A Study of the Movement in Service of the Wood of Ten Ghanaian Lesser Used Timber Species

by

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Philosophy and that, to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Movement in service of wood causes the tightening of joints, reduction of actual finished sizes and widening of gaps between joints of furniture, cupboards, doors and windows due to changes in atmospheric temperature and humidity. In this study, the movement in service of the wood of ten air dried high density Ghanaian Lesser Used Species lumber (*Piptadeniastrum africanum* (Dahoma), *Nauclea diderrichii* (Kusia/Opepe), *Nesogordonia papaverifera* (Danta), *Celtis milbraedii* (Esafufuo), *Celtis zenkeri* (Esakokoo), *Sterculia rhinopetala* (Wawabima), *Petersianthus macrocarpus* (Essia), *Strombosia glaucescens* (Afina), *Cynometra ananta* (Ananta) and *Lophira alata* (Kaku/Ekki)) obtained from four forest reserves – (Bobiri, Pra-Anum, Nueng and Subri River) in four different forest ecological zones were determined to provide information that would be useful for their effective utilization as well as dimensional changes in their final products. The specific objectives were to determine the density, equilibrium moisture content (EMC), shrinkage/swelling, dimensional changes and movement in service of the wood of ten Ghanaian LUS and the relationship between relative humidity and density, EMC, shrinkage/swelling and dimensional changes. The movement in service of the species were determined following the recommendations of the ASTM standards D 4442-92 (2003), D 4933-99 (2004), and E 104-02 (2002) by exposing wood samples over saturated salt solutions of Lithium chloride (LiCl), Magnesium chloride ($MgCl_2$), Potassium carbonate (K_2CO_3), Sodium chloride (NaCl) and Copper sulphate ($CuSO_4$) (at relative humidites of 12%, 33%, 43%, 76% and 98% respectively) in an airtight lid container (conditioning chamber). Six each of tangential and radial samples of the ten LUS lumber of length, width and thickness 10cm x 5cm x 1cm were used. The density, equilibrium moisture content, shrinkage/swelling, dimensional change and dimensional difference were determined by taking the masses, widths, thicknesses and lengths of the samples with an electronic balance, micrometer screw gauge and vernier calipers before and after each saturated solution in the conditioning chamber. The dimensional differences were then interpolated for movement in service between 60% and 90% relative humidity. The density ranged from a low of 626kg/m^3 for Dahoma to a high of 1040kg/m^3 for Kaku. The initial mean tangential EMC ranged from a low of 11.01% for Essia to a high of 13.45 % for Kaku whilst the initial mean radial EMC ranged from a low of 11.06% Essia to a high of 13.58 % for Kusia. The initial mean tangential and radial shrinkage/swelling varied from a low of 2.50% and 1.97% to a high of 4.74% and 3.67% for Essia and Kaku respectively. The mean longitudinal shrinkage/swelling also varied from a low of 0.12% for *Celtis zenkeri* to a high of 0.25% for Ananta. The mean tangential dimensional change ranged from a low of 0.52% for Ananta to a high of 2.29 % for Wawabima and mean radial dimensional change ranged from a low of 0.24% for Ananta to a high of 1.90 % for Dahoma. There were no definite trends established between density and tangential and radial shrinkage for the other nine species except for Kaku. The density, equilibrium moisture content, dimensional change, shrinkage and movement of the ten species increases as the relative humidity of the saturated salt solutions increases from 12% to 98%. Dimensional changes were greatest for all the species at 12% relative humidity except Dahoma and Kusia. Ananta had the lowest tangential and radial movement, whiles Wawabima had the highest tangential and radial movement. Movement in service of the species studied with respect to the sum of their tangential and radial movement values decrease in the following order: Wawabima > Essia > *Celtis zenkeri* > Dahoma > Kaku > Celtis *meldbraedii* > Kusia > Danta > Afina > Ananta. Finally, all the ten Ghanaian lesser used species studied could be classified as "small" movement, except Wawabima, which has medium movement in service. The species with small movement in service could be used for cabinet making, high quality joinery works, flooring and furniture. Species with medium movement in service could be used for applications such as cabinet making and furniture, however, in high quality joinery work; species with medium movement should not be used.

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CHAPTER ONE

1.0 Introduction

Wood has many desirable features that make it the material of choice for many projects, especially in construction and furniture-making. Changes in properties of wood are caused by climatic conditions, drying techniques and sawing patterns. The climatic conditions are caused by relative humidity (RH), rainfall, and temperature. Prior to the use of wood, it is dried to an appropriate moisture content depending on the application. Since wood is hygroscopic, moisture content of wood in use changes with relative humidity of surrounding air.

There are about 680 different species of trees in the forest reserves of Ghana. Approximately 420 tree species attain timber size and are therefore of potential economic value. About 126 of these species occur in sufficient volumes to be considered exploitable as a raw material base for the timber industry (Ghartey, 1989). However, only about ten species contribute 90% of the wood products export earnings (Jayanetti et al 1999), and only four species contribute roughly 60% of the total production (Upton & Attah 2003). The dependence of the timber export trade on a few species represents an inefficient utilisation of the timber resource. Improved utilisation of tropical wood species can help increase economic value of the forest and thus improve the chances of sustainable management (Ofori and Brentuo, 2005). The over reliance on the few timber species is a major problem confronting Ghana's timber industry and sustainable forest management. With the dwindling volumes of the primary species and the 'acceptable' lesser used timber species due to over-exploitation, there is imminent reduction in the timber supply for both domestic and international market, thus reducing forest revenue to the economy. It has become necessary to promote lesser used species (LUS) to replace those species that are being overexploited and threatened or being endangered.

Despite the beauty, durability and workability of wood, it does have some disadvantages. Movement is the dimensional change of timber in service due to changes in atmospheric temperature and relative humidity between 60% and 90%. Wood movement is one of the most difficult characteristics to manage (Wynn, 2011). This is because conditions controlling the movement of wood in service vary widely from place to place even within the same geographical location. In Ghana for example, Navrongo and Takoradi exhibit different monthly equilibrium moisture content (EMC) values in the range of 4.8 to 19.3% corresponding to relative humidity of 22% - 88% at 25°C which influence the behaviour of wood dramatically (Ofori, 1985). There is therefore the need to know the movement in service of the Ghanaian lesser used species (for relative humidity between 60 % and 90%. Knowledge in movement in service of timber species will help wood users to utilize wood in extremes of EMC conditions.

Movement in service of wood causes the tightening of joints, reduction of actual finished sizes, and causing of wider gaps between joints of furniture, cupboards, doors and windows due to changes in atmospheric temperature and humidity. However, movement in service is one of the properties of wood that is frequently misunderstood. Whilst shrinkage is due to seasoning (loss in dimension that occurs in the drying of green wood to equilibrium moisture content); movement is the dimensional changes that occur during the service life of seasoned wood due to environmental changes (CSIRO, 1965). Wood tends to experience the greater part of its expansion and contraction in one particular direction. Wood movement parallel to the grain is negligible, whereas expansion and contraction across the grain is significant (Wynn, 2011). Quarter sawn lumbers for example, undergo much less wood movement than their plain (flat) sawn counterparts. The rate of expansion and contraction of wood varies from species to species and even from board to board. It is important for users of wood to have good understanding of the effects of moisture content changes on wood properties. Many problems affecting wood usage are due to faulty seasoning specifications, inadequate seasoning standards, or a misunderstanding of the influence of moisture content on the behaviour of a particular species under service conditions. The control of movement is the most important consideration to take when seasoned timber is being used for such purposes as cabinet making, joinery, flooring, furniture, wood carving, pattern work, and the like (CSIRO, 1965). Movement values enable a comparison of the species from the point of view of stability in service. Proper understanding of dimensional changes of wood in service will help to determine safety values in designs and construction, the suitability of species for specific end uses. Literature indicates that, data on movement in service of most Ghanaian timber species are 1nsufficient hence the need to provide more information to ensure their efficient and effective utilization and hence sustainability of the forest.

The main objective of this study was to determine the movement in service of the wood of ten Ghanaian Lesser Used Timber Species (LUS), namely: *Piptadeniastrum africanum* (Dahoma), *Nauclea diderrichii* (Kusia), *Nesogordonia papaverifera* (Danta), *Celtis mildbraedii* (Esafufuo), *Celtis zenkeri* (Esakokoo), *Petersianthus macrocarpus* (Essia), *Sterculia rhinopetala* (Wawabima), *Strombosia glaucescens* (Afina), *Cynometra ananta* (Ananta) and *Lophira alata* (Kaku). According to TEDB (1994), the availability of the species, is based on the mean volumes (m^3) per km^2 in the production forests of Ghana (7,600km^2) and are indicated as: '*Abundant* '[over 1,000 m^3 per km^2], '*Plentiful*' [250 – 1,000 m^3 per km^2], '*Average*' [50 – 250 m^3 per km^2], and '*Below Average*' [below 50m 3 per km^2]. Of the ten species selected for the study *Piptadeniastrum africanum, Celtis mildbraedii, Celtis zenkeri* and *Nesogordonia papaverifera* were classified as '*Abundant'; Petersianthus macrocarpus* and *Sterculia rhinopetala* as '*Plentiful*'; and *Strombosia glaucescens*, *Cynometra ananta*, *Nauclea diderrichii* and *Lophira alata* as '*Average*' (Ofori *et al* 2009a).

The specific objectives were to

- Determine the density of the wood of ten Ghanaian LUS
- Determine the equilibrium moisture content (EMC) of the wood of ten Ghanaian LUS
- Determine the tangential, radial and longitudinal shrinkage/swelling of the wood of ten Ghanaian LUS
- Determine the tangential and radial dimensional changes of the wood of ten Ghanaian LUS
- Determine the tangential and radial movement in service of the wood of ten Ghanaian LUS
- Determine the relationship between relative humidity and density, EMC, shrinkage/swelling and dimensional changes of the wood of ten Ghanaian LUS

CHAPTER TWO

2.0 Literature Review

The total dimensional changes that occur in a piece of wood, in drying to say 12% moisture content, are an important consideration in manufacture. Even more important, however, are the changes in dimensions that accompany the normal fluctuations of relative humidity after wood has been placed in service. This behaviour is known as movement and cannot be predicted from the dimensional changes based on shrinkage from the green condition. It is a useful index to the employment of wood under the range of atmospheric conditions that affect wood in service. In selecting a timber for a purpose where its shrinkage *Cynometra ananta* characteristics are important, the rate at which it absorbs or losses moisture – and hence the rate at which it may tend to change dimensions – should also be considered. According to Ofori *et al* (2009a), the mean tangential shrinkage from green to 12% moisture content is small [2.5-4.0%] in *Piptadeniastrum africanum* (Dahoma), *Nauclea diderrichii* (Kusia), *Nesogordonia papaverifera* (Danta), and *Cynometra ananta* (Ananta); medium [4.0-5.5%] in *Petersianthus macrocarpus* (Essia), *Celtis mildbraedii (*Esafufuo*), Celtis zenkeri (*Esakokoo*), Strombosia glaucescens (*Afina) and *(*Kaku) ; and large [over 5.5%] in *Sterculia rhinopetala* (Wawabima). The corresponding radial shrinkage is small [1.0-2.0%] in *Piptadeniastrum africanum* (Dahoma), and *Nauclea diderrichii (*Kusia); medium [2.0-3.0] in *Nesogordonia papaverifera (*Danta), *Celtis mildbraedii (Esafufuo)*; *Celtis zenkeri (Esakokoo), Petersianthus macrocarpus (*Essia), *Sterculia rhinopetala* (Wawabima), *Cynometra ananta* (Ananta) and *Strombosia glaucescens* (Afina); and large in *Lophira alata* (Kaku) [over 3.0]. According to http:// www.senaint/com/exp.imp/wood.htm, (*Piptadeniastrum africanum* (Dahoma), *Nauclea diderrichii* (Kusia), *Nesogordonia papaverifera* (Danta), *Celtis mildbraedii (Esafufuo), Celtis zenkeri (Esakokoo), Petersianthus macrocarpus (*Essia), *Sterculia rhinopetala* (Wawabima), *Strombosia glaucescens* (Afina), *Cynometra ananta* (Ananta) and *Lophira alata* (Kaku) were classified as large/large, medium/small, medium/medium, not available (na)/na, na / na, na /large, large/large, na / na, na /large, and large/large for shrinkage/movement in service respectively. In this study, the species were classified as small/large, small/medium, small/large, small/medium, small/large, small/small, small/medium, small/medium, small/medium and medium/large for tangential /radial shrinkage respectively. They also exhibited small movement in service except *Sterculia rhinopetala* (Wawabima) which exhibited medium movement in service.

2.1 Description of selected species

2.1.1 *Piptadeniastrum africanum* (Dahoma)

Piptadeniastrum africanum is abundantly found in Ghana in all major forests types except the dry forest. The tree is up to 40m high and 3.5m in girth with a wide spreading crown. The bole is straight and clear of branches to a considerable height, with broadly triangular buttresses 3m high or more. Heartwood is light-brown to yellow-brown, clearly demarcated from sapwood; coarse texture with low luster. It has an ammoniac unpleasant odour. Wood is hard and of medium density (Oteng-Amoako, 2006). *Piptadeniastrum africanum* is a moderately durable wood used for the following: exterior construction for beams, joist and other structures, exterior joinery, frames and trims, sleepers. crossties, pile and deckings, industrial and domestic floorings, steps and stair, common and outdoor furniture, vehicle and truck bodies (Oteng-Amoako, 2006).

2.1.2 *Nauclea diderrichii* (Kusia)

Nauclea diderrichii is sparsely found in Ghana in the Wet Evergreen and Moist Semi-deciduous forest. The tree is up to 40m high and about 5m in girth with a rounded crown. The bole is cylindrical up to 27m with low buttresses if present. Heartwood is yellow to orange-yellow, clearly demarcated from white to pale-yellow sapwood. The wood is hard and of medium density (Oteng-Amoako, 2006). *Nauclea diderrichii* is a very durable wood used for the following: bridges, sleepers, piles, sea defence and pilings boat construction, floorings, steps and stairs, panellings, claddings and mouldings, exterior structures, beams and joists, furniture and luxury cabinet works, vehicle and truck bodies (Oteng-Amoako, 2006).

2.1.3 *Nesogordonia papaverifera* (Danta)

Nesogordonia papaverifera is frequently found in Ghana in all forest types except the Wet Evergreen. The tree is up to 30m high and 3m in girth, with narrow buttresses. Heartwood is red-brown (Irvine, 1961), clearly demarcated from the pale sapwood. Texture is fine with low luster. It has an ammoniac unpleasant odour. Wood is hard and of medium density (Oteng-Amoako, 2006). *Nesogordonia papaverifera* is a moderately durable wood used for the following: decorative furniture and luxury cabinet works and bench tops, floorings parquets, steps and stairs, panellings claddings and mouldings, quality joinery, frames and trims, tools, turneries and ornaments, decorative veneer and plywood, vehicle and truck bodies (Oteng-Amoako, 2006).

2.1.4 *Celtis mildbraedii* (Esafufuo)

Celtis mildbraedii is abundantly distributed in the Semi-deciduous forests of Ghana, being more abundant in the Moist Semi-deciduous than in the Dry semi-deciduous forest but entirely absent from the Wet Evergreen forest (Oteng-Amoako, 2006). Tree is up to 36m high and 3m in girth with narrow crown. The slender bole is up to 27m, with thin sharp buttresses 3m. Heartwood is cream to yellowish-white or grey, not clearly demarcated from sapwood ((Irvine, 1961, Oteng-Amoako, 2006). *Celtis mildbraedii* is a non-durable wood used for the following: handicrafts and artifacts, joists and beams, flooring, steps and stairs, panellings and claddings, core veneer for plywood, common furniture and cabinet works, heavy pallets, match boxes and splints (Oteng-Amoako, 2006).

2.1.5 *Celtis zenkeri* (Esakokoo)

Celtis zenkeri is abundantly found in all the forest types and the forest outliers near the Savanna woodland, except the Wet Evergreen forest of Ghana (Oteng-Amoako, 2006). The tree is up to 40m high, 3m in girth straight bole of 20m with 3m high buttress. Heartwood is cream to yellowish-white or pale-yellow (Irvine, 1961), not clearly demarcated from the yellowish- white sapwood. The wood is hard and of medium density (Oteng-Amoako, 2006). *Celtis zenkeri* is a non-durable wood used for the following: handicrafts and artifacts, flooring and parquets, frames, panellings and mouldings core veneer for plywood, pallet, match splints and boxes (Oteng-Amoako, 2006).

2.1.6 *Petersianthus macrocarpus* (Essia)

Petersianthus macrocarpus is abundantly available in Ghana in the Moist evergreen and Moist semi-deciduous forest. The tree is up to 40m high, and 2.5m in girth. The bole is straight and cylindrical with no buttresses. Heartwood is pinkish-brown, clearly demarcated from the yellowish- white sapwood; unpleasant scent of freshly cut wood disappears on drying. Air-seasoning is not too difficult, though the wood tends to warp or split on drying (Irvine, 1961). From Oteng-Amoako, (2006), the wood is hard and of high density. *Petersianthus macrocarpus* is a moderately durable wood used for the following: sleeper, crossties, deckings and piles, heavy construction, industrial floorings, exterior joinery frames and trims, vehicle and truck bodies (Oteng-Amoako, 2006)

2.1.7 *Sterculia rhinopetala* (Wawabima)

Sterculia rhinopetala (Wawabima) is frequently found in Ghana in the Moist and Dry Semi-deciduous forests. The tree is up to 40m high, 4m in girth with small open crown and short branches. The bole is cylindrical with buttresses up to 3m high. Heartwood is dark red-brown, and differentiated from the pale sapwood. It has a coarse texture. Wood is hard and of high density (Oteng-Amoako, 2006). *Sterculia rhinopetala* is a moderately durable wood used for the following: floorings, steps and stairs, exterior joinery, frames and doors, rotary veneer and plywood, industrial structures, joists and beams (Oteng-Amoako, 2006).

2.1.8 *Strombosia glaucescens* (Afina)

Strombosia glaucescens is frequently found in the Wet and Moist Evergreen, and Moist Semi-deciduous forests of Ghana but absent from drier forests. The tree is up to 30m high, and rarely above 2.2m girth with a straight bole. Heartwood is brown or pale-brown with purple streaks, clearly demarcated from the paler sapwood, texture fine and moderate luster. Wood is hard and of high density (Oteng-Amoako, 2006). *Strombosia glaucescens* is a durable wood used for the following: poles posts and stakes (a major use for high transmission pole in Ghana), heavy industrial structural work, beams joists and trusses, sleepers, crossties, deckings and piles, industrial floorings steps and stairs, tool handles, vehicle and truck bodies (Oteng-Amoako, 2006).

2.1.9 *Cynometra ananta* (Ananta)

Cynometra ananta is frequently found in the Wet and Moist Evergreen forests of Ghana. The tree is up to 35m girth, with straight bole and thin creeping buttresses. Heartwood is dark-red with darker streaks, clearly demarcated from the pink-brown sapwood. It has a moderate coarse texture. Wood is hard and of high density (Oteng-Amoako, 2006). *Cynometra ananta* is a durable wood used for the following: handicrafts and air crafts, beams, joists and other structural works, industrial floorings and parquets, decorative carbinet and furniture, exterior joinery, frames and mouldings, poles, posts and sleepers, vehicle and wagon bodies (Oteng-Amoako, 2006).

2.1.10 *Lophira alata* (Kaku)

Lophira alata is sparsely distributed in Ghana, predominantly in the Wet Evergreen and scattered in Moist Evergreen forests. The tree is usually 50m high, occasionally 60m and 5m in girth. It has a straight, occasionally fluted bole. Heartwood is dark-red to purple-brown, clearly demarcated from the sapwood which is pale-pink. It is coarse textured. Wood is very hard and of very high density (Oteng-Amoako, 2006). *Lophira alata* timber is very durable (Irvine, 1961), and used for the following: bridges, sleepers, crossties and pilings, poles, post and stakes, industrial floorings and parquets, heavy construction works and beams, vehicle and truck bodies (Oteng-Amoako, 2006).

2.2 Solubility

Solubility is the property of a solid, liquid, or gaseous chemical substance called solute to dissolve in a solid, liquid, or gaseous solvent to form a homogeneous solution of the solute in the solvent. The solubility of a substance fundamentally depends on the used solvent as well as on temperature and pressure. The extent of the solubility of a substance in a specific solvent is measured as the saturation concentration where adding more solute does not increase the concentration of the solution. The extent of solubility ranges widely, from infinitely soluble (fully miscible) (http:// en.wikipedia.org/wiki/solubility.mht) such as ethanol in water, to poorly soluble, such as silver chloride in water.. The maximum equilibrium amount of solute that can be dissolved per amount of solvent is the solubility of that solute in that solvent under the specified conditions (http:// en.wikipedia.org/wiki/solubility.mht). Solubility is usually an experimentally determined value. To measure it, the simplest way is to add a little more of a substance than will actually dissolve in a known volume of the liquid in question (make a saturated solution with some solid still undissolved). You could slowly keep adding compound to the liquid, adding bit by bit and waiting each time for what you just added to dissolve completely (which may take some time). Then you keep adding until what you just added won't dissolve. This requires time because (a) you have to add very small amounts of compound each time to make it precise and (b) you have to wait a while (minutes-hours) each time you add more because some compounds, while very soluble, dissolve very slowly (http://www.agilent.com/chem/applicationkit).

2.3 Saturated salt solution

A solution is saturated if it contains at a given temperature as much of a solute as it can retain in the presence of an excess of that solute (Weast, 1976). To make a saturated salt solution, a quantity of the selected salt is added gradually in a container of distilled water, stirring well after each addition, until the salt can absorb no more water(ASTM E 104-02(2002)).

2.4 Sorption of water

It is important to distinguish between two terms that have been used interchangeably, namely, 'absorption' and 'adsorption'. Absorption - is the mechanical take-up of a liquid by a porous solid within its gross capillary structure as a result of surface tension forces. It can occur in capillaries large enough to be visible without magnification. It is accompanied by only a limited reduction in vapour pressure of the liquid. In other words, the energy required to evaporate an absorbed liquid is only slightly greater than that required to evaporate the liquid from an extensive flat surface. Adsorption - is the intimate take-up of a gas, a liquid from the vapour phase, or a solute from solution by a fine powder, a porous material, or a swelling gel substance. In many cases the take up is only one molecule thick (monomolecular), and when polymolecular, rarely exceeds an average of ten molecules thick. The term desorption is used to indicate the reverse of adsorption, namely the loss of adsorbate from an adsorbent. The term sorption is used when combined process of adsorption and desorption are being considered or when no distinction is being made between gain or loss of absorbate. Sorption Isotherm - is the relationship between the amount of material sorbed, in terms of either weight or volume of sorbate taken up or loss per unit weight or volume of sorbent, and the gas pressure, relative vapour pressure, or concentration of sorbate in solution, at constant temperature.

2.5 Relative humidity

Relative humidity is a measure of the moisture content in air relative to the amount of moisture the air can hold at a given temperature (Hoadley, 2000). Relative humidity depends on temperature – cold air can hold less moisture than warm air. According to Kaye and Laby (1986), as quoted by Ahmet *et al* (1999), relative humidity is controlled by the inclusion of saturated salt solutions in air tight chambers. Salt solutions provided effective, low-cost method of ensuring constant relative humidity. The use of saturated salt solutions with an excess of undissolved salt present, gives the equilibrium relative humidity for the salts. There are salt solutions which give definite reproducible relative vapour pressure or relative humidity, as long as an excess of salt is present. Table 2.1 below gives the equilibrium relative humidity for some suitable salts.

Table 2.1: Equilibrium relative humidity for some suitable salts at 25°C

Salts	Relative humidity %
Potassium acetate (CH_3COOK)	19.0
Potassium carbonate ($K_2CO_3.1\frac{1}{2}H2O$)	43.0
Sodium chloride ($NaCl$)	75.5
Potassium Chloride (KCl)	96.0
Ammonium Phosphate ($NH_4H_2PO_4$)	93.0

Source: Martin, (1967)

Wood is a hygroscopic material, and under normal use conditions all wood products contain some moisture. Wood readily exchanges this molecular moisture with the water vapor in the surrounding atmosphere depending on the existing relative humidity. In high humidity, wood picks up moisture and swells, and in low humidity, wood releases moisture and shrinks. Problems directly or indirectly attributed to dimensional change of wood are sometimes the result of faulty design, or improper storage of wood on project sites and improper installation, of the wood. The important factor in preventing dimensional change problems is with proper design, fabrication, installation and humidity control.

Wood burns, rots, and has different strength properties depending on the direction of the grain. It expands and contracts due to changes in relative humidity. Wood expands differently in the three axial directions.

2.6 Chemical properties of some Salts

2.6.1 Lithium chloride

Lithium chloride is a chemical compound with the formula LiCl. Solubility in water is 83.2g/100 mL at 25°C (Weast, 1976). The salt is a typical ionic compound, although the small size of the Li^+ ion gives rise to properties not seen for other alkali metal chlorides, such as extraordinary solubility in polar solvents and its hygroscopic properties (Holleman and Wilberg, 2001), and http://en.wikipedia.org/wiki/Lithium_chloride_data page). Saturated salt solution of Lithium chloride at 25°C gives a relative humidity of 12%. It is used as a desiccant for drying air streams (Holleman and Wilberg, 2001). Lithium chloride is used as a relative humidity standard in the calibration of hygrometers. Additionally, lithium chloride can itself be used as a hygrometer. This deliquescent salt forms a self solution when exposed to air. The equilibrium LiCl concentration in the resulting solutionis directly related to the relative humidity of the air. Lithium salts affect the central nervous system (http://en.wikipedia.org/wiki/Lithium_chloride_).

