to the analysis of variance (ANOVA); and F-test at 1% and 5% significance were used to find out if there were significant differences in mean moisture changes in the five different packaging materials, time and the interaction between packaging materials and time.

Regression analysis was also carried out to determine the correlation between the time of packaging and the change in moisture content of furniture parts packaged using the various packaging materials.

Colour chart was also used to aid in the visual comparison of colours of the initial and final surface finish of the furniture parts.

III. Results

3.1 Effect of packaging materials on the moisture content of furniture parts

The results of the effect of packaging materials on the moisture content(MC%) of furniture parts from Iroko (*Millicia excelsia*) within the three different time levels of 2, 4 and 6 weeks were obtained as shown with the example below:

Table 1: Effect of plastic material on the moisture content of an unfinished furniture parts

Duration (Weeks)		**Replications**										**Mean**	**SD**
		1	2	3	4	5	6	7	8	9	10		
2	A	8.8	10.3	10.4	9.8	9.5	8.7	9.8	9.5	9.2	10.1		
	B	10.1	12.4	11.4	11.8	11.8	10	10.7	10.9	11	11.1		
	C	1.3	2.1	1	2	2.3	1.3	0.9	1.4	1.8	1	1.15	0.504315
4	A	9.5	10.1	9.9	10.3	10.1	9.8	9.8	10.1	9.5	9.4		
	B	10.8	11.1	10.7	11.1	11.1	11.1	10.9	11.1	10.8	10.7		
	C	1.3	1	0.8	0.8	1	1.3	1.1	1	1.3	1.3	1.09	0.202485
6	A	9.1	9.2	9.8	9.2	9.8	9.4	9.4	9.2	9.2	9.1		
	B	10	10.7	10.6	10.1	10.3	10.3	10.5	10.3	10.4	10.8		
	C	0.9	1.5	0.8	0.9	0.5	0.9	1.1	1.1	1.2	1.7	1.06	0.347051

A=MC(%) after packaging; B=MC(%) before packaging; C=change in MC(%); Positive values=rise in MC(%)

The results obtained from the effects of the five different packaging materials on the moisture content of unfinished furniture parts from Iroko (*Milicia excelsia*) indicates that all samples recorded higher MC as compare to MC before packaging except metallic(3.33%) and PCM (13.33%) packaging that recorded a drop in moisture content. The standard deviation (SD) also showed a high variability in the MC of specimens that went through all the five packaging materials.

It was also realised that a higher mean MC was recorded for two weeks packaging with plastic (1.51%) and metallic(1.53%) packaging whiles cardboard, PC and PCM recorded higher moisture contents at the six weeks packaging (0.98%,1.79% and1.14% respectively). Plastic and metallic packaging recorded the least mean moisture contents of 1.06% and 0.74% respectively in the week six while cardboard, PC and PCM recorded least mean MCs of 0.84%, 1.13% and 0.72% respectively in the fourth week.

In the case of semi-finished furniture parts, a higher mean MC was recorded for the samples that underwent two and four weeks packaging with plastic (1.88%) and cardboard (1.45%) materials respectively whiles metallic, PC and PCM recorded higher MC at the six weeks packaging (2.21%, 1.86% and 1.57% respectively). of cardboard, metallic and PC packaging respectively that recorded a drop in MC. The SD also showed a high variability in the MC of specimens that went through all the five packaging materials. plastic and cardboard packaging recorded the least mean MC of 0.88% and 0.14% respectively in the six weeks while PC recorded least mean MC of 0.65% and metallic and PMC, 0.65% and 1.09% respectively in the fourth week.

The results obtained from the effects of the five different packaging material on the MC of finished furniture parts also showed a higher mean MC recorded for the samples that underwent two weeks packaging with plastic (2.26%) and cardboard (0.37%), metallic (2.02%) and PC (1.9%) materials whiles PCM recorded higher mean MC of 2.07 in the sixth week. However, plastic and PC packaging recorded the least mean MC of 0.88% and 0.14% respectively in the six week, while cardboard, metallic packaging also recorded least MC of 0.12% and 0.65%respectively in the week four, and PMC recorded least MC of 1.16% in week two.

IV. Discussions

4.1 Effect of packaging materials on moisture content of unfinished furniture parts.

In the experiment conducted in this study, the plastic packaging showed a significant increase in moisture content of the unfinished furniture parts with time as shown in Figure 1. The general practice in many of the industries is to wrap their unfinished furniture parts with plastic sheets with the view of protecting them from moisture absorption in the course of transit or at the warehouse. Unfortunately, pressure build-ups in the plastic wrapped cases, and can easily cause the furniture to absorb the little moisture in the enclosed air.

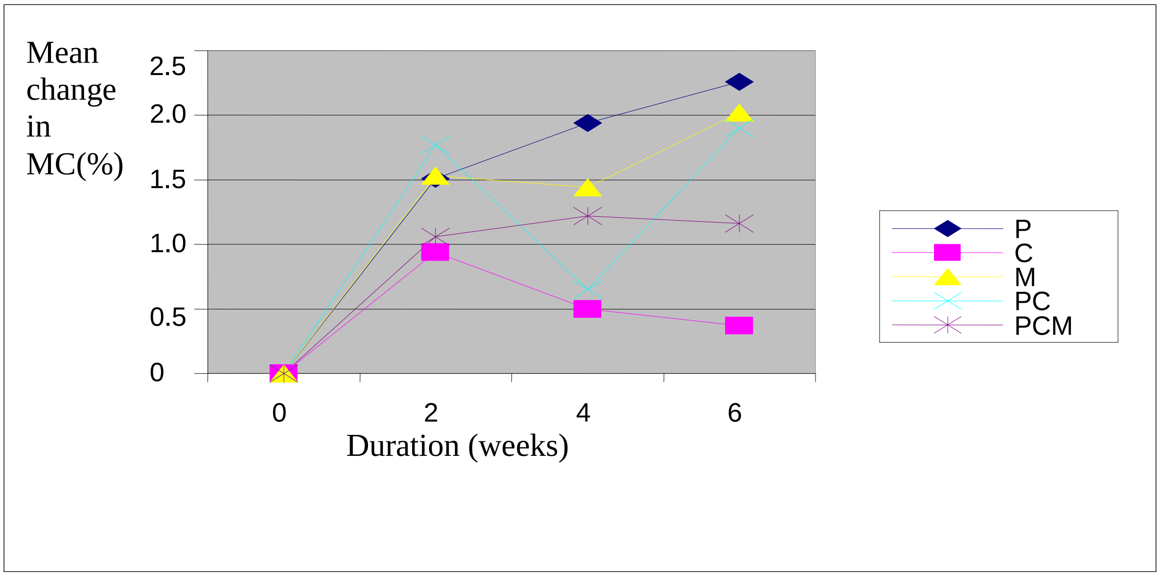

Figure 5.1 Effect of packaging materials on moisture content of unfinished furniture

Kollman and Côte (1984) emphasised that, wood is likely to absorb or desorbs moisture depending on the moisture content of the wood until equilibrium is attained. It was also noticed that, after the wood has taken up the moisture in the surrounding air after the first period (two weeks), it started releasing it. This depicted a slight decrease in moisture contents by 0.42% in week four with a further drop of about 0.03% in week six.

The cardboard packaging also recorded an increased (0.94%) in moisture content after the second week and dropped by 0.1% in week four and rose again in week six by 0.14%. Metallic packaging also showed similar trend of a rise and a continual drop after week two while Plastic plus cardboard packaging and PCM also showed a clear trend of rise and fall manner in moisture content with the three different time levels studied. This trend is presumed to have been caused by fluctuating temperature that caused the fluctuating humidity to affect the cardboard and in effect affecting the moisture content.

4.2 Effect of packaging materials on moisture content of semi-finished furniture parts

Effect of packaging materials on the moisture content of semi-finished furniture parts revealed general increase in the first two weeks. The highest and lowest moisture contents increase were 1.7% and 0.5% for plastic and cardboard respectively as shown in figure 2. The trend is due to the inability of the moisture to escape from the plastic pack, whiles in the case of the cardboard packaging, it was assumed to have absorbed some of the moisture, which was to have been taken by the furniture parts.