2.6.2 Magnesium chloride

Magnesium chloride is the name for the chemical compounds with the formulas $MgCl_2$ and its various hydrates $MgCl_2(H_2O)_x$. Solubility in water is 54.5g/100ml of water at 25°C (Perry,1963). These salts are typical ionic halides, being highly soluble in water. Saturated salt solution of Magnesium chloride at 25°C gives a relative humidity of 33%.

2.6.3 Potassium carbonate

Potassium carbonate (K_2CO_3) is a white salt, soluble in water (insoluble in alcohol), which forms a strongly alkaline solution. Solubility in water is 113.7g/100 ml of water at 25°C (Perry, 1963). Saturated salt solution of potassium carbonate at 25°C gives a relative humidity of 43%. It can be made as the product of potassium hydroxide's absorbent reaction with carbon dioxide. It is deliquescent, often appearing a damp or wet solid. Potassium carbonate is used in the production of soap and glass (http://en.wikipedia.org/wiki/Potassium Carbonate).

2.6.4 Sodium chloride

Sodium chloride, also known as salt, common salt, table salt or halite, is an ionic compound with the formula NaCl. Solubility in water is 36g/100ml at 25°C (Perry, 1963). Saturated salt solution of sodium chloride at 25°C gives a relative humidity of 76%. Sodium chloride is the salt most responsible for the salinity of the ocean and of the extracellular fluid of many multicellular organisms. As the major ingredient in edible salt, it is commonly used as a condiment and food preservative (http://en.wikipedia.org/wiki/Sodium chloride_).

2.6.5 Copper sulphate

Copper sulphate (II) sulfate, also known as cupric sulfate or copper (II) sulfate, is the chemical compound with the chemical formula $CuSO_4$ and it's solubility in water is 25g/100ml at 25°C (Weast, 1976). Saturated salt solution of Copper sulphate (II) sulfate at 25°C gives a relative humidity of 98%. The anhydrous form is a pale green or gray-white powder, whereas the pentahydrate ($CuSO_4 \cdot 5H_2O$), the most commonly encountered salt, is bright blue (http://wikipedia,copper sulfate.mht). Its blue color is due to water of hydration. When heated in an open flame the crystals are dehydrated and turn grayish-white (Holleman and Wilberg, 2001).

2.7 Moisture Content (MC)

One of the most important variables influencing the performance of wood is its moisture content (Desch and Dindoodie, 1996) as most of the wood properties are strongly affected by its moisture content. Proper understanding of moisture content is a perquisite for the study of wood properties (Shrivastava, 2000). For most uses of wood it is important that most of this moisture in wood is removed; because many of the desirable properties of wood are negatively correlated with its moisture content. Also, some utilization processes require that water solutions of various chemicals be made to penetrate wood. It is for this reason that it becomes desirable to know the location of water in wood and the manner of its movement. Moisture content of wood is the total amount of water in a given piece of wood. It is expressed as the percent of the oven-dry mass of the wood (Ofori, 2004b).

MC = {(Weight (Green) – Weight (oven-dry)) / Weight (oven-dry)} X 100%

Because environmental conditions are seldom constant, moisture content in wood is always changing. A decrease in temperature or an increase in relative humidity causes adsorption of moisture and consequent swelling.

2.7.1 Location of water in wood

The moisture in wood can exist as water and/or water vapour. This moisture is taken up by the wood as:

i. Free water held in the cell cavities (lumen)

ii. Vapour in the air in the part of cell cavities not occupied by liquid, and

iii. Bound (or Hygroscopic) water absorbed primarily on the cellulose and hemicellulose molecules which constitute the greater part of wood substance, i.e. the cell walls.

2.7.1.1 Free water

Free water (or polymolecularly adsorbed water) is contained in the cell lumen (the primary pore space) or held mechanically by surface tension forces rather than molecular attraction. The water in general does not fill the lumen entirely, and in such case the lumen contains water, water vapour, and air or gases such as CO_2. When water does fill the lumen completely (as in some Australian eucalypts), the condition tends to retard moisture movement during drying and contributes to a seasoning defect called "collapse". The quantity of free water present is limited by the porosity or fractional void volume of the wood (Ofori, 2004b).

2.7.1.2 Bound water

Bound water (monomolecularly adsorbed water, hygroscopic water, or imbibed water) is contained in the cell walls (the secondary pore space) i.e. transient cell wall capillaries and the amorphous regions of the cellulose microfibrils. The hydroxyl groups of the cellulose molecules in the amorphous regions attract molecules of water and are linked to them by hydrogen bonding (Ofori, 2004b).

2.7.2 Fibre saturation point

When wood dries, the 'free' water evaporates first, followed by the bound water. The condition existing when all the free water has been evaporated and the cell walls are still completely saturated is known as the fibre saturation point (FSP). It usually occurs at MCs between 24~30%. It varies with different wood species and somewhat within individual pieces of wood. The variation is caused by differences in chemical composition, crystallinity of the cellulose, compactness of the cell wall, specific gravity and extractive content. The MC corresponding to the FSP varies with temperature also, decreasing as temperature increases. It is also affected by prolonged exposure of wood to high temperatures which results in a permanently reduced FSP. The condition of wood at FSP is associated with maximum swollen volume of the cell wall and with major changes in the physical behaviour of wood, and hence is of primary importance. As wood dries from its natural green MC, it does not commence to shrink until the FSP is reached. Below the FSP most strength properties are negatively correlated with MC. Below the FSP wood exhibits improved electrical resistance, resistance to decay, and better gluing characteristics and nail-holding power, and a continued reduction in density. Values of FSP are determined by procedures that include:

i. Extrapolation to 100% relative humidity of sorption data on equilibrium moisture content,

ii. Observation of shrinkage initiation with loss of moisture,

iii. Correlation of strength or electrical properties with MC,

iv. Analysis by the polymer exclusion technique (Stamm, 1971).

2.7.3 Types of Moisture content determination

There are several ways of determining the moisture content of wood, but by far the most satisfactory for most purposes is the gravimetric or oven dry method.

2.7.3.1 Gravimetric or oven-drying method

The standard gravimetric or oven-drying method of determining the MC is to dry the wood in an oven to constant mass at 103±2°C. This procedure reduces the sample MC to a low value at equilibrium with a relative vapour pressure sufficiently close to zero that the sample is assumed to have attained its dry weight, W_o. The method is accurate throughout the whole range of MC, but it is destructive (i.e. cutting), time consuming and inadvertently causes the evaporation of volatile constituents other than water from the wood during drying in the oven (Ofori, 2004b).

2.7.3.2 Hygroscopic method

In a hole (6mm diameter, 95mm Length) freshly drilled into a piece of wood, the relative humidity corresponds to the MC of the surrounding wood. Thus it is possible to measure the MC of wood using a wood hygrometer. Measurements are restricted to the range between 3 and 25% MC. The instrument consists of a perforated tube containing a string of hair which changes its length in response to changes in humidity. [Samples are first conditioned to intermediate MC in the hygroscopic range] (Ofori, 2004b).

2.7.3.3 Distillation method

The evaporation of volatile components other than water during drying may cause substantial errors in the gravimetric method of measuring moisture in wood. If the wood contains volatile substances, such as resins, solvent extraction is employed. Boiling the wood sample in a water-immiscible liquid which is a solvent for volatile extractive compounds, [such as toluene, xylene, and trichloroethylene] to dissolve the volatile substance, water is distilled from the wood, at the same time and is collected in a reflux condenser system and separated from the solvent by means of a calibrated trap. By measuring the mass of the water collected, and the mass of the dry wood sample, the MC of the extractive-free wood can be calculated (Ofori, 2004b).

2.7.3.4 Karl Fischer titration method (KFTM)

The KFTM for measuring the MC of wood is another technique which is particularly useful for wood containing volatile extractives. This technique has been found to give lower MC values than the oven-drying method for some species believed to contain volatile oils. In this method the water content is measured by titration using a methanol solution of sulphur dioxide, iodine, and pyridine. At the end point of titration free iodine appears which can be detected either visually or potentiometrically, the latter method giving more precise results (Ofori, 2004b).

2.7.3.5 Electric moisture meters

Electric moisture meters permit the determination of MC without cutting or mutilating the board. They are very rapid and simple to use. Electric Moisture Meters rely on the increase in direct current [dc] resistivity and the decrease in the alternating current [ac] dielectric constant as timber dries below the fibre saturation point (FSP).

2.7.3.5.1 Electrical resistance moisture meter

The electrical resistance moisture meter is a simple instrument which expresses MC in wood as a function of dc resistivity. The meters are generally supplied with pin-type electrodes [e.g. 2 or 4 phonograph needles] that are driven into the wood being tested. The dc resistivity decreases with increasing temperature, and is affected by the presence of electrolytes [e.g. extractives] and moisture gradients over the depths penetrated by the electrodes of the instrument. The instrument must therefore be calibrated for a given kind of wood and temperature range. These instruments are useful only over a total range from 7 to 25 % MC in the outer shell of the wood (Ofori, 2004b).

2.7.3.5.2 Capacitance type moisture meter

The capacitance type moisture meter relies on the increase of dielectric constant of dry wood with increase in MC which approaches 81 of a fully saturated wood above FSP. The instrument uses integral surface-contact-type electrodes [usually 4 or more metal segments] which are pressed against the timber under test. The electric field radiating from the electrode penetrates about 20mm into the wood so that timber thickness to about 40mm may be tested. This has the advantage over dc resistivity meters in that the readings are not affected by ash or mineral content. It can also be used to measure relatively accurately MCs below 8%. However, readings must be corrected for density variations within the timber (Ofori, 2004b).

2.8 Density

2.8.1 Wood density

According to Ofori (2004a), wood density is the dry mass of wood substances per unit volume [kg/m^3, gm/cm^3]. Thus: Density (D) kg/m^3 = Mass of wood substances (M) / Volume of substances (V). Volume is measured under specific conditions of moisture (that is. green, oven-dry, air-dry or some intermediate condition below fibre saturation point, e.g. 12%, 18%). The dry mass of the wood is always used as the numerator because of the following advantages:

i. Practical implications (correlation with physical and mechanical properties of wood),

ii. Reproducibility,

iii. Ease of conversion to different moisture conditions when shrinkage information is available.

As the volume of wood becomes smaller with decrease in the moisture content, the denominator of the ratio becomes smaller, and the density value correspondingly larger. The reverse is true as the moisture content of the test block increases. Thus the minimum value of wood density is obtained when the green volume is used, and the maximum when the volume of wood is taken at the oven-dry condition in determining the mass.

2.8.2 Wood cell wall relative density/specific gravity

Wood is a porous substance, and a piece of oven-dry wood is composed of solid wood substance of the cell walls and of the cell cavities containing air and very small amounts of sap constituents such as minerals and other substances such as resin, gums, etc. The relative density or specific gravity of cell wall substance may be determined from its oven-dry mass and volume of fluid displaced. The observed relative densities measured in this way are dependent on the medium used (Table 2.2).

Table 2.2: Cell wall specific gravities and specific volumes

Displacing Fluid	Specific Gravity	Specific Volume
Water	1.53	0.653
Helium	1.46	0.685
Benzene	1.44	0.693

Source: Ofori (2004a)

The reasons for the observed variations are:

- the displacement media vary in their ability to penetrate voids in the cell wall

- the physical and chemical interactions between the displacement media and wood can alter the density of the media or the wood. The smaller helium molecule is able to penetrate more of the micro-voids in the cell-wall than that of benzene. The value obtained for helium is probably the most accurate for the above reason, and also because helium does not swell wood and is not adsorbed on the cellulose, which could cause increased density of the helium at the interfaces (Ofori (2004a).

Wood is used in a wide range of conditions and thus has a wide range of moisture contents in use. Since moisture makes up part of the weight of each product in use, the density must reflect this fact. This has resulted in the density of wood often being reported on moisture content at the time of test. The determination of density usually is sufficiently accurate to permit proper utilisation of wood products where weight is important. Such applications range from estimation of structural loads to the calculating of approximate shipping weight (Brentuo, 1998). According to Sunley & Bedding (1987), timbers vary in density depending on the species and moisture content as in Table 2.3.

Table 2.3: Densities of some wood species of Ghana

Wood Species	Mean Density at 12% kg/m^3	Mean Green Basic Density kg/m^3
Dahoma	663	557
Kusia	684	596
Danta	712	566
Celtis mildbraedii	781	631
Celtis zenkeri	743	613
Wawabima	685	550
Essia	738	589
Afina	840	655
Ananta	880	717
Kaku	1047	839

Source: Ofori *et al* (2009b)

2.9 Equilibrium Moisture Content (EMC)

2.9 .1 Understanding Equilibrium Moisture Content

The moisture content of wood is linked directly to the relative humidity of the surrounding air. The higher the relative humidity, the higher the MC of the wood. If you are installing wood that has recently been transported, it might take a little while for the material to reach its equilibrium moisture content with the air; in other words, for the wood to adjust to the humidity level for the climate around the wood: the wood may take up more moisture or lose it. For example, if wood at 10% MC is exposed to 25% RH, the wood will dry to 5% MC and shrink as it dries (http://scottscontracting.wordpress.com). Wood always remains hygroscopic, which means that it responds to changes in atmospheric humidity (Hoadley, 2000) and its moisture content will always have a tendency to change until it is in equilibrium with the amount of water vapour in the surrounding atmosphere. Therefore for any given combination of air temperature and relative humidity there is corresponding wood moisture content termed the equilibrium moisture content (EMC); the higher the temperature, or the lower the relative humidity, the lower the EMC. The EMC helps us understand the response wood will have to change in relative humidity, whether it will shrink or swell. The most important factor influencing EMC is the relative humidity of the environment (Ahadome, 1981). The Hailwood–Horrobin single hydrate equation using parameters determined by Simpson (1973) shows the relationship between moisture content, relative humidity and temperature:

$$\mathbf{M = 1800/W\ [KH/(1-KH) + (K_1KH + 2K_1K_2K^2H^2) / (1 + K_1KH + K_1K_2K^2H^2)]}$$

where: M = moisture content (%), H = relative humidity/100

For temperature T in Celsius, and for temperature T in Fahrenheit,

For temperature T in Celsius	For temperature T in Fahrenheit
$W = 349 + 1.29T + 0.0135T^2$	$W = 330 + 0.452T + 0.00415T^2$
$K = 0.805 + 0.000736T - 0.00000273T^2$	$K = 0.791 + 0.000463T - 0.000000844T^2$
$K_1 = 6.27 - 0.00938T - 0.000303T^2$	$K_1 = 6.34 - 0.000775T - 0.0000935T^2$
$K_2 = 1.91 + 0.0407T - 0.000293T^2$	$K_2 = 1.09 + 0.0284T - 0.0000047T^2$

2.9.2 EMC of wood in Ghana exposed to outdoor conditions

Wood in service is exposed to both long-term (seasonal) and short-term (daily) changes in relative humidity and temperature of the surrounding air. Thus, wood is always undergoing at least slight changes in moisture content. These changes usually are gradual, and short-term fluctuations tend to influence only the wood surface. Moisture content changes can be retarded, but not prevented, by protective coatings, such as varnish, lacquer, or paint. The objective of wood drying is to bring the wood close to the moisture content a finished product will have in service (Ofori 2004b). In Ghana, different localities have different EMC values. For example Navrongo, Kumasi and Takoradi have mean EMC values of 9.8, 15.4 and 18.3% respectively (Table 2.4) (Ofori, 1985). The monthly range of EMC of wood in Ghana exposed to normal conditions outdoors but under cover is 4.8 - 19.3% (Table 2.4).

Table 2.4: EMC values for some towns in Ghana

Town	Monthly Minimum	Monthly Maximum	Annual Mean
Takoradi	16.5	19.3	18.3
Oda	14.7	18.2	16.7
Koforidua	14.5	18.6	16.6
Tema	14.7	18.7	16.3
Accra	15.2	17.8	16.1
Kumasi	12.6	17.7	15.4
Ho	11.8	17.8	15.1
Sunyani	10.7	17.9	15.0
Tamale	5.4	16.4	11.2
Wa	5.3	16.3	10.8
Navrongo	4.8	16.1	9.8

Sources: Ofori (1985) and Ofori (1991)

2.10 Shrinkage /swelling of wood

Shrinkage in timber is the decrease in dimension due to decrease in the moisture content of the timber (TTG, 1974). Shrinkage is normally defined as the reduction in size which occurs when wood is dried from the green condition down below the fibre saturation point. Shrinkage values are useful as a guide to the allowances which should be made when converting green timber. The amount of shrinkage which occurs will not normally be uniform along each of the three axes of a tree in the longitudinal direction the amount of shrinkage is usually insignificant and can be ignored, but across the grain it can be large, particularly in a direction tangential to the growth rings. It is the differential shrinkage which can lead to the development of distortion during drying (Shrivastava, 2000). Dimensional changes, shrinkage, and swelling in wood take place below the fiber saturation point (FSP) (Bodig and Jayne, 1982) where all of the water exists only within the cell wall. Shrinkage is proportional to the amount of water exchanged between a piece of wood and its environment. Wood is an anisotropic material; that is, its dimensions change differently in three directions: tangentially, radially, and longitudinally. Tangential dimensional change has the highest rate of change due to parallel orientation of microfibrils along the axis of the cell wall. Shrinkage in the radial direction is the second largest, while longitudinal shrinkage is negligible for most practical applications. In general, dimensional change is expressed as percent and can be calculated using the following formula:

Shrinkage or S (%) = (Change in dimension or volume / Initial dimension or volume) X 100

There is a direct relationship between density of wood and shrinkage values. Species with higher density shrink more than those with lower density. Even though shrinkage values of many species are relatively low, they still play a significant role in designing wood structures. If shrinkage of wood is not taken into consideration during the design stages, certain construction defects such as warping, cracking, and buckling may occur, lowering the overall quality of the finished product (Hiziroglu, 1990).

One of the most important practical problems which arise during the use of wood is the hygroscopic shrinking and swelling of wood that occurs as a result of moisture changes. When wood takes up moisture into the cell wall, the walls swell volumetrically in proportion to the volume of water absorbed. The volumetric swelling of gross wood [i.e. wood including air spaces] depends on the dimensional changes that occur in the air spaces or cell cavities when the cell wall swells. Three possibilities are envisaged:

i. The lumens or cavities may shrink so that all the swelling [or at least part of it] takes place into the cell cavities

ii. The lumens may remain constant in size, or

iii. The lumens may swell in the same proportion as the cell wall.

Conceivably, all or part of the swelling may take place into the cell cavity with reduction in lumen volume. The external swelling of the gross wood is then relatively small. If all the swelling takes place in the cavity no external dimensional changes takes place at all. If the cavity remains constant, the swelling of the gross wood for a given moisture change should be proportional to the volume of water absorbed and therefore to the density of the wood. If the cavity swells to some degree, the gross wood swelling is expected to be maximum. If the lumen swelling is in the same proportion as that of the cell-wall itself, then the gross wood swelling should be the same for all woods over a given moisture range. This situation would be anticipated if all of the cell-wall layers had the same fibril orientation – a homogenous cell wall. Of all these possibilities discussed above, the behaviour of the individual woods appears to fit all three situations. In some woods the lumen appears to swell, in others it appears to shrink, and in others to remain constant.

As a general rule, however, the cell cavity appears to change only to a small extent during change of MC unless collapse occurs during drying above fiber saturation point. The reason why cell lumens on the average tends to remain constant during shrinkage and swelling of the gross wood is probably related to the orientation of the fibrils in the three layers of the secondary wall. The S2 layer has its fibril orientation nearly parallel with the long axis of the cell and swells transversely in proportion to the moisture change. The outer S1 and inner S3 layers, however, have their fibril orientation nearly perpendicular to the cell axis and act to restrain the external and internal dimensional changes in the secondary wall. During swelling, for example, the outer S1 layer may act as a cross-band or restraining influence and may thus minimize the amount of external swelling. In order for this layer to swell appreciably the cellulose chains must be stretched to some extent, and since they are very strong along the length of the chain or fibril direction, they resist the stretching, thus reducing external swelling. The inner S3 layer probably acts in much the same way to modify the swelling into the cell cavities. There are variations among different woods and even within the same wood in the relative thickness and fibril orientations of the various cell-wall layers. These variations may cause the deviations among woods from the general relationship (Ofori, 2004c). Thus on drying, cell walls diminish in thickness, but microscopic evidence indicates that the areas of the lumens remain unchanged. This results in shrinkage of wood. When wood is exposed to air at a higher RH than is in equilibrium with it, the microfibrilar net absorb water molecules made available to them and move apart or expand / swell in proportion to the amount of liquid which has been added. This is the basis for the swelling of wood. This continues until the FSP has been reached. Further addition of water to the wood produces no change in the volume of the cell wall substance because additional water, above this level, is concentrated in the lumen.

These external dimensional changes during desorption or adsorption are usually expressed as a % of the swollen or green dimension in the case of shrinkage, and as a % of the oven dry dimension in the case of swelling:

% Shrinkage = (Change in dimension from swollen size / swollen dimension) x 100

% Shrinkage = [(Green dimension – Dry dimension) / Green dimension] × 100

% Swelling = (Change in dimension from dry size / dry dimension) x 100

% Swelling = [(Green dimension – Dry dimension) / Dry dimension] × 100.

Shrinkage, swelling and these differential dimensional changes are the principal sources of problems in the drying, manufacture and use of lumber. When water begins to leave the cell walls at 25 to 30 percent moisture content, the walls begin to shrink. Even after drying, wood will shrink and swell in service as relative humidity varies. Drying stresses develop because wood shrinks by different amounts in the radial, tangential, and longitudinal directions and because during drying, shrinkage starts in the outer fibers before it starts in the inner fibers. These stresses can cause cracks and warp to develop (Ofori, 2004c).

2.10.1 Effect of grain direction on shrinkage

Wood is not a homogenous material with equal shrinkage in all directions. Its anatomical structure results in shrinkage behaviour which varies between the different structural axes of the wood. Wood shrinks about 1.5 to 2 times as much parallel to the growth rings (tangential) as it does at a right angle to the growth rings (radial). The shrinkage along the grain (longitudinal) is small (0.2 percent or less for normal wood) (Table 2.5). The amount of shrinkage and the difference between radial and tangential shrinkage have a direct influence on the development of drying defects. The bound water responsible for the shrinking and swelling is attached to sites on the sides of the cellulose chains, and since most of the cellulose chains are inclined at 10^{o}-15^{o} to the vertical axis, any dimensional change due to loss of moisture will be primarily be across the grain with only a very small component in the longitudinal direction.

Table 2.5: Total shrinkage [from green to oven-dry] mean values of some Ghanaian species

	Shrinkage, %		
Species	Tangential	Radial	Longitudinal
Dahoma	6.2	3.9	0.35
Kusia	7.3	4.3	0.35
Danta	6.9	4.8	0.23
Celtis mildbraedii	7.7	5.2	0.27
Celtis zenkeri	8.0	5.4	0.29
Wawabima	9.5	4.6	0.26
Essia	9.0	4.4	0.39
Afina	8.3	5.7	0.35
Ananta	7.8	5.0	0.43
Kaku	9.9	7.6	0.41

Source: Ofori *et al* (2009a)

2.10.2. Effect of moisture content on shrinkage

The most important factor affecting shrinkage or swelling is the change in MC below FSP. Shrinkage is found to be directly proportional to the amount of water removed from the cell walls. Shrinkage is expressed as a percent of the green dimension since this dimension is stable at all MCs above FSP. At zero MC, maximum shrinkage is attained. As wood dries, the surface of the wood normally dries first, and its MC may be considerably below the FSP while the core remains wet, so that the average MC of the piece is still comparatively high.

2.11 Dimensional changes of wood in service

The total dimensional changes that occur in a piece of wood (movement) in drying from the green condition are an important consideration in manufacture. Even more important, however, are the changes in dimensions that accompany the normal fluctuations of relative humidity after wood has been placed in service. Movement cannot be predicted from the dimensional changes based on shrinkage from the green state. It is a useful index to the employment of wood under the range of atmospheric conditions that affect wood in service. In selecting a timber for a purpose where its shrinkage characteristics are important, the rate at which it absorbs or losses moisture – and hence the rate at which it may tend to change dimensions – should be considered. In this case, density, size, the nature of the wood (example its permeability and extractive content, the drying conditions used, the presence of certain preservatives or other chemical salts, and the factors previously mentioned all affect rate of moisture absorption or loss, and hence, movement behaviour (Ofori 2004c) Because environmental conditions are seldomly constant, moisture content in wood is always changing. A decrease in temperature or an increase in relative humidity causes adsorption of moisture and consequent swelling. Conversely, a drop in relative humidity or temperature causes drying and shrinking. When changes in temperature and humidity are large and occur over a long period of time, wood dimensional changes can be damaging. For instance, doors and windows can swell and be difficult to open and close, flooring boards can dry out and separate unattractively or joints in furniture can loosen (http://www.warnell.forestry.uga.edu.service/libruary/for93-034/node3.html).