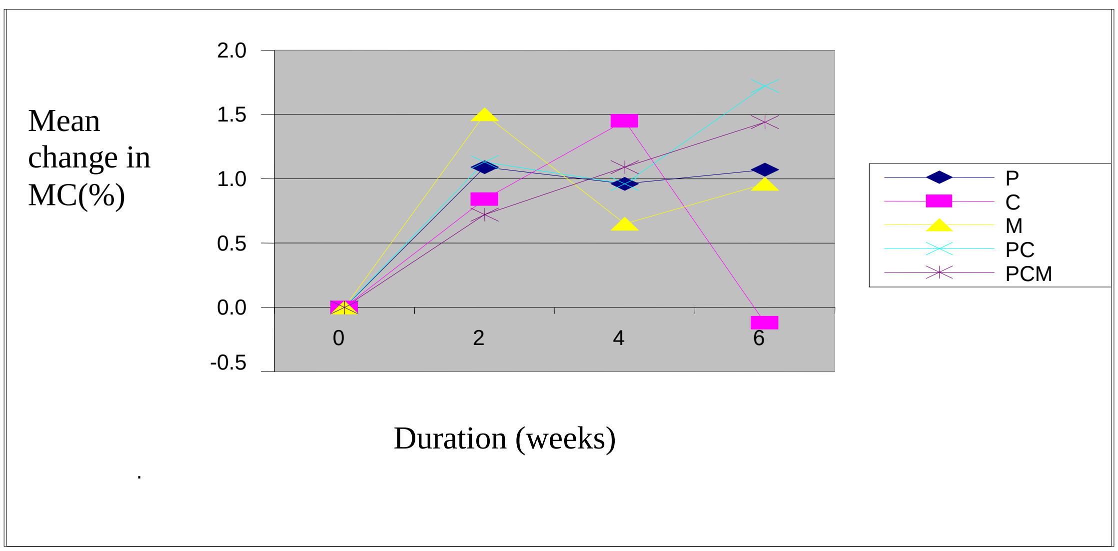

Figure 2. Effects of packaging materials on moisture content of semi-finished furniture

The fourth week duration revealed a different case, where all the materials that recorded high increase in MC rather gave low moisture content and vice-versa. Moisture content of furniture parts with plastic packaging dropped by 0.92%. This may be due to the fluctuating temperature and humidity during the fourth week period. However, it could also be seen that the change in temperature and humidity was too low to effect much change in the moisture contents of the packaged furniture parts.

Cardboard packaging recorded a lower increase in moisture content as compared to metallic, which gave a higher MC increase of 2.21%. Apart from plastic, that also showed a decrease in the four-week period, all the other three packaging methods with metallic parts recorded an increase in the four-week period as shown in figure 2. This can be attributed to the fact that the accumulated air in the corrugated inner layer of the cardboard tend to absorb the moisture in the pack since air is a good conductor of heat.

4.3 Effect of packaging materials on moisture content of finished furniture parts

The test conducted on the finished furniture parts to determine the effect revealed that plastic packaging recorded higher MC after the two weeks period and started dropping until it recoded a mean MC below the initial moisture content of the samples by the sixth week.

Cardboard that recorded low mean MC throughout all the three time levels also recorded a drop in MC as against the initial MC of the samples. This indicates that finished furniture parts that are to be packaged for a period of about six weeks must be packaged with cardboard. The metallic packaging also kept on dropping from 2% to 0.7% as indicated in figure 3.

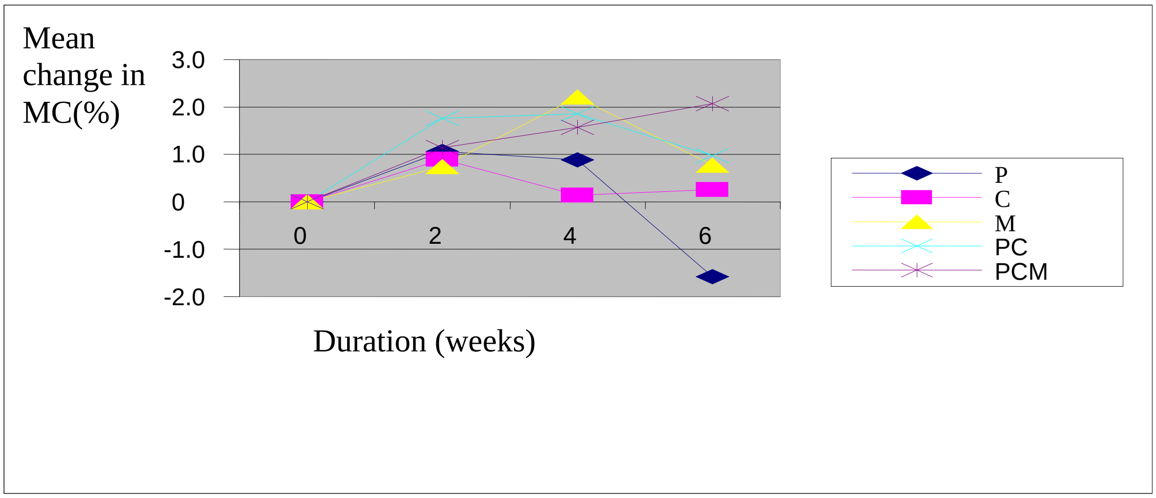

Figure 3. Figure 5.3 Effects of packaging materials on moisture content of finished furniture.

In the case of the plastic and cardboard packaging, the moisture contents of the different packaging materials were consistently decreasing after the two-week period as indicated in the figure 3, but the drop was minimal (0.2%) in week four, and subsequently dropped heavily by 1% in week six. This trend of change can be due to the continual heat generated in the packs because of the finish applied on the parts, which are highly volatile.

4.4 Discolouration of the surface finish of furniture parts.

A visual comparative analysis conducted with the photographs taken before and after packaging revealed that, there were no significant change in the colour with the samples packaged for the period of two weeks. However, 10% of the unfinished specimens packaged with plastic slightly darkened in colour from 14 to 12 on the colour chart. This could be attributed to the rise in MC (1.4%) of the furniture parts after packaging since moisture, dehydration and temperature has damaging effect on packaged furniture. The four-week duration also showed no difference in colour but in the case of the finished furniture parts, about three out of ten specimens were slightly faded from 14 to 16. This may also be due to the internal heat generated in the pack for two weeks as indicated in the work of Kollman and Côte, (1984)

V. Conclusion and Recommendations

This study on the effects of packaging materials on the moisture content (MC) and surface finish of packaged furniture was necessitated by the need to prevent the number of packaging problems associated with moisture changes that confront furniture manufacturers and exporters in Ghana. The study looked at the effect of five different packaging on the moisture content with time. The test was also concurrently undertaken on unfinished, semi-finished and finished furniture parts. It was found generally that cardboard packaging recorded the least change in MC throughout the test. However, plastic and metallic packaging recorded higher moisture contents in most of the test conducted.

In the case of the unfinished furniture, it was realized that cardboard and the combination of plastic and cardboard recorded the least and highest MC changes respectively for two weeks packaging. The four weeks packaging revealed the combination of plastic, cardboard and metallic as the method with least MC changes whiles metallic packaging recorded the highest.

However, metallic recorded the lowest while plastic and cardboard packaging recorded the highest MC change.

Semi-finished furniture parts packaging also proved that, cardboard recorded the lowest and highest moisture content respectively for the two weeks packaging. Metallic and cardboard-recorded least and highest moisture content respectively for four weeks while cardboard and metallic recorded lowest and highest MC changes respectively in the sixth week.

The finished furniture parts' test further proved cardboard's superiority as the packaging material with the lowest MC increase throughout the three time levels. That is, plastic for two weeks, plastic plus cardboard for four weeks and plastic plus cardboard and metallic for six weeks.

In the case of the effect of the packaging materials on the surface finish of the furniture parts, it was found generally that there was no clear-cut difference in the colours of the furniture parts before and after packaging. Some recorded slight differences but it was too slight that it could not be quantified.

It was noted that not every packaging situation should call for the same packaging material. The selection of a packaging material must be based on most likely events that are "normally" encountered. A packaging material to protect against every event would be extremely expensive if not practicable.