2.12 Movement in service

In normal use the moisture content in wood is not steady but varies with atmospheric conditions to which it is exposed in service. The moisture content of air dried timber is known as its EMC which depends on the ambient temperature and relative humidity of the surrounding. When the temperature or relative humidity or both changes, the moisture content also changes. The change is rather slow and it occurs only when the changed conditions persist for some time. In tropical countries, variations in EMC of 6% and 18% are normal (Ofori, 1985 & 1991). Such changes are sufficient to cause appreciable shrinkage and swelling, depending on the species and method of sawing (Shrivastava, 2000). According to Sunley & Bedding (1987) and Shrivastava (2000) movement is the term used to describe the extent of shrinking and swelling which occurs with dried timber as its moisture content responds to changes in temperature and RH in service. Sharma et al (1976) also used the term movement in referring to the dimensional changes that take place when timber which has been dried is subjected to the changes in atmospheric conditions. Below the fiber saturation point wood generally swells with an increase and shrinks with a decrease in moisture content but, as noted with shrinkage, movement can occur in differing amounts in the length, width and thickness of the piece. Because the amount of movement will vary between different timber species, it is convenient to establish a movement rating system which can help in timber selection. Movement values are currently expressed as the dimensional differences which exist, at 25°C, between timber in equilibrium with air at 60% and at 90% relative humidity. The three categories of movement which are recognized are based on tangential and radial movement and are expressed as a percentage change in dimension. Movement is expressed either quantitatively as a percentage value for tangential and radial directions separately, or qualitatively as belonging to one of the three arbitrarily defined movement classes (Sunley & Bedding 1987), where each class is defined in terms of the sum of the movement percentages in the tangential and radial directions. Thus, in woods with a "small" movement the sum of the tangential and radial movement is less than 3.0 percent; in woods with a "medium" movement, the sum will lie between 3.0 and 4.5 per cent; while in those woods having "high" movement, the sum of the individual values will be greater than 4.5 percent (Desch & Dinwoodie, 1996). It may be noted that low values of shrinkage or movement are not necessarily an indication that minimal distortion of wood would occur during drying or conditioning. According to Farmer (1972) and FPRL (1954), to determine the movement values quoted, test samples after being kiln dried to 12% moisture content, were conditioned first in air at 90% relative humidity, and dried in air at 60% relative humidity, the temperature being 25°C (77°F) in both cases. The moisture content values of the samples when in equilibrium at the two humidities are given, together with the movements corresponding to the particular moisture content range. It is necessary to stress here that shrinkage and movement are not directly related one to the other. For example, it is possible that a wood may shrink quite appreciably in drying from the green to 12 percent moisture content, yet it may undergo comparatively small dimensional changes when subjected to a given range of atmospheric conditions in service. The reason is that the "fibre saturation point", or the moisture content value at which appreciable shrinkage begins to take place, varies between species. Shrinkage values therefore are useful only in estimating roughly the dimensional allowances necessary in converting green material. It must be pointed out that a further allowance must also be made for possible losses owing to distortion (Farmer, 1972). Movement values, on the other hand, give some indication of how the dried timber will tend to behave when subjected to atmospheric changes in service. A stable timber is one that exhibits comparatively small dimensional changes in passing from the 90 per cent to the 60 per cent relative humidity conditions, together with small distortional propensities (Farmer, 1972). It is a natural fact that wood moves. You can nail it, glue it and reinforce it but you will never stop the wood in your project from shrinking and swelling with seasonal changes in humidity. Most wood movement affects work occurring across the width of the piece (http://scottscontracting.wordpress.com). Timber with low movement values is always in demand, particularly so for high-quality joinery work, paneling and domestic flooring. Movement in service can be minimized by initially selecting wood of a moisture content midway in the range to be expected (Desch and Dindoodie, 1996).

CHAPTER THREE

3.0 Materials and Methods

3.1 Materials

3.1.1 Species

Ten (10) air dried LUS lumber were collected from CSIR-FORIG air-drying shed which were excess samples from work done on Timber Bridges project funded by the United Kingdom Department of Foreign and International Development (DFID) (Ofori et al, 2009a and 2009b). They were obtained from four forest reserves in four different forest ecological zones. These were: Bobiri Forest Reserve (Moist Semi-deciduous-North-East Type) – (6^{o} 39'N - 6^{o} 44'N and 1^{o} 15'W - 1^{o} 23'W), Pra-Anum forest Reserve (Moist Semi-Deciduous- South-East Type) - (6^{o} 12'N - 6^{o} 19'N and 1^{o} 9'W - 1^{o} 17'W), Nueng Forest Reserve (Moist Evergreen) – (5^{o} 02'N - 5^{o} 14'N and 1^{o} 55'W - 2^{o} 07'W), and Subri River Forest Reserve (Wet Evergreen) - (5^{o} 05'N - 5^{o} 30'N and 1^{o} 35'W - 1^{o} 55'W) (Ofori et al, 2009a).

The species were *Piptadeniastrum africanum* (Dahoma), *Nauclea diderrichii* (Kusia), *Nesogordonia papaverifera* (Danta), *Celtis mildbraedii* (Esafufuo), *Celtis zenkeri* (Esakokoo), *Petersianthus macrocarpus* (Essia), *Sterculia rhinopetala* (Wawabima), *Strombosia glaucescens* (Afina), *Cynometra ananta* (Ananta) and *Lophira alata* (Kaku)

3.1.2 Apparatus

A conditioning chamber (Plate 3.1) supplied by GTZ (German Agency for Technical Co-operation) to CSIR-FORIG was used. The apparatus consist of five humidity chambers with a thick layer of insulation in each chamber. In the center of each chamber is a power driven stirrer above the solution (Plate 3.2). Each chamber is securely closed with a lid to prevent the escape of water vapour (ASTM E104). Within each chamber is a metal mesh supported about half-way the depth of the chamber, on which the wood species were packed edgewise Plate 3.3 (Ahadome, 1981). The chambers were appropriately labeled indicating the type of salt contained in, as well as the measured relative humidity. Five different saturated salt solutions were contained in different chambers to provide different relative humidities in the chambers. The saturated salt solutions were selected to provide a relative humidity range of 12 to 98 percent.

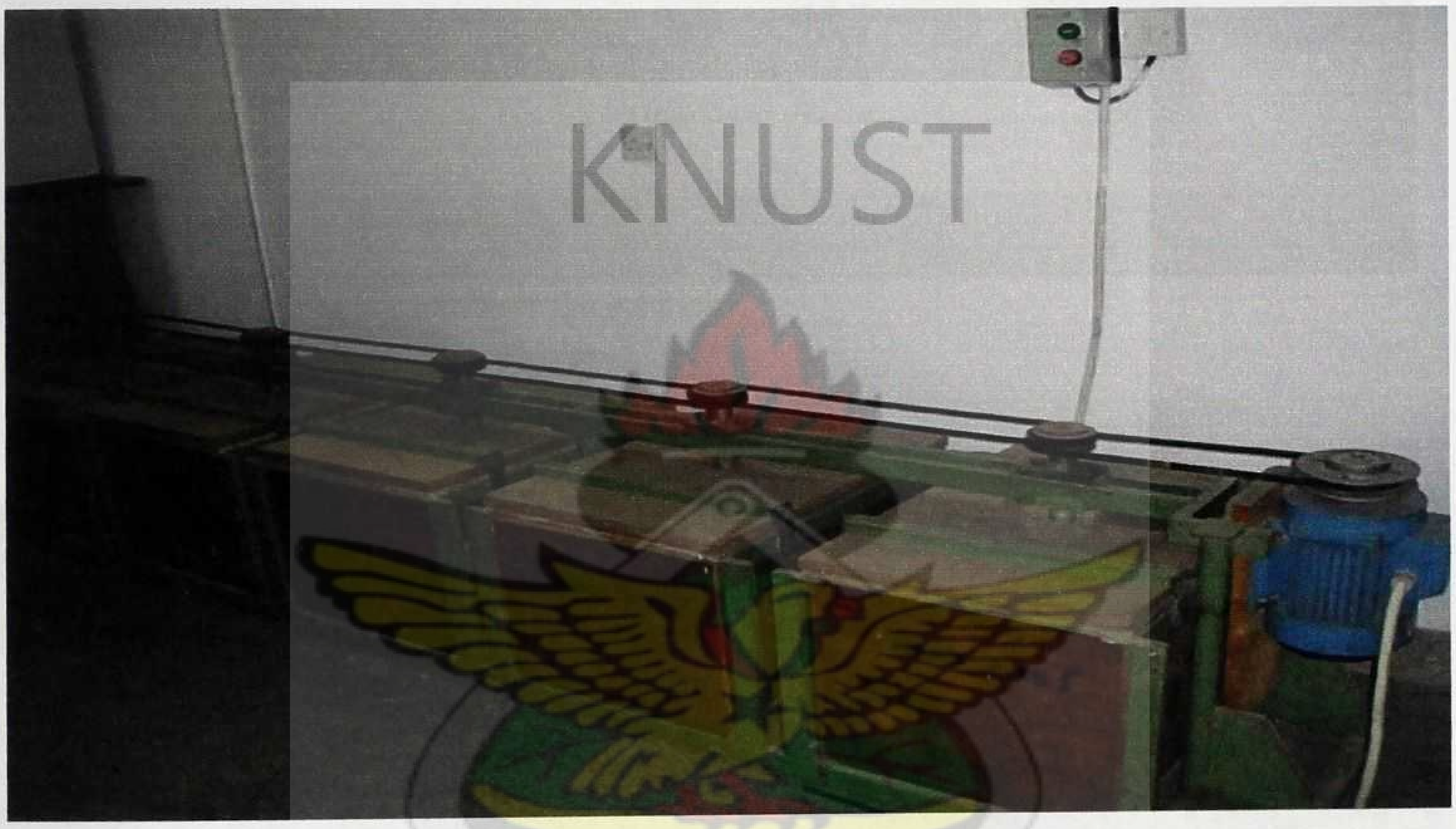

Plate 3.1: Conditioning Chamber for the experiment

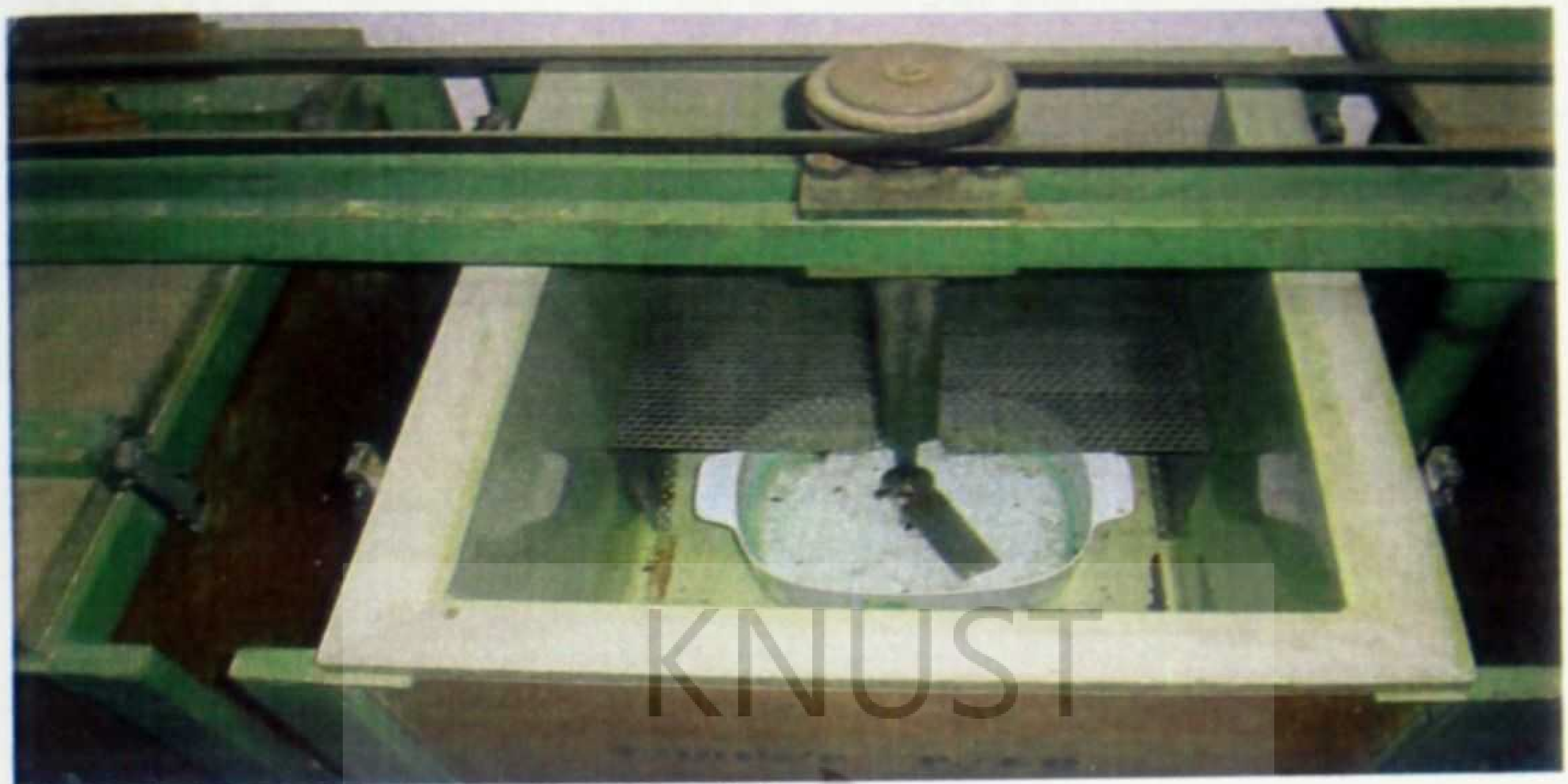

Plate 3.2: Power driven stirrer above the solution

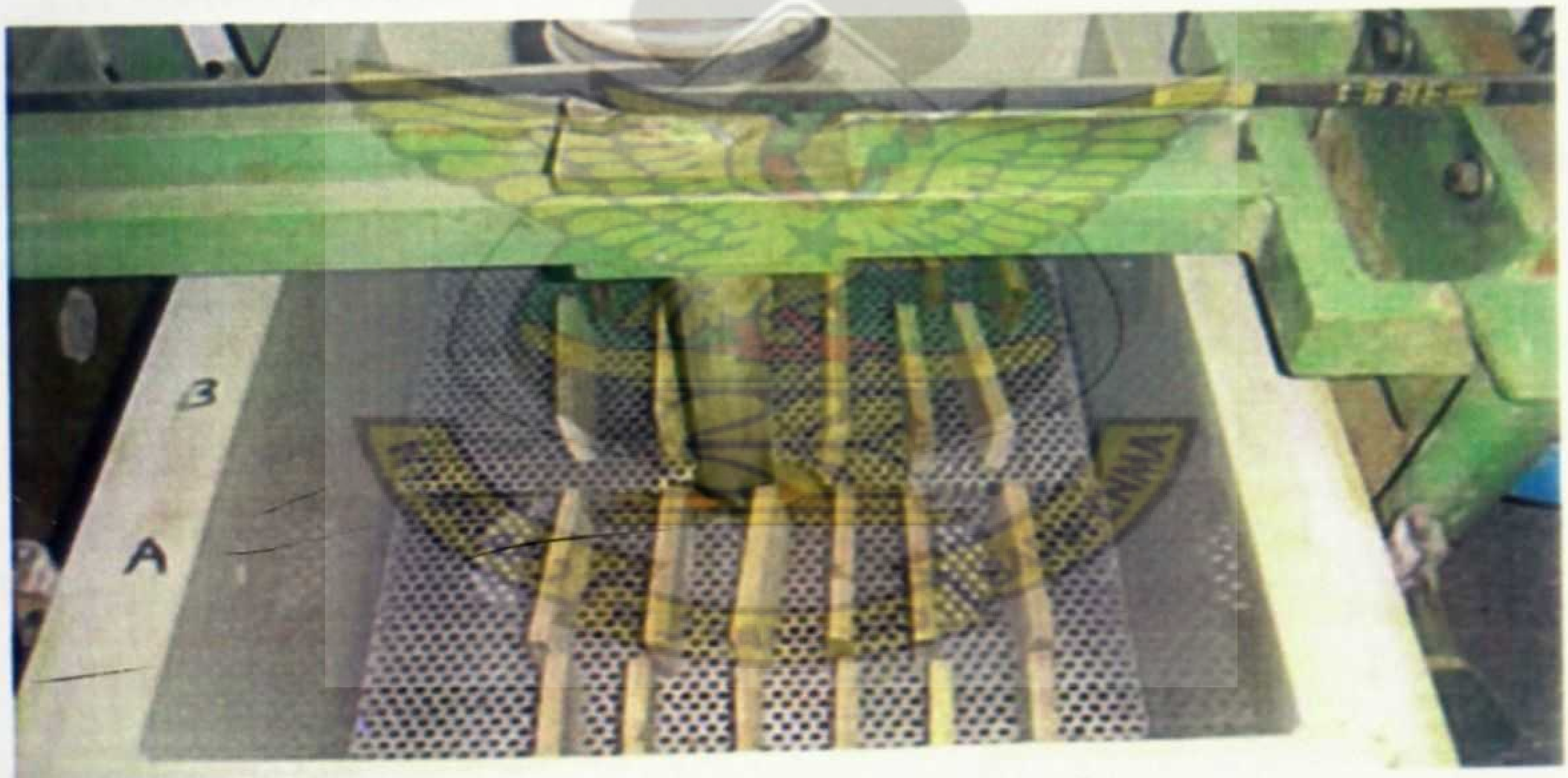

Plate 3.3: Packed wood samples arranged edgewise on a metal mesh

3.1.3 Chemicals selection

Chemicals with relative humidites between 12% and 98% were selected based on their availability in the market (Table 3.1) at the time of the study.

Table 3.1 List of chemicals used with their respective RHs, EMCs and solubilities in g/100ml of water at 25°C.

Salt solution	Relative Humidity	EMC	Solubility
Lithium chloride (LiCl)	12.0	3.2	83.2g
Magnesium chloride ($MgCl_2$)	33.0	6.4	54.5g
Potassium carbonate (K_2CO_3)	43.0	7.95	113.7g
Sodium chloride (NaCl)	76.0	14.7	36.0g
Copper sulphate ($CuSO_4$)	98.0	>23.5	25.0g

Source: EMC according to Hailwood –Horrobin Table (Simpson, 1973)
Relative humidity according to Martin (1967)
Solubility according to Weast (1976).

3.2 Methodology

3.2.1 Sample Preparation

Six (6) each of radial and tangential samples of the ten LUS lumber of length 2.5m and thicknesses of 2.5cm and 5cm were sawn and planed into lengths, widths and thicknesses of 10cm x 5cm x 1cm using circular or band saws and planner respectively. These thicknesses were chosen to ensure rapid moisture equilibrium of the wood at each condition of relative humidity. The required conditioning time is proportional to the square of ratio of thickness (ASTM D4933-99 (2004)).

3.2.2 Sample markings

The samples were marked (W1, T11 and T12) and (W2, T21 and T22) for width (W) and thickness (T) respectively on each end as shown in Plate 3.4 and Plate 3.5. The first three letters of the species common names were marked on each sample as DAH, KUS, DAN, CEM, CEZ, WAW, ESS, AFN, ANA and KAK for Dahoma, Kusia, Danta, *Celtis mildbraedii*, *Celtis zenkeri*, Essia, Wawabima, Afina, Ananta and Kaku respectively. They were also numbered T1 to T6 for tangential and R1 to R6 for radial for easy identification.

Plate 3.4: Markings on the Tangential samples

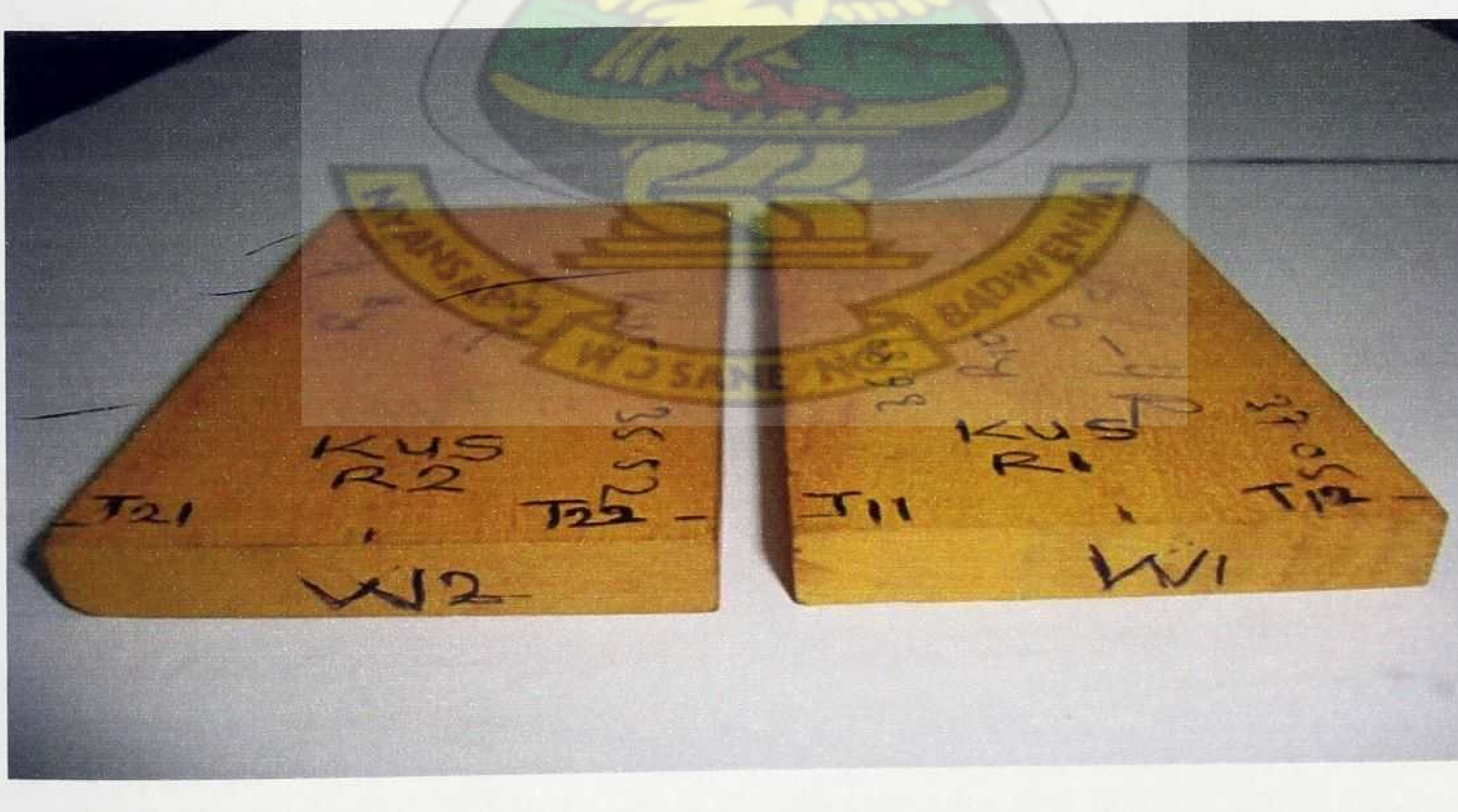

Plate 3.5: Markings on the Radial samples

3.2.3 Preparation of saturated salt solution

A saturated solution of one and a half litres (1.5l) was prepared from each salt according to their solubility in water (Table 3.1). The saturated salt solution was prepared by adding a quantity of the salt gradually in a container of distilled water, stirring well after each addition, until the salt could absorb no more water (ASTM E 104-02, (2002)).

3.2.4 Preliminary studies

3.2.4.1 The use of desiccators

Twelve (12) 10cm x 5cm x 1cm tangential *Celtis mildbraedii* samples were put in one desiccators (Plate 3.6) over saturated Copper sulphate salt solution after taking their initial masses (M). The masses were taken thrice a week until constant masses was attained. The samples were oven dried at 101 °C -105°C until constant masses (D) were attained. The moisture content (MC) was calculated according to the formula:

MC, % = (M-D)/D) X 100 [ASTM D4442-92, 2003].

This was done in order to know how long it will take the samples to stabilize.

Plate 3.6: Desiccators with Copper Sulphate ($CuSO_4$) saturated salt solution and *Celtis mildbraedii* trial samples

3.2.4.2 Tangential and radial trial samples

The initial masses (M_i) of some air-dried trial samples were taken at 25°C with relative humidity of 72%. Twenty (20) 10cm x 5cm x 1cm tangential Kusia samples were then placed in one of the conditioning chambers and ten (10) each of tangential and radial were also placed in another conditioning chamber, both containing saturated solution of Copper sulphate. This was done in order to know whether to put the tangential and the radial samples together or to separate them in the chamber. The samples were placed in the chamber edgewise (Plate 3.3) for maximum exposure and rapid stabilization. Masses of the samples were monitored from time to time and recorded after equilibrium (M_e), that is, when there was no appreciable change in mass of the samples in each of the conditioning chambers. The samples were oven dried at 101°C -105°C until constant masses (M_o) were attained. The initial and final Moisture Content, (MC) were then calculated respectively according to the formulae:

Initial MC, % = $((M_i - M_o)/ M_o) \times 100$

Final MC, % = $((M_e - M_o)/ M_o) \times 100$.

3.2.5 Determination of Density, EMC, Shrinkage/Swelling, Dimensional change and Movement in service

The initial air-dried dimensions [length (L_i), width (W_i) and thickness (T_i)] and mass (M_i) of each of the six tangential and radial samples [10cm x 5cm x 1cm] of each of the ten lesser used species were recorded at 25°C. Samples were then placed on the metal mesh in the conditioning chamber edgeways (Plate 3.3) for maximum surface exposure.

i. Six tangential and radial samples each of two species were put into the first conditioning chamber (Plate 3.1) containing saturated salt solution of Lithium chloride (LiCl) (12% relative humidity) at 25°C. The masses of the samples were recorded and monitored from time to time (i.e. at three or four day's intervals) until equilibrium and the equilibrium mass (M_e), length, (L_e), width (W_e), and thickness (T_e) were attained.

ii. The samples were then transferred to the second conditioning chamber containing Magnesium chloride ($MgCl_2$) (at relative humidity of 33 %). The masses and dimensions of the samples were also monitored from time to time until equilibrium was attained; and the equilibrium mass (M_e), length, (L_e), width (W_e), and thickness (T_e) recorded.

iii. This procedure was repeated (Sharma et al, 1976) in the third, fourth and fifth conditioning chambers with saturated salt solutions of Potassium carbonate (K_2CO_3), Sodium chloride

(NaCl) and Copper sulphate ($CuSO_4$) at relative humidities of 43%, 76 % and 98% respectively (Plate 3.1).

iv. After the final conditioning to equilibrium mass and dimensions in the fifth chamber containing the $CuSO_4$, the samples were oven dried at 101°C-105°C to constant masses (M_o) and width (W_o).

v. After the samples in the first chamber were transferred to the second chamber, two new wood species were introduced into the first chamber and the procedures i to iv repeated until all ten species had undergone procedures i to iv.

The procedure described above was used in the determination of density, equilibrium moisture content, shrinkage/swelling, dimensional change and movement in service. The same sample dimensions and masses were used in all the experiments.

3.2.5 1 Density Determination

The density (D) was then calculated at each condition according to the formula:

Density (D) kg/m^3 = (M/ V) x 1000,

where: V (Volume) = L x W x T, W (Width) = (W1+W2)/2,

T (Thickness) = (T11+T12+T21+T22)/4 [See Plates 3.4 and 3.5]

3.2.5.2 Equilibrium Moisture Content Determination

The Equilibrium Moisture Content was calculated using the relation

EMC(%) = ((M_i- M_o)/ M_o) x 100,

Where: M_i is the initial mass of the samples, M_o is the oven dried mass of the samples.

3.2.5.3 Shrinkage/Swelling Determination

The tangential and radial widths and longitudinal length shrinkage/swelling were expressed as percentages of the initial measurements using the formula:

Shrinkage/Swelling, % = $((W_i - W_o) / W_i) \times 100$,

Where: W_i is the initial width of the samples, W_o is the oven dried width of the samples.

3.2.5.4 Dimensional Change Determination

The width at each equilibrium (W_e) state was recorded. The dimensional change was calculated at the various relative humidities according to the formula:

Dimensional change, % = $((W_i - W_e) / W_i) \times 100)$,

Where: W_i is the initial width of the samples, W_e is the equilibrium width of the samples.

3.2.5.5 Movement in service Determination

According to Farmer (1972) and FPRL (1967), to determine the movement, test samples, after being kiln dried to 12% moisture content, are conditioned first in air at 90% relative humidity, and dried in air at 60% relative humidity, the temperature being 25°C (77°F) in both cases. In this study, there were difficulties in getting chemical salts which gives relative humidity of 60% and 90% therefore chemical salts whose relative humidities were below 60% and above 90% were used. The tangential and radial dimensional differences were calculated as the percent change in width of the samples from 12 percent to 98 percent relative humidity condition relative to the width at each condition of the various relative humidities using the formula:

Dimensional differences, % = $((W_i - W_e) / W_i) \times 100$.

The movements at 60 percent and 90 percent relative humidity were calculated by interpolating within 12-33% and 12-76% for 12-60%, and 12-76% and 12-98% for 12-90% of dimensional differences. For example, Dahoma mean tangential dimensional differences at 60 % and 90% relative humidity were calculated as follows:

At 60%, (76-60)/ (76-33) = (2.02-X)/ (2.02-1.01) =1.64 (Table 4.6)

At 90 %,(98-90)/ (98-76) = (3.42-Y)/ (3.42-2.02) =2.91(Table 4.6)

Where X and Y are unknown values at 60% and 90% relative humidity.

Hence Dahoma mean tangential movement from 60% to 90% relative humidity is 2.91%-1.64% = 1.27%. The total movements for each species were also calculated by adding the tangential and radial movement (T+R) from relative humidity of 60 to 90%.That is, 1.27 + 1.21 = 2.48 (Table 4.6).

3.3 Data Analysis

Excel 2007 analysis tool pack was used to perform the Descriptive Analysis and Analysis of Variance (ANOVA).

3.4 Limitations

The saturated salt solution of Potassium carbonate (K_2CO_3) was discarded from the experiment after Dahoma, Kusia, *Celtis mildbraedii* and *Celtis zenkeri* because it was giving fluctuating and negative results and was thus suspected to be a different or an expired chemical. The values obtained for changes from 12% to 43% (K_2CO_3) relative humidity were not used for the calculations.

CHAPTER FOUR

4.0 Results

4.1 Preliminary Studies

4.1.1 Desiccators

Appendix 1a gives moisture content data for trial samples of *Celtis mildbraedii* using saturated salt solution of Copper Sulphate ($CuSO_4$) to find out how long it will take the samples to stabilize. Figure 4.1 shows the moisture content of all the twelve *Celtis mildbraedii* trial samples in the desiccators. The samples recorded maximum moisture content at the 66th day but did not stabilize but rather started reducing until 89th day. This may probably be due to insufficient movement of air in the desiccators.

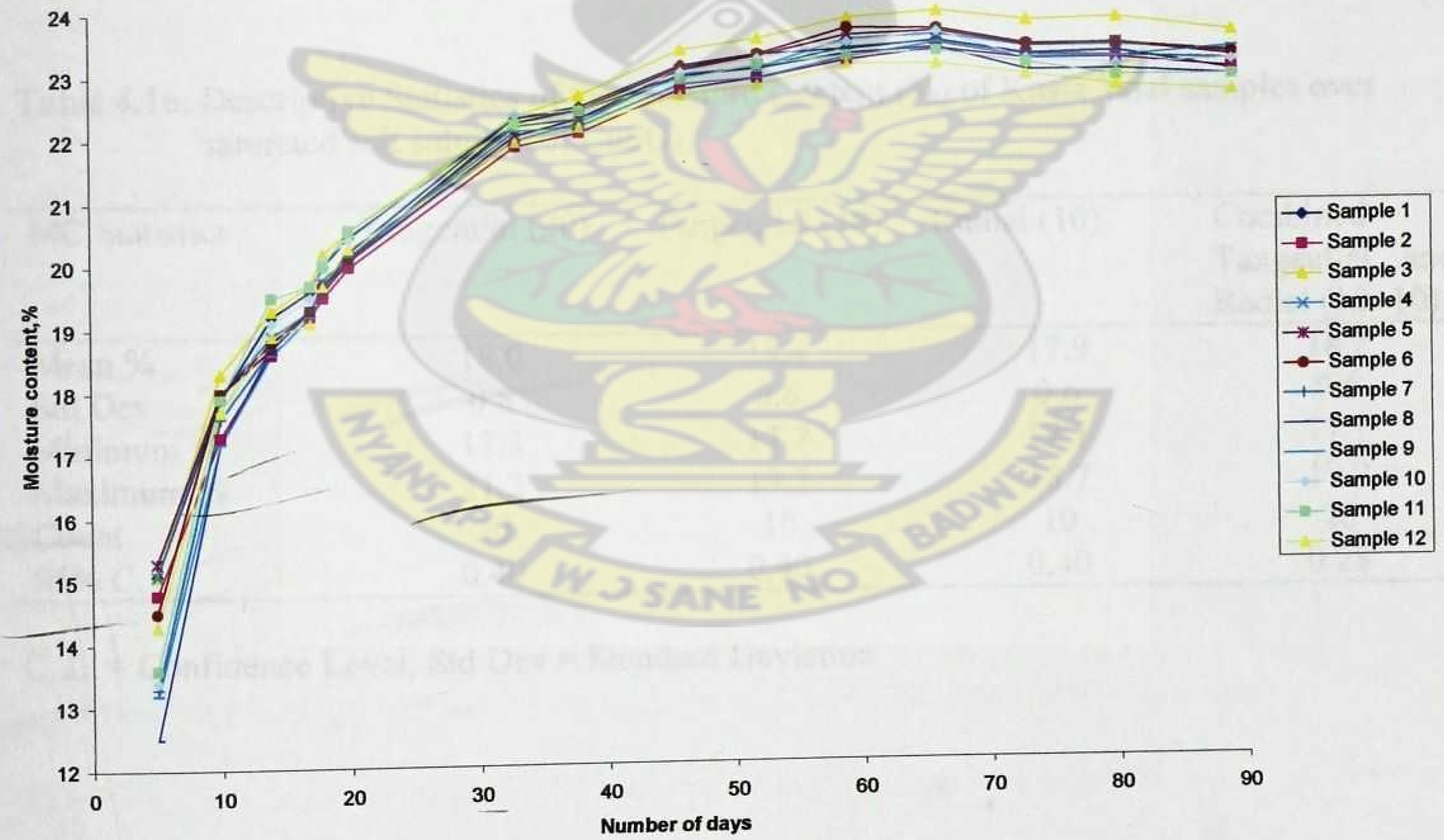

Figure 4.1 Sorption curves of *Celtis mildbraedii* trial samples with saturated salt solution of $CuSO_4$

4.1.2 Tangential and radial trial samples

Moisture content data for trial samples of Kusia is indicated in Appendix 1b. A typical summary of the basic statistics for the Kusia trial samples of the twenty (20) tangential, ten (10) combined tangential and ten (10) radial over saturated salt solution of Copper sulphate is represented in Table 4.1a. The final mean MC for the tangential (20), tangential (10), radial(10) and combined tangential and radial were 18.0%, 18.4% ,17.9% and 18.2% with standard deviation of 0.8%, 0.6%, 0.6% and 0.6% respectively. A summary of analysis of variance (ANOVA) of the Kusia trial samples of the combined tangential and radial, tangential (20), tangential (10) and radial (10) is shown in Table 4.1b. The ANOVA indicates that differences between final MC of combined tangential and radial, tangential (10) and radial (10) were insignificant (F = 0.6614, P =0.4211 and F = 4.2445, P =0.0541) respectively.

Table 4.1a: Descriptive Statistics of the Moisture Content (%) of Kusia Trial samples over saturated salt solution of $CuSO_4$

MC Statistics	Tangential (20)	Tangential (10)	Radial (10)	Combined Tangential and Radial (10+10)
Mean %	18.0	18.4	17.9	18.2
Std Dev	0.8	0.6	0.6	0.6
Minimum %	17.3	17.7	17.1	17.1
Maximum %	21.2	19.2	18.7	19.2
Count	20	10	10	20
95% C. L.	0.40	0.40	0.40	0.28

C .L. = Confidence Level, Std Dev = Standard Deviation

Table 4.1b: Summary of Analysis of variance (ANOVA) of moisture content of Kusia samples taken it tangential and radial directions (trial samples over saturated salt solution of $CuSO_4$)

	Degrees of Freedom	F	P-value	F critical
Combined Tangential and Radial (10+10) Tangential (20)	1	0.6614	0.4211	4.0982
Tangential (10) Radial (10)	1	4.2445	0.0541	4.4139

The purpose of this pre study was to find out if tangential and radial samples could be combined together or separated. There were no significant differences from the results: six each of tangential and radial samples of the ten species were thus combined for the study.

4.2 Density

Appendices 2a-11e shows the density data and the basic statistics for the various saturated salt solutions for the ten wood species. A summary of the descriptive statistics of the density at the various equilibrium relative humidities of the ten species is presented in Table 4.2. The initial mean density at 12.5 % moisture content for combined tangential and radial samples ranged from a low of 626, 672, 695, 698, 745, 748, 761, 812, 889 and 1040kg/m^3 for Dahoma, Danta, *Celtis mildbraedii*, *Celtis zenkeri*, Essia, Wawabima, Afina, Ananta and Kaku. The standard deviations were 23, 26, 43, 40, 68, 16, 38, 57, 32 and 22 kg/m^3 respectively. The high standard deviations for *Celtis zenkeri* and Afina may be due to the lumber selected for the study. There were significant differences between the tangential and radial densities. This may most likely be due to the fact that, the samples for radial could be denser than the tangential samples since they were from different boards. The mean density for the species increase from LiCl (12) to $CuSO_4$ (98) for Dahoma - 613 to 654 kg/m^3, Kusia – 662 to 685 kg/m^3, Danta – 692 to 711 kg/m^3, *Celtis mildbraedii* – 690 to 715 kg/m^3, *Celtis zenkeri* – 731 to 759 kgm^3, Essia -736 to 746 kgm^3, Wawabima – 752 to 771 kgm^3, Afina – 812 to 823 kg/m^3, Ananta – 896 to 899 kg/m^3 and Kaku – 1040 to 1042kg/m^3.Generally, mean density varied significantly between and within species. The wood species were arranged in Table 4.2 according to their density in ascending order as Dahoma, Kusia, Danta, *Celtis mildbraedii*, *Celtis zenkeri*, Essia, Wawabima, Afina, Ananta and Kaku.

Table 4.2: Descriptive Statistics of Density (kg/m³) of the ten wood species in an increasing order of RH of saturated solutions. The upper figures represent the mean and standard deviation while the lower figures give the range of the mean values.

Species	Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Dahoma	626 ± 23 [583-658]	613 ± 26 [572-654]	623 ± 23 [580-655]	623 ± 22 [580-652]	636 ± 27 [590-682]	654 ± 27 [608-688]
Kusia	672 ± 26 [625-714]	662 ± 24 [612-701]	670 ± 27 [618-713]	670 ± 26 [623-713]	675 ± 26 [627-717]	685 ± 25 [635-726]
Danta	695 ± 43 [621-749]	692 ± 43 [620-745]	699 ± 43 [625-751]	-	705 ± 43 [630-758]	711 ± 43 [637-764]
Celtis m	698 ± 40 [639-749]	690 ± 36 [633-740]	703 ± 38 [642-750]	699 ± 33 [645-750]	705 ± 36 [648-753]	715 ± 33 [660-758]
Celtis z	745± 68 [641-815]	731 ± 71 [626-800]	740 ± 69 [635-810]	740 ± 70 [635-815]	747 ± 66 [650-815]	759 ± 61 [671-825)]
Essia	748 ± 16 [729-776]	736 ± 12 [723-756]	742 ± 12 [730-765]	-	744 ± 12 [730-768]	746 ± 14 [729-772]
Wawabima	761 ± 38 [707-835]	752 ± 36 [701-822]	758 ± 35 [707-825]	-	762 ± 38 [711-834]	771 ± 38 [717-846]
Afina	812 ± 57 [746-890]	812 ± 58 [746-890]	817 ± 57 [751-895]	-	821 ± 57 [756-899]	823 ± 55 [759-899]
Ananta	889 ± 32 [841-945]	893 ± 35 [837-942]	895 ± 35 [839-945]	-	899 ± 34 [845-946]	899 ± 38 [849-951]
Kaku	1040 ± 22 [985-1066]	1040 ± 21 [985-1067]	1041 ± 21 [987-1069]	-	1046 ± 21 [993-1074]	1042 ± 21 [991-1069]

4.3 Equilibrium Moisture Content (EMC)

Appendices 12a-21d shows the equilibrium moisture content data and the basic statistics for the various saturated salt solutions for the ten wood species. A summary of the descriptive statistics of the equilibrium moisture content at the various equilibrium relative humidities of the ten species is presented in Table 4.3. The initial mean tangential EMC ranged from a low of 11.01% (in the range 10.87-11.15%) for Essia to a high of 13.45 % (in the range 13.22-13.83%) for Kaku with standard deviation of 0.12% and 0.22% respectively. The initial mean radial EMC ranged from a low of 11.06% (in the range 10.32-11.40%) for Essia to a high of 13.58 % (in the range 13.45-13.75%) for Kusia with standard deviation of 0.44% and 0.11% respectively. The EMC of the ten species increases with the relative humidity of the saturated salt solutions from 12% (LiCl) to 98% ($CuSO_4$) as shown in Table 4.3 after the 33% ($MgCl_2$).

Table 4.3: Descriptive Statistics of the Equilibrium moisture content (%) of the ten wood species in an increasing order of RH of saturated solutions. The upper figures represent the mean and standard deviation while the lower figures give the range of the mean values.

		Equilibrium Moisture Content, %					
Species	Orientation	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Tangential	11.83 ± 0.65 (11.05-12.83)	5.67 ± 0.62 (5.09-6.78)	9.74 ± 0.70 (8.67-10.61)	9.21 ± 0.77 (8.22-10.32)	14.33 ± 0.68 (13.23-15.12)	20.97 ± 2.17 (17.26-23.21)
Dahoma	Radial	12.29 ± 0.57 (11.80-13.16)	6.44 ± 0.51 (5.75-7.23)	9.94 ± 0.52 (9.33-10.72)	9.55 ± 0.61 (8.86-10.31)	13.79 ± 0.43 (13.26-14.38)	19.26 ± 1.60 (17.28-21.70)
	Tangential	12.60 ± 0.74 (11.19-13.14)	7.08 ± 0.36 (6.45-7.56)	11.03 ± 0.23 (10.73-11.43)	10.75 ± 0.16 (10.51-10.99)	13.17 ± 1.03 (12.60-15.26)	17.89 ± 1.70 (16.54-21.21)
Kusia	Radial	13.58 ± 0.11 (13.45-13.75)	7.12 ± 0.06 (7.06-7.19)	10.92 ± 0.06 (10.82-11.01)	10.71 ± 0.08 (10.57-10.79)	12.81 ± 0.06 (12.74-12.92)	17.35 ± 0.16 (17.17-17.62)
	Tangential	11.53 ± 0.29 (11.12-1188)	9.63 ± 0.18 (9.39-9.84)	10.69 ± 0.06 (11.49-11.85)	-	14.08 ± 0.12 (13.90-14.19)	16.86 ± 0.26 (16.67-17.26)
Danta	Radial	11.89 ± 0.34 (11.31-12.36)	9.84 ± 0.20 (9.68-10.24)	11.91 ± 0.15 (11.76-12.19	-	14.24 ± 0.19 (14.05-14.60)	17.67 ± 0.69 (16.96-18.53)
	Tangential	12.17 ± 1.18 (11.49-14.54)	7.59 ± 0.87 (7.13-9.36)	11.91 ± 2.50 (10.65-17.00)	11.16 ± 0.08 (10.52-13.35)	14.09 ± 2.25 (12.23-17.95)	18.51 ± 0.43 (17.95-19.13)
Celtis m	Radial	12.10 ± 0.22 (11.88-12.45)	7.62 ± 0.19 (7.36-7.85)	11.24 ± 0.19 (11.04-11.55)	11.04 ± 0.19 (10.70-11.28)	12.90 ± 0.16 (12.72-13.01)	18.71 ± 0.34 (18.37-19.15
	Tangential	12.37 ± 0.68 (11.16-13.19)	6.22 ± 0.88 (5.20-7.53)	10.01 ± 0.74 (8.79-11.03)	9.59 ± 0.68 (8.43-10.52)	14.22 ± 0.73 (13.06-15.00)	20.18 ± 1.58 (17.93-22.23)
Celtis z	Radial	12.94 ± 0.31 (12.44-13.20)	7.19 ± 0.44 (6.44-7.67)	10.59 ± 0.42 (9.82-1.096)	10.18 ± 0.50 (9.29-10.61)	13.34 ± 0.48 (12.88-14.16)	17.88 ± 1.14 (16.81-20.02)
	Tangential	11.01 ± 0.11 (10.87-11.15)	8.22 ± 0.15 (7.98-8.35)	10.36 ±1.02 (8.29-10.91)	-	13.08 ± 0.11 (12.89-13.20)	17.48 ±0.20 (17.63-18.21)
Essia	Radial	11.06 ± 0.44 (10.32-11.40)	8.42 ± 0.09 (8.26-8.52)	10.91 ± 0.10 (10.76-11.05)	-	13.21 ± 0.18 (12.91-13.39)	17.53 ±2.15 (13.25-19.02)
	Tangential	11.04 ± 0.12 (10.90-11.19)	8.63 ± 0.05 (8.57-8.68)	11.20 ± 0.07 (11.09-11.29)	-	13.72 ± 0.09 (13.61-13.87)	19.24 ± 0.47 (18.68-19.85)
Wawabima	Radial	11.79 ± 0.40 (11.01-12.05)	8.91 ± 0.14 (8.27-9.08)	11.37 ± 0.12 (11.14-11.47)	-	13.87 ±0.09 (13.73-13.99)	19.53 ± 0.60 (18.60-20.29)
	Tangential	11.56 ± 0.12 (11.42-11.76)	9.49 ± 0.07 (9.41-9.58)	11.53 ± 0.04 (11.48-11.58)	-	13.93 ± 0.07 (13.85-14.00)	17.31 ± 0.50 (16.74-17.99)
Afina	Radial	11.35 ± 0.31 (10.78-11.61)	9.50 ± 0.16 (9.26-9.75)	11.41 ± 0.17 (11.14-11.67)	-	13.64 ± 0.07 (13.54-13.74)	16.36± 0.10 (16.25-16.50)
	Tangential	13.00 ± 0.28 (12.69-13.38)	11.18 ± 0.17 (11.00-11.42)	12.13 ± 0.21 (11.93-12.43)	-	13.87 ± 0.27 (13.55-14.25)	15.83 ±1.07 (13.79-16.87)
Ananta	Radial	13.00 ± 0.16 (12.82-13.27)	11.27 ± 0.23 (11.01-11.60)	12.25 ± 0.22 (12.00-12.57)	-	14.03 ± 0.29 (13.71-14.38)	17.38 ± 0.30 (16.71-17.76)
	Tangential	13.45 ± 0.22 (13.22-13.83)	11.78 ± 0.15 (11.57-12.03)	12.70 ± 0.19 (12.46-13.02)	-	14.56 ± 0.20 (14.31-14.86)	17.67± 0.40 (17.19-18.06)
Kaku	Radial	13.30 ± 0.49 (12.36-13.81)	11.58 ± 0.29 (11.10-11.85)	12.50 ± 0.27 (12.04-12.77)	-	14.41 ± 0.34 (13.79-14.76)	17.54 ± 0.43 (16.80-18.02)

4.4 Shrinkage / Swelling

Appendices 22a-31d shows the shrinkage / swelling data and the basic statistics for the various saturated salt solutions for the ten wood species. A summary of the descriptive statistics of the shrinkage / swelling with respect to the oven dried dimensions at the various equilibrium relative humidities of the ten species is presented in Table 4.4. The initial mean tangential shrinkage/swelling varied from a low of 2.50% for Essia (from 12.5% MC to oven-dry) to a high of 4.74% for Kaku (Table 4.4). The initial mean radial shrinkage/swelling varied from a low of 1.97% for Essia to a high of 3.67% for Kaku. The mean longitudinal shrinkage/swelling also varied from a low of 0.12% for *Celtis zenkeri* to a high of 0.25% for Ananta.

Table 4.4: Descriptive Statistics of the Shrinkage/Swelling (%) of the ten wood species in an increasing order of RH of saturated solutions. The upper figures represent the mean and standard deviation while the lower figures give the range of the mean values.

Species	Orientation	Shrinkage, %					
		Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Dahoma	Tangential	3.35 ± 0.17	1.45 ± 0.19	2.43 ± 0.21	2.32 ± 0.18	3.34 ± 0.22	4.70 ± 0.36
		(3.17-3.65)	(1.17-1.62)	(2.13-2.68)	(2.12-2.56)	(3.30-3.51)	(4.12-5.07)
	Radial	3.33 ± 0.32	1.46 ± 0.21	2.36 ± 0.25	2.28 ± 0.24	3.03 ± 0.31	4.18 ± 0.79
		(2.92-3.79)	(1.19-1.75)	(2.09-2.73)	(2.01-2.61	(2.76-3.41)	(2.85-5.07)
	Longitudinal	0.19 ± 0.1	0.05 ± 0.03	0.11± 0.08	0.10 ± 0.07	0.12 ± 0.06	0.19 ± 0.07
		(0.05-0.37)	(0.01-0.09)	(0.03-0.28)	(0.03-0.28)	(0.03-0.23)	(0.11-0.34)
Kusia	Tangential	3.95 ± 0.15	1.99 ± 0.12	3.11 ± 0.15	2.99 ± 0.17	3.65 ± 0.16	5.22 ± 0.37
		(3.69-4.14)	(1.82-2.14)	(2.88-3.31)	(2.72-3.22)	(3.50-3.89)	(4.77-5.80)
	Radial	2.10 ± 0.16	0.80 ± 0.16	1.48 ± 0.22	1.40 ± 0.18	1.82 ± 0.18	2.68 ± 0.26
		(1.93-2.39)	(0.58-1.08)	(1.31-1.76)	(1.11-1.61)	(1.66-2.07)	(2.41-3.12)
	Longitudinal	0.17 ± 0.04	0.08 ± 0.03	0.17 ± 0.20	0.11± 0.06	0.19 ± 0.04	0.21 ± 0.03
		(0.10-0.23)	(0.03-0.13)	(0.05-0.80)	(0.04-0.23)	(0.15-0.28)	(0.16-0.26)
Danta	Tangential	3.20 ± 0.37	2.49 ± 0.36	3.03 ± 0.34		3.65 ± 0.39	4.53 ± 0.38
		(2.87-3.82)	(2.06-2.99)	(2.26-3.56)	-	(3.25-4.25)	4.06-5.11)
	Radial	3.19 ± 0.26	2.42 ± 0.21	2.92 ± 0.15		3.59 ± 0.16	4.47 ± 0.42
		(2.27-3.47)	(2.02-2.62)	(2.62-3.03)	-	(3.29-3.27)	(3.72-4.89)
	Longitudinal	0.15 ± 0.03	0.09 ± 0.04	0.14 ± 0.03		0.16 ± 0.03	0.16 ± 0.03
		(0.09-0.20)	(0.04-0.15)	(0.09-0.18)	-	(0.13-0.21)	(0.13-0.23)
Celtis m	Tangential	3.47 ± 0.42	2.09 ± 0.35	2.86 ± 0.19	2.54 ± 0.20	3.60 ± 0.73	4.86 ± 0.85
		(3.16-4.28)	(1.80-2.63)	(2.67-3.18)	(2.31-2.73)	(3.18-5.05)	(3.18-5.54)
	Radial	2.01 ± 0.12	1.00 ± 0.07	1.67 ± 0.07	2.63 ± 0.21	1.99 ± 0.13	3.02 ± 0.29
		(1.87-2.21)	(0.94-1.14)	(1.58-1.79)	(2.36-2.88)	(1.87-2.19)	(2.75-3.49)
	Longitudinal	0.16 ±0.06	0.09 ± 0.06	0.11 ± 0.06	0.11 0.06	0.17 ± 0.04	0.19 ± 0.04
		(0.08-0.28)	(0.03-0.21)	(0.05-0.25)	(0.04-0.23)	(0.12-0.25	(0.13-0.26)
Celtis z	Tangential	3.30 ± 0.38	1.61 ± 0.30	2.63 ± 0.27	2.54 ± 0.20	3.27 ± 0.26	5.06 ± 0.51
		(2.87-3.79)	(1.26-2.00)	(2.30-2.94)	(2.31-2.73)	(3.00-3.26)	(4.33-5.90)
	Radial	3.36 ± 0.17	1.73 ± 0.10	2.68 ± 0.17	2.63 ± 0.21	3.26 ± 0.19	4.60 ± 0.36
		(3.15-3.61)	(1.57-1.82)	(2.53-3.00)	(2.36-2.88)	(3.05-3.49)	(4.12-5.07)
	Longitudinal	0.12 ± 0.04	0.08 ± 0.04	0.12 ± 0.03	0.10 ± 0.03	0.13 ± 0.05	0.19 ± 0.05
		(0.06-0.22)	(0.02-0.150	(0.07-0.17)	(0.05-0.14)	(0.08-0.25)	(0.14-0.32)

Table 4.4 continues: Descriptive Statistics of the Shrinkage/Swelling (%) of the ten wood species in an increasing order of RH of saturated solutions. The upper figures represent the mean and standard deviation while the lower figures give the range of the mean values.