In view of the observations made during the study, the following recommendations are made:

1. For better understanding of the test, adequate samples of different ecological zones must be tested to confirm the absorption rate of the wood with the five different packaging materials.
2. Products to be packaged for six weeks are to be packaged in metallic container. However, for the problem of moisture ingression of the furniture parts due to high humidity on sea, they must be packaged with the plastic and cardboard and metallic combination as being done by some companies.
3. Furniture parts to be packaged for less than six weeks must be packaged with cardboard but in the case of high humidity, the plastic plus cardboard and metallic can be used with an absorbent material enclosed to absorb any form of moisture likely to build-up on the surfaces to change the colour of the wood.
4. Wood finishes add to the beauty and protect the product, but no finish is indestructible, therefore where plastics are to be employed on finished furniture, gaps should be created between the furniture surfaces and the plastic sheet since their ingredients can react to soften the finish to smudges and streaks when in contact with hard surfaces.

References

[1] Amoako D.K. (1993). Wood and wood products consumption by Kumasi based end use sectors. MSc. Thesis, KNUST, Kumasi, Ghana. 12-13pp

[2] Appiah, S.K. (1990). Timber Industry Development Division Annual Report, 1990

[3] Ashby, M.F, D.R.H. Jones, (1998), Engineering Materials. Volume 2, 2nd Ed, Guildford And King's Lynn, London, 212-213pp.

[4] Baidoe, J.F. (1987), The Export Development and the Ghana Timber Trade and Industry. TIDD, Takoradi, Ghana, 10pp.

[5] Bolton, W. (1988), Engineering Materials. Vol.3, Bodmin, London.

[6] Covell, P. (2002), Packaging, Microsoft Encarta Encyclopaedia, USA.

[7] FEIT, (2001), Furniture Packaging Optimization , Research Report, Hertfordshire, London, U. K. 16pp

[8] Gloag, J. (1969), A Short Dictionary Of Furniture, George Allen And Unwin Ltd London; 40 Museum Street, WC 1, Revised And Enlarged Edition, 345pp.

[9] ITTO, (2004), Enticing small operators out of the woodwork, Tropical Forest Update (14), (2), Yokohama, Japan. 9pp

[10] Kollmann, F.F.P., W.A. Côte, (1984), Principles of Wood Science and Technology, (1), New York, 528-529 pp.

[11] Kotler, P. (1984), Marketing Management, Eagle Wood Cliffs NJ Prentice Hall.

[12] Kellogg, R. M., R .W. Meyer, (1982), Structural Use Of Wood In Adverse Environment, Van No strand Reinhold Company Inc, New York,U.S.A,170pp

[13] Metcalfe, H.C., J.E. Williams and J.F. Castka (1966), Modern Chemistry, Holt, Rinehart and Winston, Inc. USA, 295pp.

[14] Okai R, (2002), A study on the Milling and Strength Properties of Branchwood suggests that ogging residues could be used to help meet the timber demands of the downstream processing sector: In ITTO Tropical Forest Update (12), (1)

[15] Page,J.M Jr, (1973), Economic Efficiency And Comparative Advantage In Ghana's Wooden Furniture Manufacturing Industries. A Report Prepared For The U.S Agency For International Development Mission In Ghana, 3pp.

[16] Prempeh, A. A. (1993), Construction In The Production And Marketing Of Knock-Down Furniture In Ghana, Msc. Thesis, KNUST, Kumasi, Ghana.

[17] Pröyry, J., (2003), World Paper Markets Up To 2015, (6), Vantaa Finland. 5pp.

[18] Ratnasingam, J. (1998). The South East Asian Furniture Industry Under Siege, Southern African Wood And Timber Times 24(1): 68-72pp

[19] Rietz, R. C. (1957), Importance Of Dry Lumber, U.S. Forest Products Laboratory Report No.1779, Madison, Wisconsin. U.S.A.

[20] Willinston , M. (1988), Lumber Manufacturing, Revised Ed, U.S.A. 434pp

Authors

First Author – Rogerson Anokye, PhD Research Scholar, Department of Wood Science and Technology, Faculty of Forestry, Universiti Putra Malaysia. rogeranokye@gmail.com