Species	Orientation	Shrinkage, %					
		Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Essia	Tangential	2.50 ± 0.55 (1.92-3.35)	1.55 ± 0.48 (0.94-2.03)	2.29 ± 0.54 (1.60-2.97)	-	3.26 ± 0.52 (2.69-4.02)	5.35 ± 0.57 (4.69-6.17)
	Radial	1.97 ± 0.35 (1.62-2.60)	1.42 ± 0.43 (1.03-2.20)	1.93 ± 0.33 (1.62-2.47)	-	2.46 ± 0.35 (2.05-3.03)	3.62 ± 0.40 (3.05-4.01)
	Longitudinal	0.17 ± 0.06 (0.09-0.28)	0.12 ± 0.06 (0.05-0.24)	0.15 ± 0.04 (0.08-0.22)	-	0.24 ± 0.07 (0.15-0.37)	0.3 ± 0.09 (0.16-0.43)
Wawabima	Tangential	2.88 ± 0.28 (2.60-3.39)	2.08 ± 0.20 (1.89-2.45)	2.91 ± 0.10 (2.81-3.09)	-	3.88 ± 0.17 (3.73-4.20)	6.08 ± 0.29 (5.73-6.51)
	Radial	2.15 ± 0.08 (2.04-2.27)	1.54 ± 0.05 (1.49-1.62)	2.07 ± 0.14 (1.92-2.28)	-	2.77 ± 0.13 (2.56-2.93)	4.15 ± 0.28 (3.76-4.55)
	Longitudinal	0.16 ± 0.08 (0.06-0.30)	0.12 ± 0.07 (0.03-0.23)	0.12 ± 0.08 (0.02-0.25)	-	0.16 ± 0.06 (0.08-0.26)	0.17 ± 0.07 (0.08-0.28)
Afina	Tangential	3.74 ± 0.15 (3.50-3.93)	2.81 ± 0.06 (2.71-2.88)	3.45 ± 0.11 (3.33-3.61)	-	4.20 ± 0.11 (4.06-4.36)	5.39 ± 0.20 (5.13-5.66)
	Radial	2.07 ± 0.13 (1.92-2.30)	1.52 ± 0.11 (1.44-1.75)	1.98 ± 0.11 (1.86-2.18)	-	2.41 ± 0.11 (2.33-2.63)	3.02 ± 0.15 (2.88-3.31)
	Longitudinal	0.18 ± 0.06 (0.10-0.29)	0.09 ± 0.06 (0.02-0.19)	0.15 ± 0.06 (0.04-0.27)	-	0.19 ± 0.06 (0.09-0.27)	0.22 ± 0.06 (0.12-0.30)
Ananta	Tangential	3.19 ± 0.37 (2.86-3.75)	2.69 ± 0.35 (2.43-3.27)	2.98 ± 0.37 (2.66-3.66)	-	3.48 ± 0.41 (3.18-4.22)	4.29 ± 0.59 (3.80-5.29)
	Radial	2.94 ± 0.40 (2.34-3.57)	2.52 ± 0.50 (1.68-3.05)	2.63 ± 0.45 (1.90-3.25)	-	3.16 ± 0.50 (2.26-3.78)	4.25 ± 0.67 (3.04-5.01)
	Longitudinal	0.25 ± 0.06 (0.16-0.35)	0.21± 0.07 (0.11-0.30)	0.22 ± 0.06 (0.13-0.30)	-	0.25 ± 0.06 (0.16-0.36)	0.29 ± 0.07 (0.16-0.39)
Kaku	Tangential	4.74 ± 0.14 (4.48-4.86)	4.08 ± 0.12 (3.90-4.21)	4.37 ± 0.15 (4.16-4.59)	-	5.05 ± 0.14 (4.85-5.20)	6.01 ± 0.66 (5.18-6.76)
	Radial	3.67 ± 0.50 (3.24-4.52)	3.08 ± 0.50 (2.73-3.97)	3.39 ± 0.53 (2.98-4.38)	-	3.92 ± 0.46 (3.50-4.72)	5.11± 0.69 (4.52-6.35)
	Longitudinal	0.19 ± 0.04 (0.12-0.28)	0.15 ± 0.05 (0.06-0.26)	0.17 ± 0.04 (0.12-0.27)	-	0.21 ± 0.04 (0.16-0.32)	0.22 ± 0.05 (0.16-0.33)

4.5 Dimensional Change

Appendices 32a-41d shows the dimensional change data and the basic statistics for the various saturated salt solutions for the ten wood species. A summary of the descriptive statistics of the dimensional change at the various equilibrium relative humidities of the ten species is presented in Table 4.5. Table 4.5 also shows the summary of the descriptive statistics of the dimensional change at the various equilibrium relative humidities of the ten species. The mean tangential dimensional change ranged from a low of 0.52% (in the range 0.43-0.59%) for Ananta to a high of 2.0 % (in the range 1.87-2.26%) for Kusia with standard deviation of 0.06% and 0.16% respectively over a saturated salt solution of LiCl. The mean radial dimensional change ranged from a low of 0.51% (in the range 0.39-0.67%) for Ananta to a high of 1.90 % (in the range 1.61-2.29%) for Dahoma with standard deviation of 0.10% and 0.28% respectively over a saturated salt solution of LiCl (12%). From Table 4.5, Ananta and Kaku have the lowest mean dimensional change of 0.30% with standard deviation of 0.05% and 0.04% for tangential and radial respectively over a saturated salt solution of $MgCl_2$. Kusia and Ananta also have the highest mean dimensional change of 1.51% and 0.24% with standard deviation of 0.12% and 0.04% for tangential and radial respectively over a saturated salt solution of $MgCl_2$ (33%). In saturated salt solution of NaCl (76%), Ananta has the lowest mean tangential dimensional change of 0.58% with standard deviation of 0.14%. Dahoma has the lowest mean radial dimensional change of 0.92 with standard deviation of 0.12%. Dahoma has the highest mean dimensional change of 1.17% and 0.92% for tangential and radial with the standard deviation of 0.23% and 0.12% respectively over a saturated salt solution of NaCl (76%). Danta and Wawabima have the lowest and highest mean tangential dimensional change of 0.91% and 2.29% with the standard deviation of 0.06% and 0.16% respectively over a saturated salt solution of $CuSO_4$ (98%). Afina and Dahoma have the lowest and highest mean radial dimensional change of 0.63% and 1.547% with the standard deviation of 0.06% and 0.23% respectively over a saturated salt solution of $CuSO_4$ (98%). The mean tangential and radial dimensional change of the ten species rincrease with the relative humidity of the saturated salt solutions, from LiCl (12%), $MgCl_2$ (33%), NaCl (76%) and $CuSO_4$ (98%). The dimensional change over K_2CO_3 (43%) were negative as shown in Table 4.4 and Appendix 32a-41d and were therefore discarded from the study. The dimensional change of the lower relative humidity of 12 and 33% shows a trend of inverse proportionality to the density of the species but not with the higher relative humidities of 76 and 98%.

Table 4.5: Descriptive Statistics of the Dimensional change (%) of the ten wood species in an increasing order of RH of saturated solutions. The upper figures represent the mean and standard deviation while the lower figures give the range of the mean values.

Species	Orientation	Dimensional Change, % LiCl (12)	MgCl$_2$ (33)	K$_2$CO$_3$ (43)	NaCl (76)	CuSO$_4$ (98)
Dahoma	Tangential	1.93 ± 0.21	1.00 ± 0.08	0.16 ± 0.37	1.17 ± 0.23	1.42 ± 0.23
		(1.61-2.18)	(0.89-1.11)	(-0.03-0.92)	(0.74-1.33)	(1.11-1.70)
	Radial	1.90 ± 0.28	0.92 ± 0.13	0.01 ± 0.12	0.92 ± 0.12	1.47 ± 0.26
		(1.61-2.29)	(0.75-1.12)	(-0.28-0.35)	(0.79-1.10)	(1.18-1.82)
Kusia	Tangential	2.00 ± 0.16	1.51 ± 0.12	-0.10 ± 0.05	0.68 ± 0.26	1.63 ± 0.25
		(1.87-2.26)	(1.02-1.34)	(-0.01-(-0.15))	(0.50-1.21)	(1.29-1.98)
	Radial	1.31 ± 0.11	0.68 ± 0.10	-0.05 ± 0.07	0.44 ± 0.09	0.88 ± 0.10
		(1.13-1.47)	(0.56-0.80)	(-0.16-0.06)	(0.32-0.55)	(0.77-1.07)
Danta	Tangential	0.73 ± 0.10	0.55 ± 0.07	-	0.64 ± 0.10	0.91 ± 0.08
		(0.62-0.85)	(0.46-0.64)		(0.45-0.71)	(0.82-1.04)
	Radial	0.79 ± 0.12	0.52 ± 0.06	-	0.69 ± 0.04	1.31 ± 0.40
		(0.67-0.98)	(0.41-0.60)		(0.63-0.75)	(0.99-2.10)
Celtis m	Tangential	1.41± 0.22	0.78 ± 0.36	0.04 ± 0.05	0.53 ± 0.15	1.95 ± 0.14
		(1.10-1.70)	(0.12-1.21)	(0.10-0.04)	(0.24-0.66)	(1.80-2.10)
	Radial	1.02 ± 0.10	0.68 ± 0.06	0.09 ± 0.04	0.42 ± 0.13	1.05 ± 0.17
		(0.90-1.17)	(0.60-0.78)	(-0.13-0.04)	(0.20-0.58)	(0.87-1.33)
Celtis z	Tangential	1.17 ± 0.24	1.04 ± 0.05	(-0.02) ± 0.07	0.89 ± 0.33	1.85 ± 0.47
		(1.38-2.00)	(0.96-1.09)	((-0.13)-0.06)	(0.37-1.32)	(1.22-2.45)
	Radial	1.66 ± 0.14	0.98 ± 0.15	0.08 ± 0.34	0.80 ± 0.13	1.42 ± 0.20
		(1.50-1.84)	(0.80-1.22)	((-0.24)-0.73)	(0.66-1.02)	(1.21-1.78)
Essia	Tangential	0.97 ± 0.21	0.75 ± 0.16	-	0.78 ± 0.10	2.17 ± 0.19
		(0.70-1.35)	(0.48-0.96)		(0.63-0.91)	(1.83-2.35)
	Radial	0.56 ± 0.13	0.52 ± 0.14	-	0.41± 0.04	1.19 ± 0.22
		(0.41-0.78	(0.28-0.66)		(0.35-0.46)	(0.91-1.55)
Wawabima	Tangential	0.82 ± 0.18	0.85 ± 0.12	-	0.85 ± 0.05	2.29 ± 0.16
		(0.50-1.00)	(0.65-0.95)		(0.77-0.95)	(2.06-2.46)
	Radial	0.62 ± 0.12	05.6 ± 0.11	-	0.51 ± 0.08	1.42 ± 0.21
		(0.43-0.75)	(0.34-0.74)		(037-0.59)	(1.06-169)
Afina	Tangential	0.94 ± 0.12	0.64 ± 0.08	-	0.88 ± 0.27	1.47 ± 0.46
		(0.70-1.05)	(0.58-0.80)		(0.75-1.43)	(1.08-2.36)
	Radial	0.55 ± 0.04	0.46 ± 0.03	-	0.44 ± 0.05	0.63 ± 0.06
		(0.49-0.60)	(0.42-0.50)		(0.36-0.52)	(0.52-0.70)
Ananta	Tangential	0.52 ± 0.06	0.30 ± 0.05	-	058 ± 0.14	0.98 ± 0.34
		(0.43-0.59)	(0.22-0.35)		(0.45-0.82)	(0.62-1.54)
	Radial	0.51 ± 0.10	0.24 ± 0.04	-	0.49 ± 0.10	1.12 ± 0.20
		(0.39-0.67)	(0.17-0.28)		(0.36-0.62)	(0.80-1.36)
Kaku	Tangential	0.69 ± 0.07	0.30 ± 0.06	-	0.75 ± 0.12	1.55 ± 0.21
		(0.60-0.79)	(0.24-0.40)		(0.63-0.99)	(1.36-1.89)
	Radial	0.72 ± 0.12	0.33 ± 0.08	-	0.54 ± 0.11	1.24 ± 0.25
		(0.60-0.99)	(0.25-0.42)		(0.36-0.69)	(1.06-1.71)

4.6 Movement in Service

Appendices 42a-51d shows the dimensional differences data and the basic statistics for the various saturated salt solutions for the ten wood species. A summary of the descriptive statistics of the dimensional differences and movement in service at the various equilibrium relative humidities of the ten species is presented in Table 4.6. The dimensional differences from 12-33%, 12-76% and 12-98% for $MgCl_2$ (33), NaCl (76%) and $CuSO_4$ (98%) and movement at 60%, 90% and from 60%-90% relative humidity is also shown in Table 4.6. The movements were determined by conditioning dried samples first in air at 90% relative humidity, and then to 60% relative humidity the temperature being 25^0C in both cases. In this study movements were determined by conditioning dried samples first below 60% relative humidity, and above 90% relative humidity then interpolated to get movements at 60-90% relative humidity. This was done since there were no chemicals available that will equilibrate at relative humidity of 60% and 90%. From Table 4.6, the mean tangential dimensional differences varied from a low of 0.30% for Ananta and Kaku to a high of 1.16% for Kusia whilst mean radial dimensional differences varied from a low of 0.24% for Ananta to a high of 0.98% for *Celtis zenkeri* from 12-33%. The mean tangential dimensional differences varied from a low of 0.82% for Ananta to a high of 2.02% for Dahoma whilst mean radial dimensional differences varied from a low of 0.74% for Ananta to a high of 1.76% for *Celtis zenkeri* from 12-76%. From 12-98%relative humidity, the mean tangential dimensional differences varied from a low of 1.68% for Ananta to a high of 4.26% for Wawabima whilst the respective mean radial dimensional differences varied from a low of 1.55% for Afina to a high of 3.19% for *Celtis zenkeri*. The tangential movement in service between 60% and 90% relative humidity, from Table 4.6 is low from 0.74% to a high of 1.90% in the order of 0.84%, 1.10, 1.27, 1.28, 1.29, 1.46, 1.47 and 1.82% for Ananta, Danta, Afina, Dahoma, Kaku, Kusia, *Celtis zenkeri, Celtis mildbraedii,* Essia and Wawabima respectively.

The radial movement in service between 60% and 90% relative humidity is from a low of 0.57% in Afina to a high of 1.21% in Dahoma in the order of 0.70, 0.81, 0.92, 0.98, 0.99 1.02, and 1.20% for Kusia, *Celtis mildbraedii,* Ananta, Essia, Danta, Kaku, and *Celtis zenkeri*/Wawabima respectively. The total movement in service that is, both tangential and radial for the individual species ranged from a low of 1.66% for Ananta to a high of 3.10% for Wawabima in the order of 1.68, 1.83.1.99, 2.27, 2.30, 2.48, 2.66 and 2.80 for Afina, Danta, Kusia, *Celtis mildbraedii,* Kaku, Dahoma, *Celtis zenkeri* and Essia respectively.

Table 4.6: Descriptive Statistics of the Dimensional Difference and Movement in service (%) of the ten wood species in an increasing order of RH of saturated solutions. The upper figures represent the mean and standard deviation while the lower figures give the range of the mean values.

Species	Orientation	Dimensional Difference, %						Movement, %	
		From RH 12 - 33%	From RH 12 - 43%	From RH 12 - 76%	From RH 12 - 98%	RH at 12-60%	RH at 12-90%	From RH 60-90%	T + R (60-90%)
Dahoma	Tangential	1.01 ± 0.08 (0.90-1.12)	0.89 ± 0.09 (0.74-1.00)	2.02 ± 0.20 (1.73-2.26)	3.42 ± 0.44 (2.60-3.89)	1.64	2.91	1.27	2.48
	Radial	0.93 ± 0.13 (0.75-1.14)	0.85 ± 0.08 (0.72-0.95)	1.63 ± 0.18 (1.32-1.78)	3.11 ± 0.47 (2.33-3.63)	1.37	2.57	1.21	
Kusia	Tangential	1.16 ± 0.12 (1.03-1.36)	1.03 ± 0.09 (0.94-1.19)	1.73 ± 0.24 (1.54-2.16)	3.42 ± 0.49 (2.87-4.23)	1.52	2.81	1.29	1.99
	Radial	0.69 ± 0.10 (0.57-0.81)	0.61 ± 0.10 (0.48-0.73)	1.03 ± 0.12 (0.90-1.22)	1.93 ± 0.15 (1.73-2.11)	0.91	1.61	0.70	
Danta	Tangential	0.56 ± 0.07 (0.46-0.65)	-	1.20 ± 0.12 (1.04-1.32)	2.13 ± 0.15 (1.95-2.29)	0.96	1.80	0.84	1.83
	Radial	0.51 ± 0.06 (0.41-0.60)	-	1.21 ± 0 07 (1.14-1.32)	2.36 ± 0.16 (2.14-2.50)	0.95	1.94	0.99	
Celtis m	Tangential	0.93 ± 0.16 (0.77-1.22)	0.86 ± 0.23 (0.55-1.24)	1.40 ± 0.34 (0.79-1.82)	3.42 ± 0.35 (2.95-3.96)	1.23	2.69	1.47	2.27
	Radial	0.69 ± 0.06 (0.61-0.78)	0.59 ± 0.10 (0.47-0.74)	1.01 ± 0.13 (0.93-1.26)	2.08 ± 0.29 (1.82-2.63)	0.89	1.70	0.81	
Celtis z	Tangential	1.05 ± 0.08 (0.97-1.11)	0.96 ± 0.12 (0.75-1.08)	1.78 0.41 (1.23-2.36)	3.64 0.69 (2.99-4.93)	1.51	2.97	1.46	2.66
	Radial	0.98 ± 0.16 (0.78-1.23)	0.92 ± 0.18 (0.73-1.14)	1.76 ± 0.49 (1.27-2.70)	3.19 ± 0.54 (2.41-3.93)	1.47	2.67	1.20	
Essia	Tangential	0.76 ± 0.17 (0.48-0.97)	-	1.77 ± 0.19 (1.49-2.07)	4.03 ± 0.35 (3.38-4.41)	1.40	3.22	1.82	2.80
	Radial	0.51 ± 0.14 (0.28-0.66)	-	1.07 ± 0.16 (0.85-1.32)	2.28 ± 0.33 (1.89-2.67)	0.86	1.84	0.98	
Wawabima	Tangential	0.86 ± 0.12 (0.66-0.96)	-	1.88 ± 0.07 (1.83-2.01)	4.26 ± 0.19 (3.97- 4.44)	1.50	3.40	1.90	3.10
	Radial	0.56 ± 0.11 (0.44-0.74)	-	1.26 ± 0.12 (1.05-1.39)	2.72 ± 0.27 (2.34-3.14)	1.00	2.20	1.20	
Afina	Tangential	0.65 ± 0.08 (0.58-0.81)	-	1.44 ± 0.08 (1.36-1.58)	2.71 ± 0.23 (2.42-2.99)	1.15	2.25	1.10	1.68
	Radial	0.47 ± 0.03 (0.43-0.50)	-	0.91 ± 0.04 (0.85-0.95)	1.55 ± 0.07 (1.45-1.64)	0.74	1.32	0.57	
Ananta	Tangential	0.30 ± 0.05 (0.22-0.35)	-	0.82 ± 0.09 (0.76-1.00)	1.68 ± 0.27 (1.43-2.14)	0.63	1.37	0.74	1.66
	Radial	0.24 ± 0.04 (0.17-0.28)	-	0.74 ± 0.10 (0.60-0.91)	1.88 ± 0.29 (1.40-2.17)	0.55	1.47	0.92	
Kaku	Tangential	0.30 ± 0.06 (0.25-0.40)	-	1.02 ± 0.05 (0.94-1.06)	2.61 ± 0.24 (2.42-2.98)	0.75	2.03	1.28	2.30
	Radial	0.33 ± 0.08 (0.25-0.43)	-	0.88 ± 0.12 (0.79-1.06)	2.15 ± 0.23 (1.87-2.54)	0.67	1.69	1.02	

CHAPTER FIVE

5.0 Discussions

5.1 Preliminary Studies

From the preliminary studies, conditioning chamber was used for both tangential and radial samples for the experiment. The trial samples in the desiccators took one hundred and seventy-four days (Appendix 1a) to stabilize over one solution and contained a maximum of twelve samples whilst conditioning chamber could contain twenty four samples. Again the conditioning chambers have fans to circulate the air in the chambers uniformly and also increased the adsorption and desorption rates depending on the saturated salt solution used.

5.2 Density and Relative Humidity Relationship

A summary of the basic statistics for the density of the ten wood species is presented in Table 4.2. The initial mean density ranged from 626 kg/m^3 for Dahoma to 1040 kg/m^3 for Kaku with standard deviation of 23 kg/m^3 and 57 kg/m^3 respectively. The densities of the ten species increase as the relative humidity of the saturated salt solutions over which they were placed increases from 12% (LiCl) to 98% ($CuSO_4$) (Figure 5.2.1) (Table 4.2). The observed increase may be due to the hygroscopic nature of wood that responds to the changes in the atmospheric humidity (Hogan, 2005). The wood species were arranged in the table according to the magnitude of their density in ascending order (Figure 5.2.1), Dahoma, Kusia, Danta, *Celtis mildbraedii*, *Celtis zenkeri*, Essia, Wawabima, Afina, Ananta and Kaku. From Figure 5.2.1, the various relative humidities could be seen apart or separated from each other for the species with lower density but crowded with denser species of Ananta and Kaku. Again, the densities of all the ten species increase with increasing relative humidity from 12 to 98% (Figure 5.2.2 and Table 4.2). Generally, with increase in relative humidity from 12% to 98%, wood species with relatively low densities turned to swell more as compared to those with relatively high densities, except, Wawabima, thus showing that woods presenting high densities had more hygroscopic stability (Almeida, 2006).

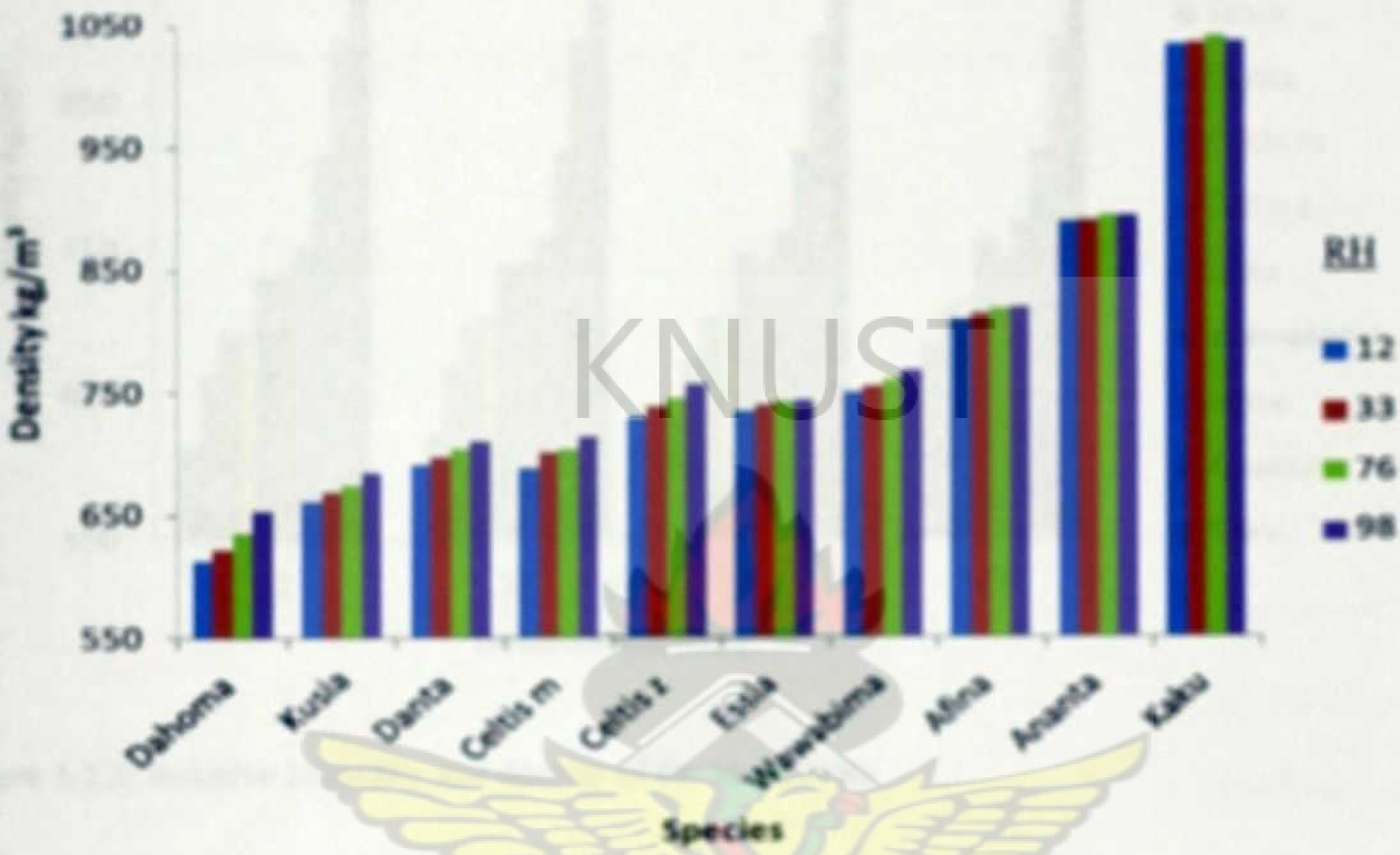

Figure 5.2.1: Ten species with their density at the various relative humidity

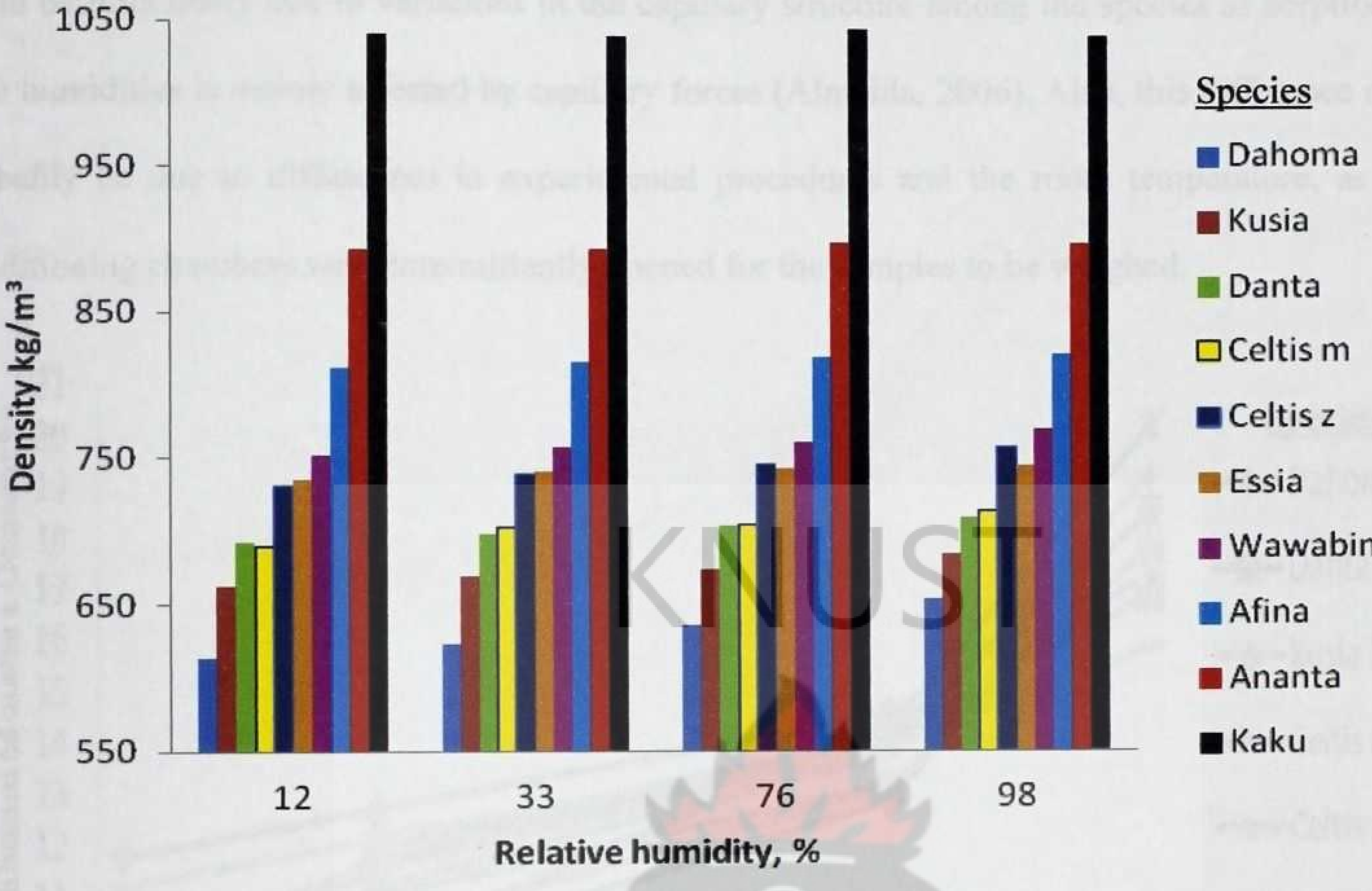

Figure 5.2.2: Relative humidity and density of the ten species

5.3 Equilibrium Moisture Content and Relative Humidity Relationship

From Figures 5.3a, 5.3b and Table 4.3, for all the ten species, both tangential and radial equilibrium moisture content increase with increase in relative humidity from 12 to 98%. Similar trend of increase in EMC with increasing relative humidity was observed by (http://scottsconstracting.woodpress.com). This is because wood readily exchanges moisture with the water vapor in the surrounding atmosphere according to the existing relative humidity (Hogan, 2005). From table 4.3, the mean EMCs obtained in this study were higher for LiCl (12%), $MgCl_2$ (33%) and K_2CO_3 (43%) in all the ten species in both tangential and radial directions compared to the EMC reported by Simpson 1973 in the Hailwood-Horribbin single hydrate equation (Table 3.1). However, the expected EMC for NaCl (76%) and $CuSO_4$ (98%) were higher than that obtained for this studies. The higher variation in EMC at high humidities could be principally due to variations in the capillary structure among the species as sorption at high humidities is mainly affected by capillary forces (Almeida, 2006). Also, this difference may probably be due to differences in experimental procedures and the room temperature, as the conditioning chambers were intermittently opened for the samples to be weighed.

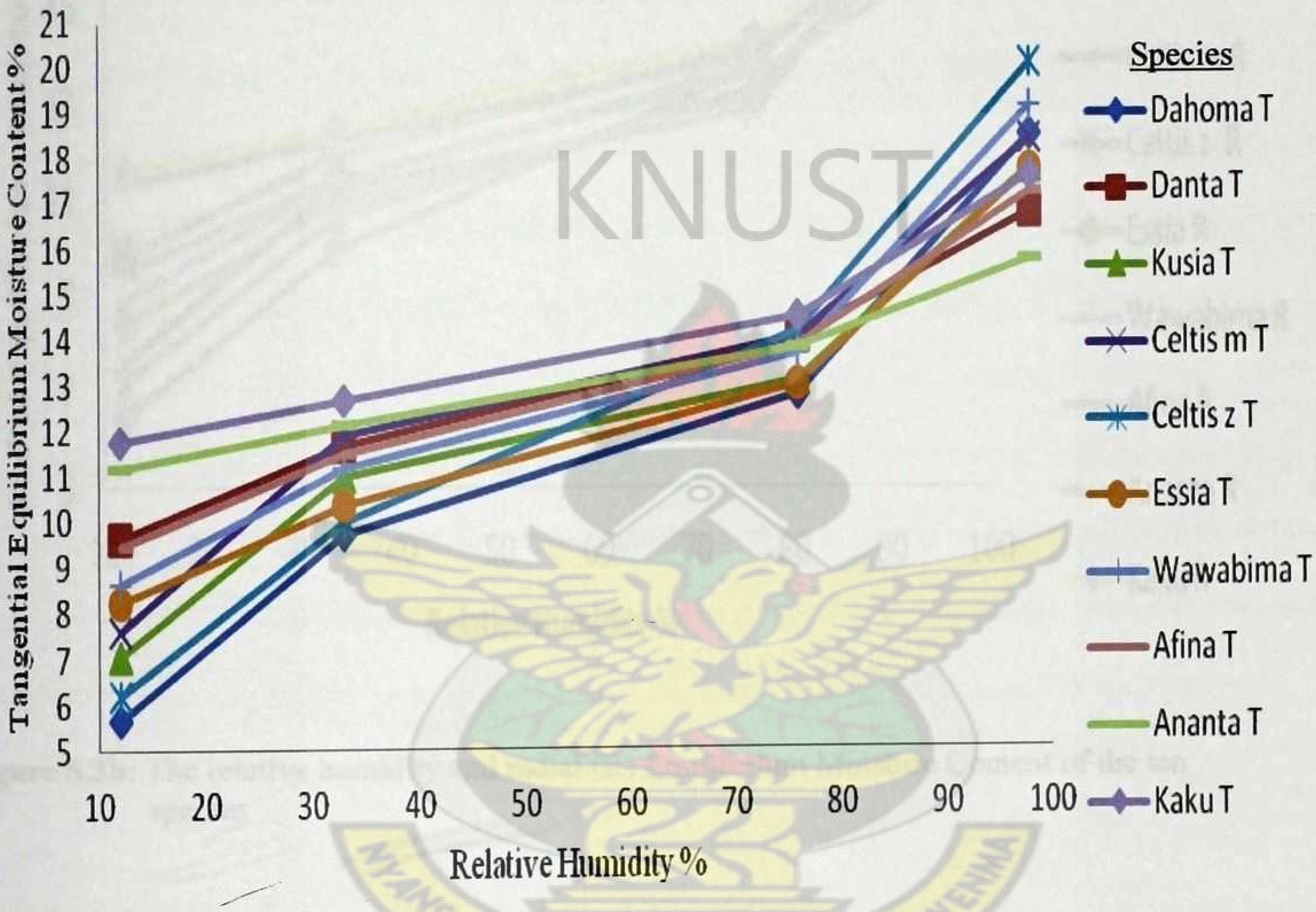

Figure 5.3a: The relative humidity and tangential (T) Equilibrium Moisture Content of the ten Species

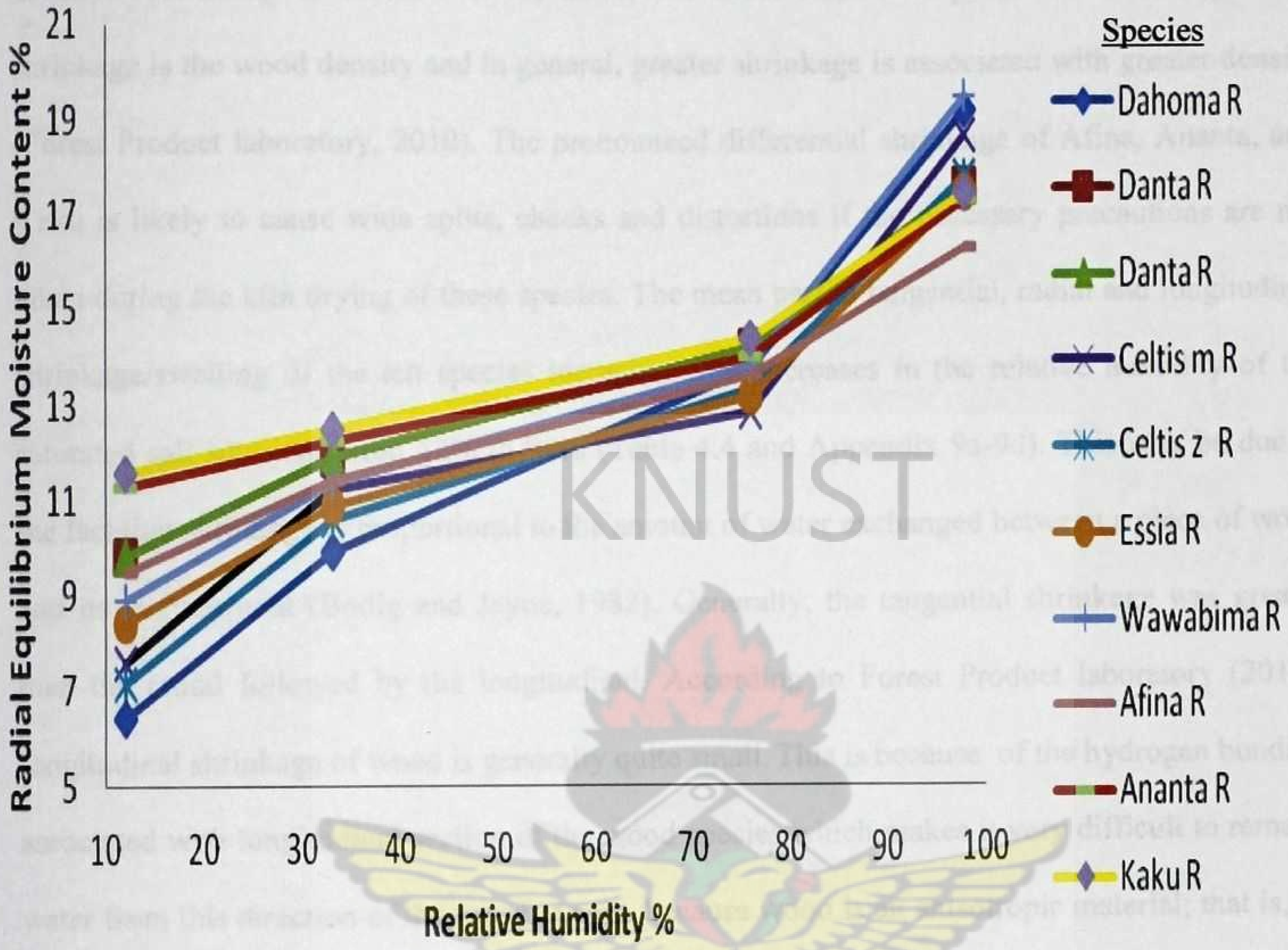

Figure 5.3b: The relative humidity and radial (R) Equilibrium Moisture Content of the ten species

5.4 Shrinkage/Swelling and Relative Humidity Relationship

All the ten wood species show increase in their tangential, radial and longitudinal shrinkage values with increase in relative humidity from 12 to 98% (see Figures 5.4a; 5.4b; 5.4c). The species had their tangential shrinkage greater than the respective radial and longitudinal shrinkage from 33 to 98% relative humidity except *Celtis zenkeri.* There were no definite trends established between density and tangential and radial shrinkage for the species studied except for Kaku (Figure 5.4a and 5.4b). That is Kaku with higher density shrink more than those of lower density. According to Abasali et al, 2011, the most important parameter affecting wood shrinkage is the wood density and in general, greater shrinkage is associated with greater density (Forest Product laboratory, 2010). The pronounced differential shrinkage of Afina, Ananta, and Kaku is likely to cause wide splits, checks and distortions if the necessary precautions are not taken during the kiln drying of these species. The mean partial tangential, radial and longitudinal shrinkage/swelling of the ten species increases with increases in the relative humidity of the saturated salt solutions from 12% to 98% (Table 4.4 and Appendix 9a-9d). This may be due to the fact that shrinkage is proportional to the amount of water exchanged between a piece of wood and its environment (Bodig and Jayne, 1982). Generally, the tangential shrinkage was greater than the radial followed by the longitudinal. According to Forest Product laboratory (2010), longitudinal shrinkage of wood is generally quite small. This is because of the hydrogen bonding associated with longitudinal section of the wood species which makes it very difficult to remove water from this direction of the wood. Again, because wood is an anisotropic material; that is, its dimensions change differently in three directions: tangentially, radially, and longitudinally.

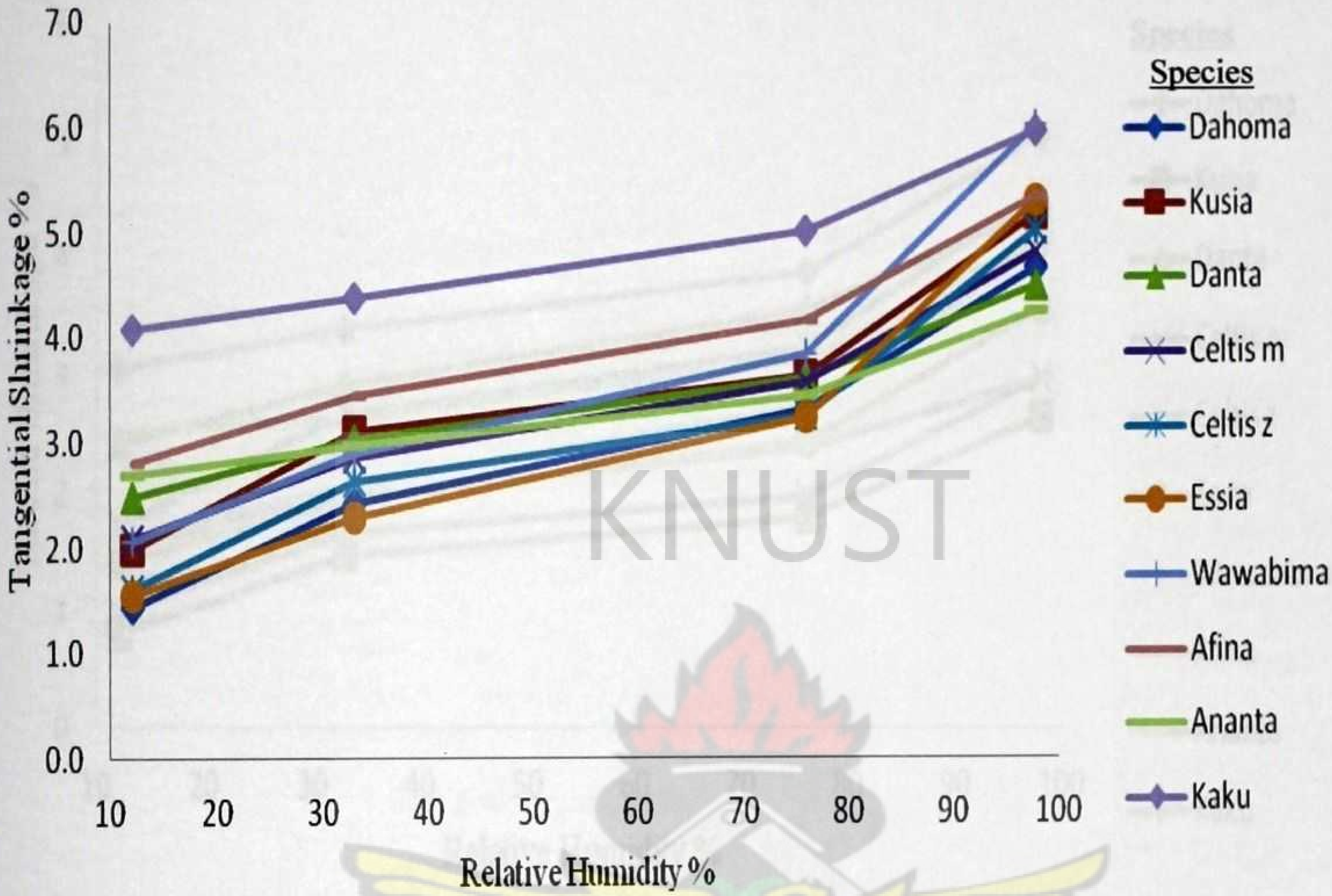

Figure 5.4a: The relative humidity and Tangential (T) Shrinkage of the ten species.

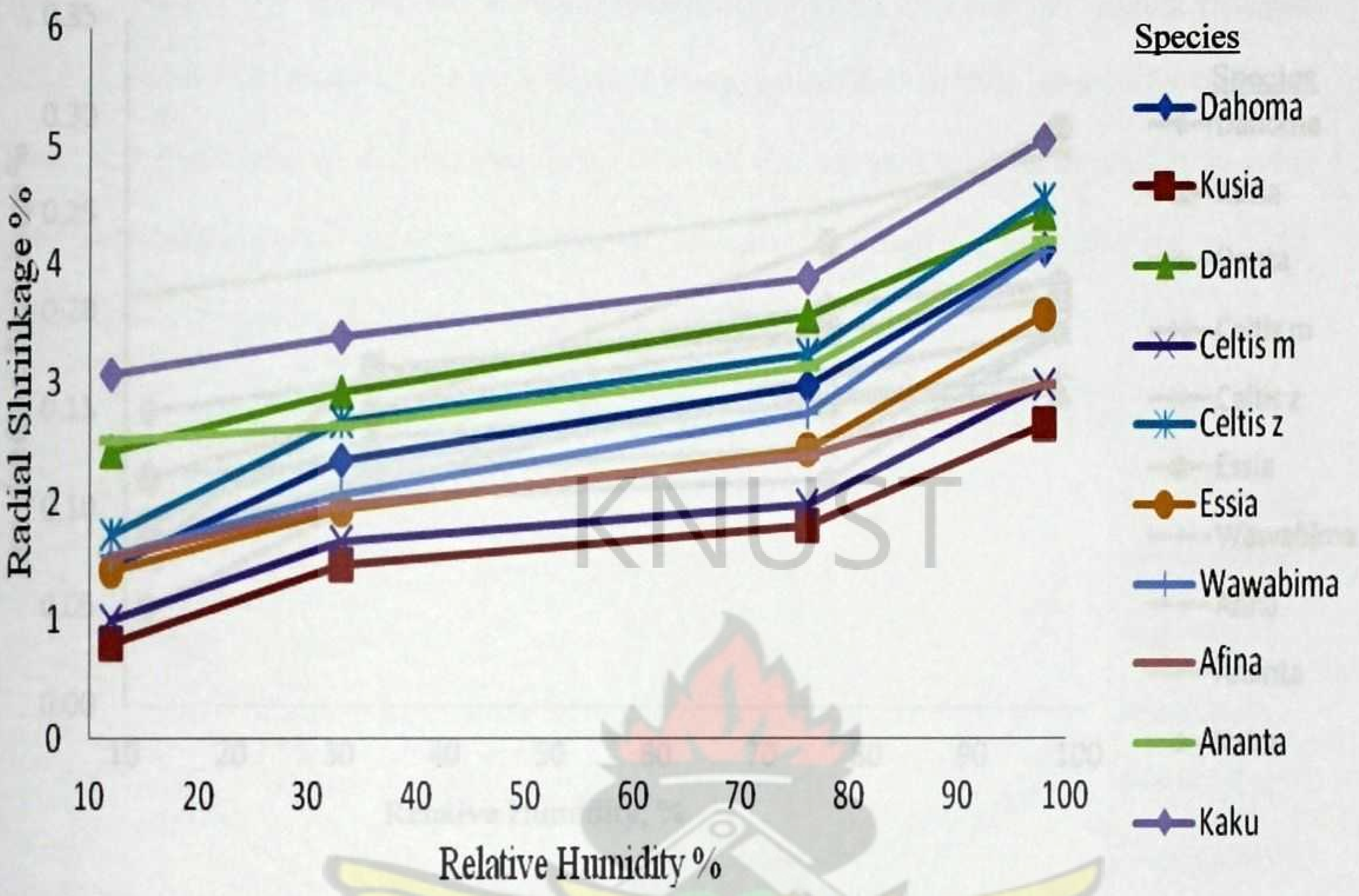

Figure 5.4b: The relative humidity and Radial (R) Shrinkage of the ten species

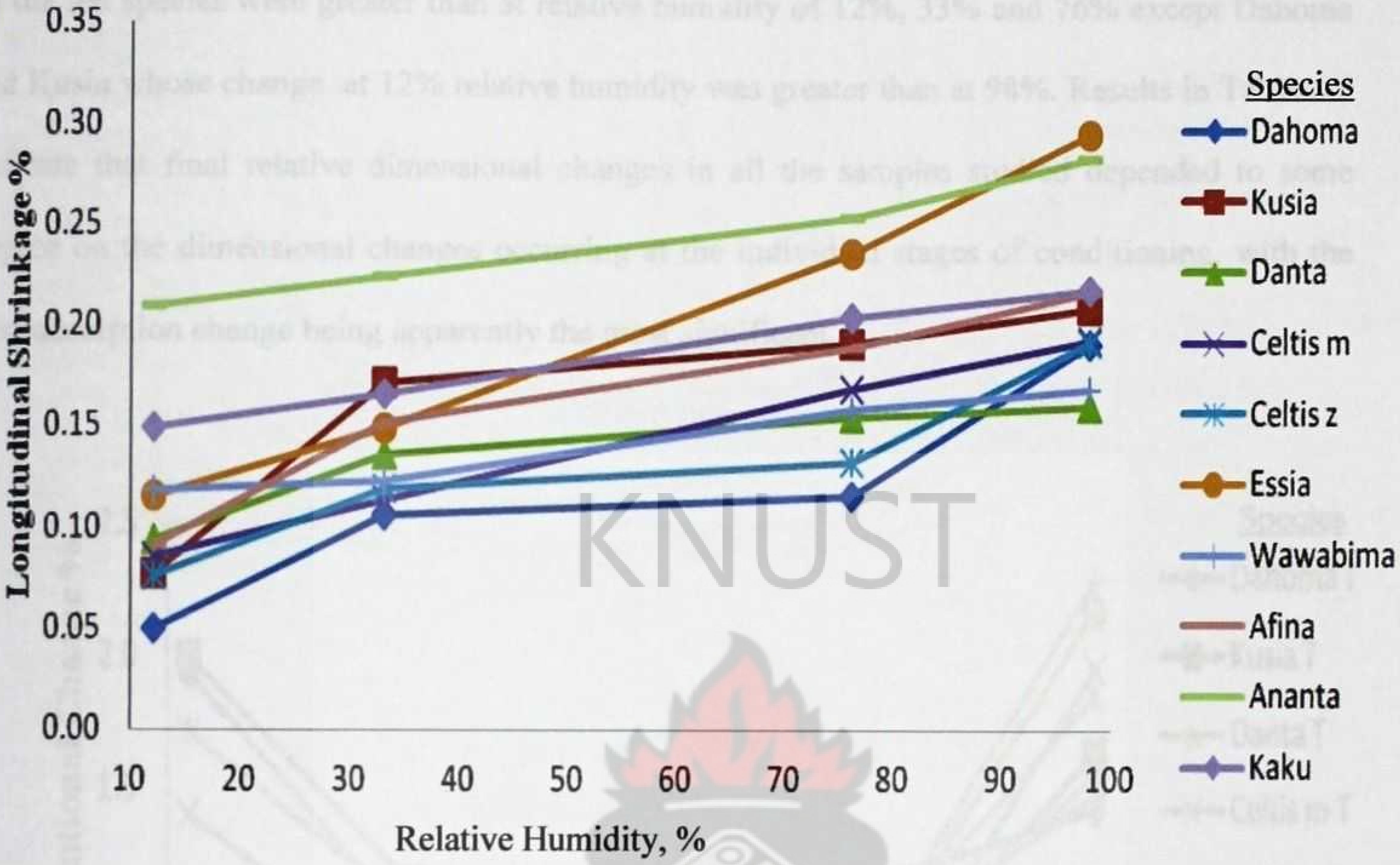

Figure 5.4c: The relative humidity and Longitudinal (L) Shrinkage of the ten species

5.5 Dimensional Change and Relative Humidity Relationship

Apart from *Celtis zenkeri,* Ananta and Kaku which had their tangential and radial dimensional change being nearly equal at 12 % relative humidity, the rest of the species had their tangential dimensional change greater than their respective radial dimensional change (Figures 5.5a, and 5.5b, and Table 4.5) at relative humidities of 33 to 98%. According to (http://www.chemisys.com.au/cutek/exposedwood.htm), below the fibre saturation point, wood changes dimension with changing moisture content and the magnitude of this change is dependent on the species and the relative humidity and is always different along the three axes: radial, tangential and longitudinal. Again, dimensional changes at 12% relative humidity were greater than at 33% and 76%, however, at relative humidity of 98%, the dimensional change in all the ten species were greater than at relative humidity of 12%, 33% and 76% except Dahoma and Kusia whose change at 12% relative humidity was greater than at 98%. Results in Table 4.5 indicate that final relative dimensional changes in all the samples studied depended to some degree on the dimensional changes occurring at the individual stages of conditioning, with the first adsorption change being apparently the most significant.

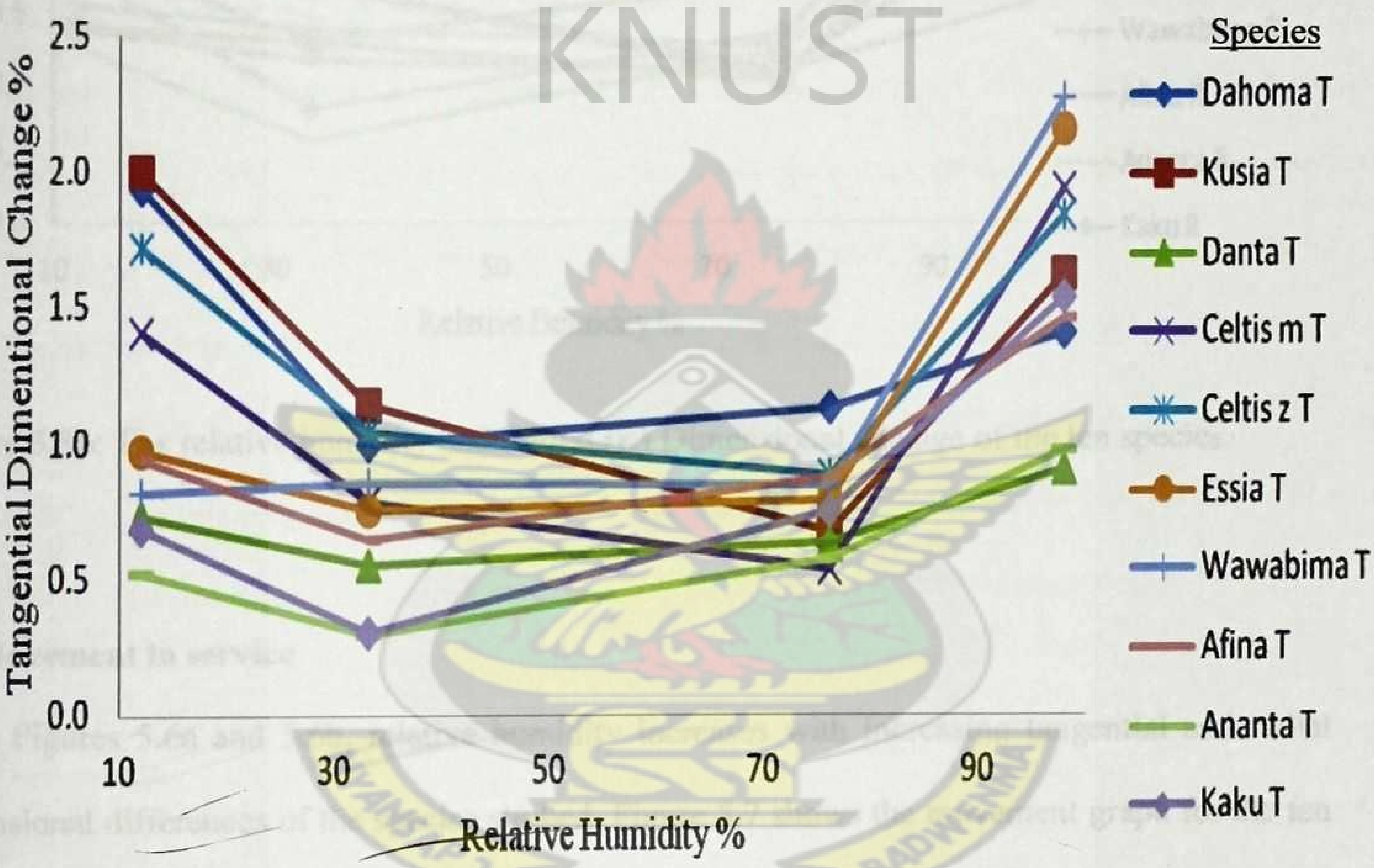

Figure 5.5a: The relative humidity and Tangential (T) Dimensional Change of the ten species

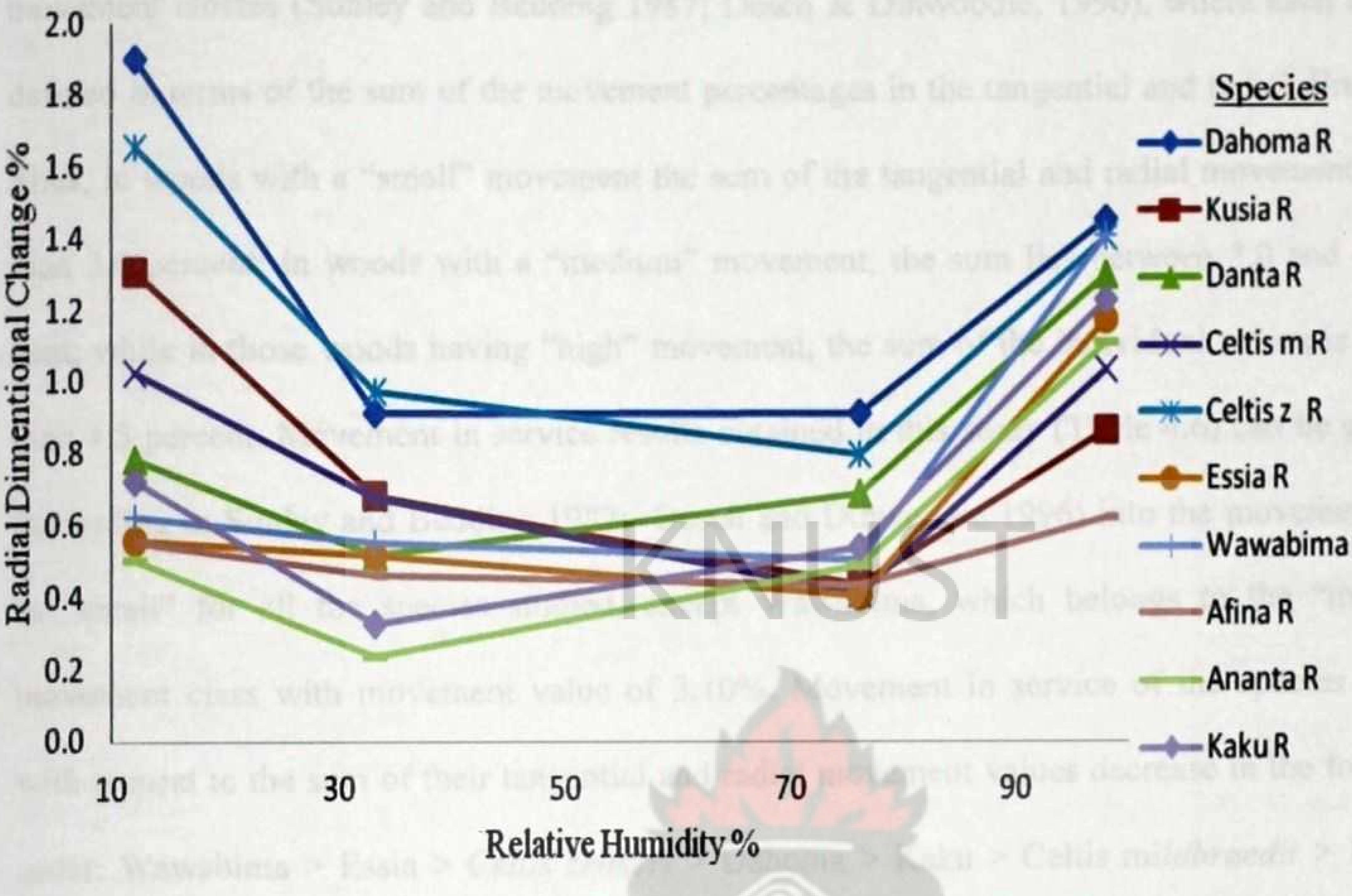

Figure 5.5b: The relative humidity and Radial (R) Dimensional Change of the ten species.

5.6 Movement in service

From Figures 5.6a and 5.6b, relative humidity increases with increasing tangential and radial dimensional differences of the species studied. Figure 5.7 shows the movement graph for the ten species. In general, tangential movements were greater than the radial movement from 60 to 90% relative humidity but Danta and Ananta have their radial movement greater than their respective tangential movement as shown in Figure 5.7. (http://www. Woodworkerssources.com, 2008), found similar patterns in wood and indicated that wood does not move in all directions equally. The greatest movement is across the grain, however, very little movement along the length. Movement is expressed either quantitatively as a percentage value for tangential and radial directions separately, or qualitatively as belonging to one of the three arbitrarily defined movement classes (Sunley and Bedding 1987; Desch & Dinwoodie, 1996), where each class is defined in terms of the sum of the movement percentages in the tangential and radial directions. Thus, in woods with a "small" movement the sum of the tangential and radial movement is less than 3.0 percent; in woods with a "medium" movement, the sum lies between 3.0 and 4.5 per cent; while in those woods having "high" movement, the sum of the individual values is greater than 4.5 percent. Movement in service results obtained in this study (Table 4.6) can be grouped (according to Sunley and Bedding 1987; Desch and Dinwoodie 1996) into the movement class as "small" for all the species studied, except Wawabima, which belongs to the "medium" movement class with movement value of 3.10%. Movement in service of the species studied with respect to the sum of their tangential and radial movement values decrease in the following order: Wawabima > Essia > *Celtis zenkeri* > Dahoma > Kaku > Celtis mi*ldbraedii* > Kusia > Danta > Afina > Ananta. Timbers with low movement values are suitable for high-quality joinery work, paneling and domestic flooring. Movement in timbers with higher values results in the loose of joints and in the development of unsightly gaps (Desch and Dinwoodie, 1996).

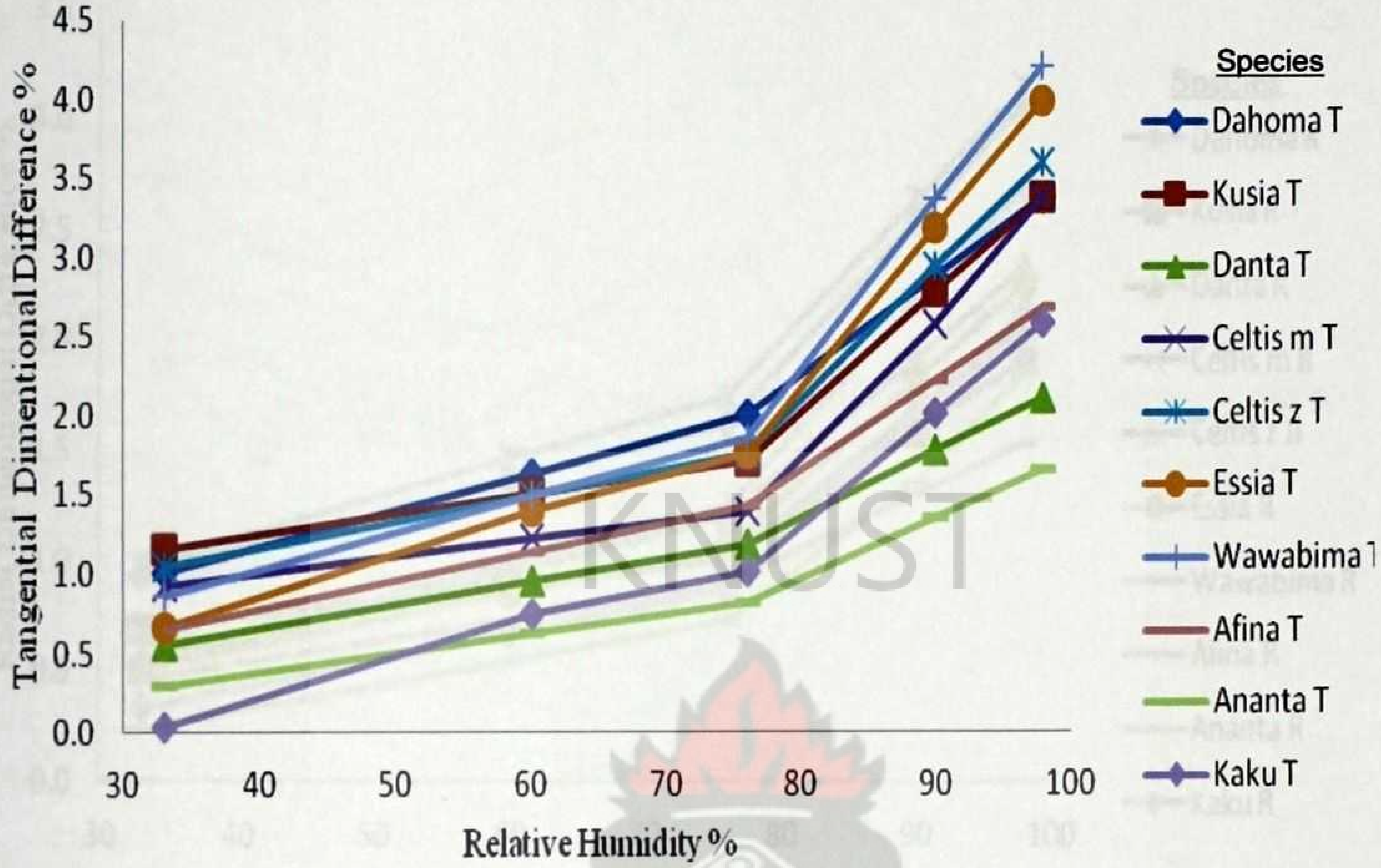

Figure 5.6a: The relative humidity and Tangential Dimensional Difference of the ten species

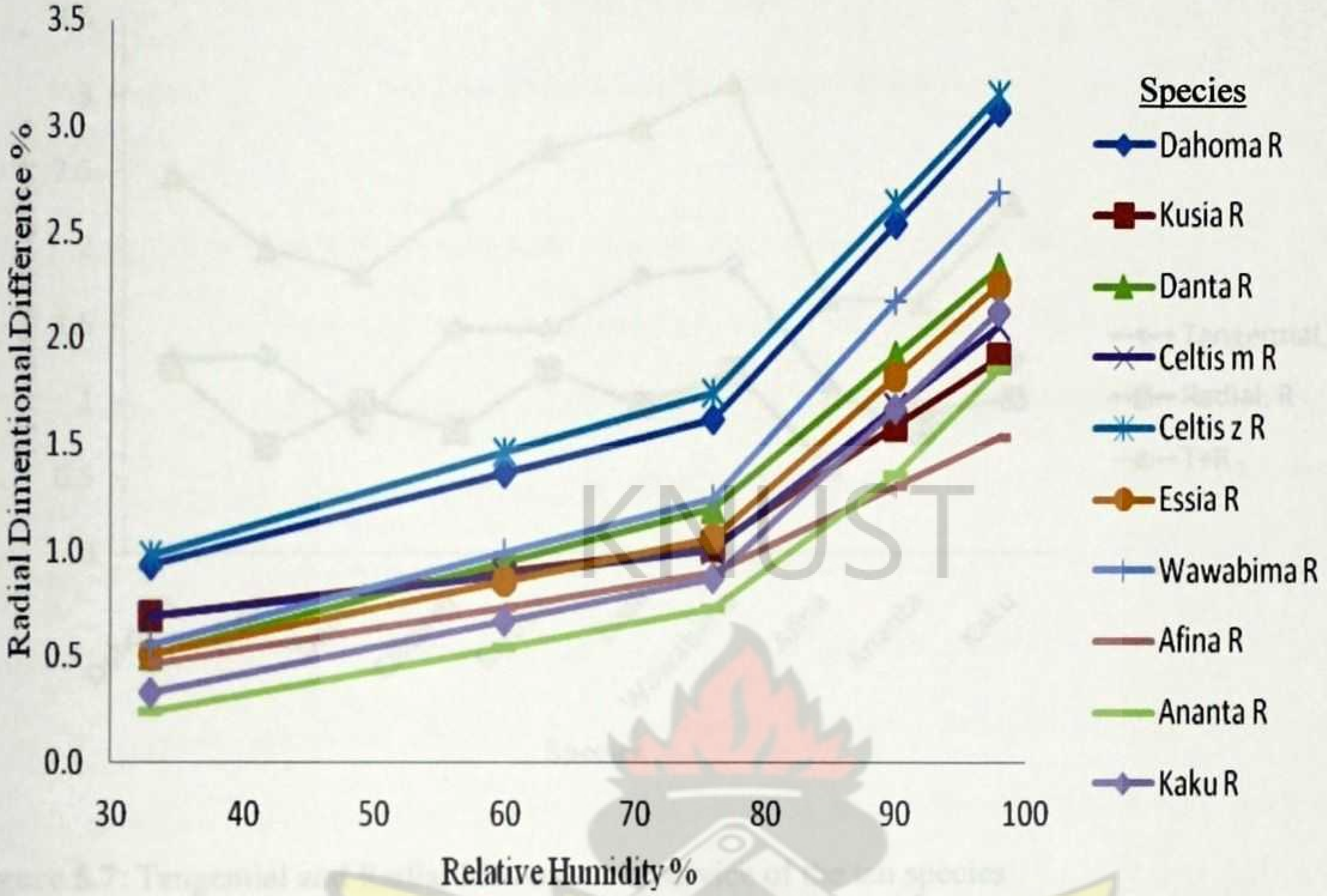

Figure 5.6b: The relative humidity and Radial Dimensional Difference of the ten species

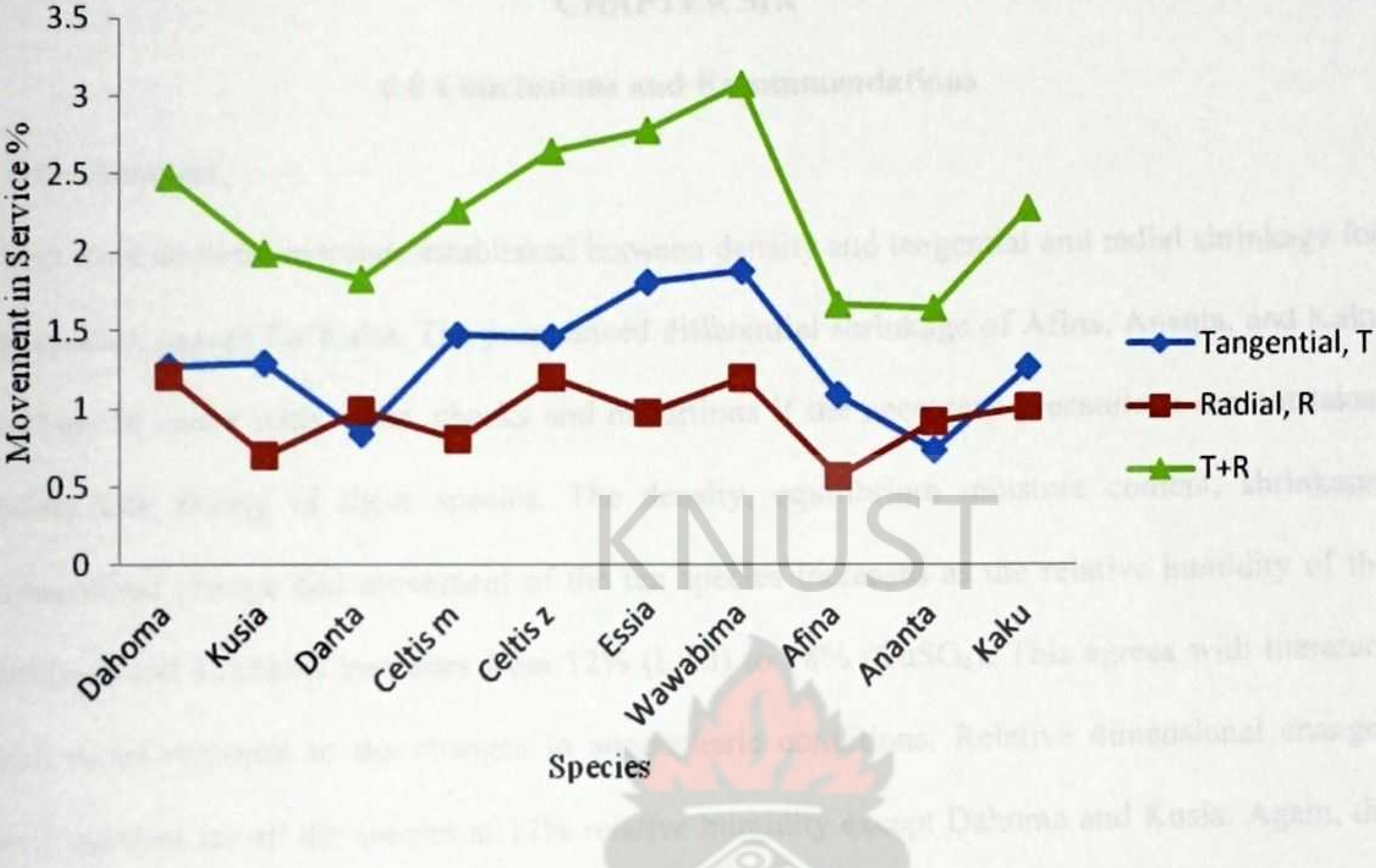

Figure 5.7: Tangential and Radial Movement in service of the ten species

CHAPTER SIX

6.0 Conclusions and Recommendations

6.1 Conclusions

There were no definite trends established between density and tangential and radial shrinkage for the species, except for Kaku. The pronounced differential shrinkage of Afina, Ananta, and Kaku is likely to cause wide splits, checks and distortions if the necessary precautions are not taken during kiln drying of these species. The density, equilibrium moisture content, shrinkage, dimensional change and movement of the ten species increases as the relative humidity of the saturated salt solutions increases from 12% (LiCl) to 98% ($CuSO_4$). This agrees with literature that, wood response to the changes in atmospheric conditions. Relative dimensional changes were greatest for all the species at 12% relative humidity except Dahoma and Kusia. Again, the study showed that, among the ten species, Ananta have the lowest tangential and radial movement, whiles Wawabima have the highest tangential and radial movement between 60% and 90% relative humidity. Movement in service of the species studied with respect to the sum of their tangential and radial movement values decrease in the following order: Wawabima > Essia > *Celtis zenkeri* > Dahoma > Kaku > Celtis *mildbraedii* > Kusia > Danta > Afina > Ananta. Finally, all the ten Ghanaian lesser used species studied could be classified as small movement, except Wawabima, which has medium movement in service. The species with small movement in service could be used for cabinet making, high quality joinery works, flooring and furniture. Species with medium movement in service could be used for applications such as cabinet making and furniture, however, in high quality joinery work; species with medium movement should not be used.

6.2 Recommendations

It is recommended that, this study of adsorption, and movement of wood in service could be continued for desorption of the species and for other Ghanaian wood species being used for cabinet making, joinery, flooring, furniture, wood carving, and pattern work since technical information are not available for most of the lesser used species.

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APPENDICES

Appendix 1a: Moisture content data for Trial samples of *Celtis mildbraedii* using saturated salt solution of Copper Sulphate ($CuSO_4$)

Number of Days	Moisture Content (%) of *Celtis Mildbraedii* Trial samples											
	1	2	3	4	5	6	7	8	9	10	11	12
5	15.1	14.8	15.1	15.1	15.3	14.5	13.3	12.5	13.2	13.4	13.6	14.3
10	17.9	17.3	18.3	18.0	18.0	18.0	17.6	17.2	17.2	17.7	17.9	17.7
14	19.2	18.6	19.3	18.9	18.7	18.8	18.7	18.7	18.6	19.1	19.5	18.9
17	19.6	19.2	19.7	19.3	19.3	19.3	19.3	19.3	19.2	19.5	19.7	19.1
18	20.0	19.5	20.2	19.6	19.6	19.7	19.6	19.7	19.8	20.1	20.0	19.7
20	20.5	20.0	20.6	20.1	20.1	20.1	20.2	20.2	20.2	20.4	20.6	20.3
33	22.3	21.9	22.4	22.0	22.1	22.3	22.2	22.3	22.1	22.4	22.2	22.0
38	22.5	22.1	22.7	22.2	22.3	22.5	22.3	22.4	22.2	22.5	22.4	22.2
46	23.1	22.8	23.4	23.0	23.1	23.1	23.0	23.0	22.8	23.0	22.9	22.7
52	23.3	22.9	23.6	23.1	23.3	23.3	23.1	23.1	22.9	23.2	23.1	22.8
59	23.4	23.2	23.9	23.5	23.6	23.7	23.4	23.3	23.3	23.5	23.3	23.1
66	23.5	23.4	24.0	23.6	23.7	23.7	23.5	23.4	23.5	23.7	23.3	23.1
73	23.3	23.2	23.8	23.4	23.4	23.4	23.3	23.0	23.2	23.2	23.1	23.0
80	23.3	23.2	23.9	23.4	23.4	23.4	23.2	23.0	23.2	23.1	22.9	22.8
89	23.0	23.0	23.6	23.3	23.2	23.3	23.2	22.9	23.4	23.2	22.9	22.7
94	23.3	23.3	23.9	23.5	23.5	23.5	23.3	23.1	23.5	23.4	23.2	22.8
102	23.3	23.3	23.9	23.4	23.1	23.3	23.1	23.0	23.3	23.4	22.8	22.5
109	22.8	23.1	23.7	23.2	22.8	23.0	22.9	22.8	23.1	23.0	22.9	22.5
115	22.9	23.1	23.9	23.2	22.6	22.9	22.7	22.7	23.0	23.1	22.8	22.1
124	22.8	22.9	23.4	23.2	22.2	22.6	22.4	22.2	22.7	22.6	22.5	21.6
130	22.9	23.0	23.2	23.0	21.8	22.5	22.4	22.3	22.8	22.6	22.7	21.3
137	22.7	22.8	22.9	22.6	21.3	22.3	22.1	22.0	22.9	22.1	22.4	21.0
150	22.6	22.9	22.3	22.2	20.6	22.2	22.1	21.8	22.7	22.0	22.1	20.5
168	22.2	22.2	19.8	21.6	19.6	21.3	21.3	20.7	21.6	21.1	20.7	19.2
174	22.2	22.2	19.8	21.6	19.6	21.3	21.3	20.7	21.6	21.1	20.7	19.2

Appendix 1b: Moisture content data for Trial samples of Kusia with saturated salt solution of Copper Sulphate ($CuSO_4$)

Sample No.	Kusia Tangential Trial samples		
	Initial weight (g)	Final weight (g)	Oven dry weight (g)
KUS T1	36.71	38.82	32.02
KUS T2	38.95	40.01	33.93
KUS T3	38.38	39.36	33.24
KUS T4	38.11	39.26	33.39
KUS T5	38.25	39.29	33.34
KUS T6	40.60	41.74	35.31
KUS T7	41.21	42.89	36.21
KUS T8	39.33	40.47	34.32
KUS T9	41.77	42.84	36.15
KUS T10	39.48	40.54	34.31
KUS T11	39.66	40.91	34.84
KUS T12	41.75	43.02	36.57
KUS T13	40.35	41.53	35.30
KUS T14	40.89	42.16	35.82
KUS T15	41.76	42.86	36.55
KUS T16	41.34	42.58	36.25
KUS T17	36.15	37.23	31.67
KUS T18	37.80	38.95	33.16
KUS T19	38.94	39.97	34.01
KUS T20	39.56	40.78	34.64

Sample No.	Kusia Tangential Trial samples			Sample No.	Kusia Radial Trial samples		
	Initial weight (g)	Final weight (g)	Oven dry weight (g)		Initial weight (g)	Final weight (g)	Oven dry weight (g)
KUS TT1	39.48	40.66	34.26	KUS TR1	35.68	36.75	31.34
KUS TT2	39.40	40.61	34.24	KUS TR2	34.75	35.86	30.55
KUS TT3	37.77	38.99	32.74	KUS TR3	35.30	36.38	30.89
KUS TT4	41.44	42.72	35.83	KUS TR4	37.51	38.70	32.64
KUS TT5	41.14	42.37	35.61	KUS TR5	37.09	38.25	32.36
KUS TT6	40.80	42.00	35.58	KUS TR6	35.06	35.84	30.46
KUS TT7	40.76	42.03	35.56	KUS TR7	33.60	34.29	29.29
KUS TT8	39.12	40.44	34.33	KUS TR8	42.80	43.91	37.09
KUS TT9	37.52	38.77	32.93	KUS TR9	41.40	42.41	35.74
KUSTT10	36.91	38.13	32.33	KUSTR10	41.80	42.87	36.28

Appendix 2a: Density data for Dahoma (Tangential) with RH of the various saturated solutions

Sample no.	Dahoma Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH T1	583	572	580	580	590	608
DAH T2	608	574	603	601	614	639
DAH T3	630	616	626	625	647	676
DAH T4	642	628	638	636	654	682
DAH T5	617	605	612	611	619	629
DAH T6	616	603	612	619	632	649

Appendix 2b: Summary of basic statistics of the Density of Dahoma (Tangential) with RH of the various saturated salt solutions

	Dahoma Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	616	599	612	612	625	648
Std Dev	20	23	20	20	23	28
Minimum	583	572	580	580	590	608
Maximum	641	628	637	636	653	684
Count	6	6	6	6	6	6
95% C. L.	21	24	21	21	24	30

Appendix 2c: Density data for Dahoma (Radial) with RH of the various saturated Solutions

Sample no.	Dahoma Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH R1	595	655	596	596	603	613
DAH R2	660	655	649	646	682	688
DAH R3	626	617	625	640	636	651
DAH R4	642	630	639	637	650	664
DAH R5	658	647	655	652	668	683
DAH R6	642	630	640	637	645	652

Appendix 2d: Summary of basic statistics of the Density of Dahoma (Radial) with RH of the various saturated salt solutions

	Dahoma Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	636	627	634	635	647	659
Std Dev	23	24	21	20	27	27
Minimum	595	588	596	596	603	613
Maximum	658	654	655	652	682	688
Count	6	6	6	6	6	6
95% C. L.	24	25	22	21	29	29

Appendix 2e: Summary of basic statistics of the Density of Dahoma (Tangential and Radial) with RH of the various saturated salt solutions

	Dahoma Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	626	613	623	623	636	654
Std Dev	23	26	23	22	27	27
Minimum	583	572	580	580	590	608
Maximum	658	654	655	652	682	688
Count	12	12	12	12	12	12
95% C. L.	15	17	14	14	17	17

Appendix 3a: Density data for Kusia (Tangential) with RH of the various saturated Solutions

Sample no.	Kusia Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS T1	681	668	679	677.69	683	691
KUS T2	649	649	661	660.03	668	683
KUS T3	663	647	662	663.54	667	674
KUS T4	625	612	618	622.53	627	635
KUS T5	650	655	648	647.95	651	662
KUS T6	661	642	652	653.18	656	668

Appendix 3b: Summary of basic statistics of the Density of Kusia (Tangential) with RH of the various saturated salt solutions

	Kusia Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	655	649	653	654	659	669
Std Dev	19	20	20	19	19	19
Minimum	625	612	618	623	627	635
Maximum	681	668	679	678	683	691
Count	6	6	6	6	6	6
95% C. L.	19	21	21	19	20	20

Appendix 3c: Density data for Kusia (Radial) with RH of the various saturated Solutions

Sample no.	Kusia Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS R1	700	687	697	697.19	701	711
KUS R2	662	646	657	657.73	664	673
KUS R3	670	653	665	665.28	670	679
KUS R4	714	701	713	712.83	717	726
KUS R5	708	692	702	702.45	708	716
KUS R6	687	672	684	684.29	690	698

Appendix 3d: Summary of basic statistics of the Density of Kusia (Radial) with RH of the various saturated salt solutions

	Kusia Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	690	675	686	687	692	701
Std Dev	21	22	22	22	21	21
Minimum	662	646	657	658	664	673
Maximum	714	701	713	713	717	726
Count	6	6	6	6	6	6
95% C. L.	22	23	23	23	22	22

Appendix 3e: Summary of basic statistics of the Density of Kusia (Tangential and Radial) with RH of the various saturated salt solutions

	Kusia Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	672	662	670	670	675	685
Std Dev	26	24	27	26	26	25
Minimum	625	612	618	623	627	635
Maximum	714	701	713	713	717	726
Count	12	12	12	12	12	12
95% C. L.	17	15	17	16	16	16

Appendix 4a: Density data for Danta (Tangential) with RH of the various saturated Solutions

Sample no.	Danta Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN T1	646	644	650	-	658	665
DAN T2	711	707	714	-	720	726
DAN T3	717	714	721	-	728	734
DAN T4	749	745	751	-	758	764
DAN T5	621	620	625	-	631	637
DAN T6	625	621	628	-	636	641

Appendix 4b: Summary of basic statistics of the Density of Danta (Tangential) with RH of the various saturated salt solutions

	Danta Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	678	676	681	-	688	693
Std Dev	54	54	54	-	54	54
Minimum	621	620	625	-	630	637
Maximum	749	745	751	-	758	764
Count	6	6	6	-	6	6
95% C. L.	57	57	57	-	57	57

Appendix 4c: Density data for Danta (Radial) with RH of the various saturated Solutions

Sample no.	Danta Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN R1	696	692	699	-	705	711
DAN R2	724	720	727	-	733	740
DAN R3	727	725	732	-	738	746
DAN R4	739	736	742	-	749	756
DAN R5	686	680	687	-	694	704
DAN R6	704	701	709	-	715	726

Appendix 4d: Summary of basic statistics of the Density of Danta (Radial) with RH of the various saturated salt solutions

	Danta Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	712	709	716	-	722	729
Std Dev	20	21	21	-	21	20
Minimum	686	680	687	-	694	704
Maximum	739	736	742	-	749	756
Count	6	6	6	-	6	6
95% C. L.	21	22	22	-	22	20

Appendix 4e: Summary of basic statistics of the Density of Danta (Tangential and Radial) with RH of the various saturated salt solutions

	Danta Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	695	692	699	-	705	711
Std Dev	43	43	43	-	43	43
Minimum	621	620	625	-	631	637
Maximum	749	745	751	-	758	764
Count	12	12	12	-	12	12
95% C. L.	27	27	27	-	27	27

Appendix 5a: Density data for *Celtis mildbraedii* (Tangential) with RH of the various saturated solutions

Sample no.	*Celtis mildbraedii* Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM T1	703	691	733	710.72	716	710
CEM T2	730	718	730	728.56	743	746
CEM T3	722	711	724	723.99	727	737
CEM T4	749	740	750	749.58	753	758
CEM T5	737	725	737	718.44	745	756
CEM T6	680	670	682	681.43	684	697

Appendix 5b: Summary of basic statistics of the Density of *Celtis mildbraedii* (Tangential) with RH of the various saturated salt solutions

	Celtis mildbraedii Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	720	709	724	719	728	736
Std Dev	25	25	28	23	25	23
Minimum	680	670	670	681	684	697
Maximum	749	740	750	750	753	758
Count	6	6	6	6	6	6
95% C. L.	26	26	29	24	26	24

Appendix 5c: Density data for *Celtis mildbraedii* (Radial) with RH of the various saturated solutions

Sample no.	*Celtis mildbraedii* Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM R1	744	733	745	723.01	727	740
CEM R2	703	693	703	703.58	708	723
CEM R3	677	670	680	679.01	683	692
CEM R4	644	633	643	644.73	648	660
CEM R5	639	664	676	675.92	680	692
CEM R6	650	639	650	649.80	653	667

Appendix 5d: Summary of basic statistics of the Density of *Celtis mildbraedii* (Radial) with RH of the various saturated salt solutions

	Celtis mildbraedii Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	676	672	682	679	683	695
Std Dev	41	37	37	30	31	31
Minimum	639	633	642	645	648	660
Maximum	744	733	744	723	727	739
Count	6	6	6	6	6	6
95% C. L.	43	39	39	32	32	32

Appendix 5e: Summary of basic statistics of the Density of *Celtis mildbraedii* (Tangential and Radial) with RH of the various saturated salt solutions

	Celtis mildbraedii Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	698	690	703	699	705	715
Std Dev	40	36	38	33	36	33
Minimum	639	633	642	645	648	660
Maximum	749	740	750	750	753	758
Count	12	12	12	12	12	12
95% C. L.	25	23	24	21	23	21

Appendix 6a: Density data for *Celtis zenkeri* (Tangential) with RH of the various saturated solutions

Sample no.	*Celtis zenkeri* Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEZ T1	765	750	759	756	771	792
CEZ T2	683	657	675	675	685	697
CEZ T3	642	626	636	635	651	673
CEZ T4	697	682	692	690	697	706
CEZ T5	692	676	686	686	694	711
CEZ T6	650	633	641	639	654	672

Appendix 6b: Summary of basic statistics of the Density of *Celtis zenkeri* (Tangential) with RH of the various saturated salt solutions

	Celtis zenkeri Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	687	670	681	680	691	708
Std Dev	44	45	45	44	44	44
Minimum	641	626	635	635	650	671
Maximum	765	751	759	756	771	792
Count	6	6	6	6	6	6
95% C. L	46	48	47	46	46	46

Appendix 6c: Density data for *Celtis zenkeri* (Radial) with RH of the various saturated solutions

Sample no.	*Celtis zenkeri* Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEZ R1	800	794	799	815	803	804
CEZ R2	815	800	810	807	816	826
CEZ R3	806	792	802	798	799	806
CEZ R4	807	800	804	803	812	815
CEZ R5	788	776	782	782	787	792
CEZ R6	802	787	795	795	802	808

Appendix 6d: Summary of basic statistics of the Density of *Celtis zenkeri* (Radial) with RH of the various saturated salt solutions

	Celtis zenkeri Radial Density, Kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	803	791	799	800	803	809
Std Dev	9	9	10	11	10	11
Minimum	788	775	782	782	786	791
Maximum	815	800	810	815	815	825
Count	6	6	6	6	6	6
95% C. L.	10	9	10	12	11	12

Appendix 6e: Summary of basic statistics of the Density of *Celtis zenkeri* (Tangential and Radial) with RH of the various saturated salt solutions

	Celtis zenkeri Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	745	731	740	740	747	759
Std Dev	68	71	69	70	66	61
Minimum	641	626	635	635	650	671
Maximum	815	800	810	815	815	825
Count	12	12	12	12	12	12
95% C. L.	43	45	44	44	42	39

Appendix 7a: Density data for Essia (Tangential) with RH of the various saturated Solutions

Sample no.	Essia Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS T1	732	726	730	-	733	734
ESS T2	730	724	730	-	732	733
ESS T3	741	733	740	-	740	741
ESS T4	729	724	730	-	730	729
ESS T5	732	723	731	-	733	734
ESS T6	753	746	750	-	748	750

Appendix 7b: Summary of basic statistics of the Density of Essia (Tangential) with RH of the various saturate salt solutions

	Essia Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	736	729	735	-	736	737
Std Dev	9	9	8	-	7	7
Minimum	729	723	730	-	730	729
Maximum	752	745	749	-	747	749
Count	6	6	6	-	6	6
95% C. L.	9	9	8	-	7	8

Appendix 7c: Density data for Essia (Radial) with RH of the various saturated solutions

Sample no.	Essia Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS R1	763	755	760	-	757	765
ESS R2	767	756	765	-	768	772
ESS R3	750	742	748	-	749	752
ESS R4	777	727	735	-	735	738
ESS R5	756	738	745	-	749	753
ESS R6	746	740	748	-	751	756

Appendix 7d: Summary of basic statistics of the Density of Essia (Radial) with RH of the various saturate salt solutions

	Essia Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	759	743	750	-	751	756
Std Dev	11	11	11	-	11	12
Minimum	745	727	734	-	735	738
Maximum	776	756	765	-	768	772
Count	6	6	6	-	6	6
95% C. L.	12	11	12	-	11	12

Appendix 7e: Summary of basic statistics of the Density of Essia (Tangential and Radial) with RH of the various saturate salt solutions

	Essia Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	748	736	742		744	746
Std Dev	16	12	12		12	14
Minimum	729	723	730		730	729
Maximum	776	756	765		768	772
Count	12	12	12		12	12
95% C. L.	10	8	8		7	9

Appendix 8a: Density data for Wawabima (Tangential) with RH of the various saturated solutions

Sample no.	Wawabima Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW T1	727	720	727	-	729	734
WAW T2	707	701	707	-	711	717
WAW T3	718	712	722	-	725	732
WAW T4	740	733	740	-	727	753
WAW T5	736	731	738	-	742	748
WAW T6	750	744	756	-	754	760

Appendix 8b: Summary of basic statistics of the Density of Wawabima (Tangential) with RH of the various saturated salt solutions

	Wawabima Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	730	724	730	-	731	741
Std Dev	16	16	15	-	15	16
Minimum	707	701	707	-	711	717
Maximum	750	744	749	-	754	760
Count	6	6	6	-	6	6
95% C. L.	16	16	16	-	15	17

Appendix 8c: Density data for Wawabima (Radial) with RH of the various saturated Solutions

Sample no.	Wawabima Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW R1	799	792	798	-	802	809
WAW R2	801	791	798	-	801	813
WAW R3	780	769	777	-	778	790
WAW R4	777	765	773	-	777	786
WAW R5	835	822	829	-	834	846
WAW R6	762	749	757	-	761	768

Appendix 8d: Summary of basic statistics of the Density of Wawabima (Radial) with RH of the various saturated salt solutions

	Wawabima Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	792	781	786	-	792	802
Std Dev	25	26	25	-	26	27
Minimum	762	749	754	-	761	768
Maximum	835	822	825	-	834	846
Count	6	6	6	-	6	6
95% C. L.	26	27	26	-	27	28

Appendix 8e: Summary of basic statistics of the Density of Wawabima (Tangential and Radial) with RH of the various saturated salt solutions

	Wawabima Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	761	752	758		762	771
Std Dev	38	36	35		38	38
Minimum	707	701	707		711	717
Maximum	835	822	825		834	846
Count	12	12	12		12	12
95% C. L.	24	23	22		24	24

Appendix 9a: Density data for Afina (Tangential) with RH of the various saturated solutions

Sample no.	Afina Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
AFN T1	746	746	751	-	756	759
AFN T2	751	752	756	-	763	764
AFN T3	765	763	768	-	773	783
AFN T4	768	767	770	-	775	777
AFN T5	779	749	755	-	761	768
AFN T6	772	772	785	-	782	789

Appendix 9b: Summary of basic statistics of the Density of Afina (Tangential) with RH of the various saturated salt solutions

	Afina Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	758	758	764	-	768	772
Std Dev	11	10	13	-	10	10
Minimum	746	746	751	-	756	759
Maximum	772	772	785	-	782	789
Count	6	6	6	-	6	6
95% C. L.	11	11	13	-	10	11

Appendix 9c: Density data for Afina (Radial) with RH of the various saturated solutions

Sample no.	Afina Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
AFN R1	862	860	864	-	867	869
AFN R2	863	852	864	-	870	871
AFN R3	890	890	895	-	899	899
AFN R4	859	860	865	-	870	869
AFN R5	849	849	854	-	857	856
AFN R6	872	874	879	-	885	886

Appendix 9d: Summary of basic statistics of the Density of Afina (Radial) with RH of the various saturated salt solutions

	Afina Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	866	866	870	-	875	875
Std Dev	14	14	14	-	15	15
Minimum	849	849	854	-	857	856
Maximum	890	890	895	-	899	899
Count	6	6	6	-	6	6
95% C. L.	15	15	15	-	16	16

Appendix 9e: Summary of basic statistics of the Density of Afina (Tangential and Radial) with RH of the various saturated salt solutions

	Afina Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	812	812	817		821	823
Std Dev	57	58	57		57	55
Minimum	746	746	751		756	759
Maximum	890	890	895		899	899
Count	12	12	12		12	12
95% C. L.	36	37	36		36	35

Appendix 10a: Density data for Ananta (Tangential) with RH of the various saturated solutions

Sample no.	Ananta Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA T1	863	860	862	-	867	868
ANA T2	841	837	839	-	845	851
ANA T3	864	861	863	-	870	849
ANA T4	879	874	877	-	884	873
ANA T5	862	856	859	-	864	864
ANA T6	940	939	940	-	946	950

Appendix 10b: Summary of basic statistics of the Density of Ananta (Tangential) with RH of the various saturated salt solutions

	Ananta Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	862	872	873	-	879	875
Std Dev	12	35	35	-	35	36
Minimum	841	837	839	-	845	849
Maximum	879	939	940	-	946	946
Count	6	6	6	-	6	6
95% C. L.	13	37	37	-	37	38

Appendix 10c: Density data for Ananta (Radial) with RH of the various saturated solutions

Sample no.	Ananta Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA R1	906	905	907	-	912	913
ANA R2	892	892	896	-	901	903
ANA R3	916	913	916	-	920	930
ANA R4	896	894	897	-	903	904
ANA R5	945	942	945	-	951	951
ANA R6	934	933	935	-	943	947

Appendix 10d: Summary of basic statistics of the Density of Ananta (Radial) with RH of the various saturated salt solutions

	Ananta Radial Density kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	915	914	916	-	919	923
Std Dev	21	21	20	-	18	21
Minimum	892	892	896	-	901	903
Maximum	945	942	945	-	945	951
Count	6	6	6	-	6	6
95% C. L.	22	22	21	-	19	22

Appendix 10e: Summary of basic statistics of the Density of Ananta (Tangential and Radial) with RH of the various saturated salt solutions

	Ananta Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	889	893	895		899	899
Std Dev	32	35	35		34	38
Minimum	841	837	839		845	849
Maximum	945	942	945		946	951
Count	12	12	12		12	12
95% C. L.	20	22	22		21	24

Appendix 11a: Density data for Kaku (Tangential) with RH of the various saturated solutions

Sample no.	Kaku Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK T1	1050	1051	1052	-	1057	1056
KAK T2	1040	1044	1038	-	1045	1040
KAK T3	1048	1047	1049	-	1052	1050
KAK T4	1050	1054	1056	-	1059	1056
KAK T5	1034	1033	1034	-	1040	1032
KAK T6	1066	1067	1069	-	1074	1069

Appendix 11b: Summary of basic statistics of the Density of Kaku (Tangential) with RH of the various saturated salt solutions

	Kaku Tangential Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1048	1049	1050	-	1054	1050
Std Dev	11	11	13	-	12	13
Minimum	1034	1033	1034	-	1040	1032
Maximum	1066	1067	1069	-	1074	1069
Count	6	6	6	-	6	6
95% C. L.	12	12	13	-	13	14

Appendix 11c: Density data for Kaku (Radial) with RH of the various saturated solutions

Sample no.	Kaku Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK R1	1052	1050	1051	-	1055	1053
KAK R2	1044	1043	1044	-	1045	1045
KAK R3	1059	1056	1057	-	1063	1059
KAK R4	985	985	987	-	993	991
KAK R5	1034	1027	1035	-	1039	1033
KAK R6	1016	1021	1020	-	1028	1022

Appendix 11d: Summary of basic statistics of the Density of Kaku with RH of the various saturated salt solutions

	Kaku Radial Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1031	1030	1032	-	1037	1034
Std Dev	28	26	25	-	25	25
Minimum	985	985	987	-	993	991
Maximum	1059	1056	1057	-	1063	1059
Count	6	6	6	-	6	6
95% C. L.	29	27	27	-	26	26

Appendix 11e: Summary of basic statistics of the Density of Kaku with RH of the various saturated salt solutions

	Kaku Density, kg/m³					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1040	1040	1041	-	1046	1042
Std Dev	22	21	21	-	21	21
Minimum	985	985	987	-	993	991
Maximum	1066	1067	1069	-	1074	1069
Count	12	12	12	-	12	12
95% C. L.	14	14	13	-	13	13

Appendix 12a: EMC data for Dahoma with RH of the various saturated solutions

Sample no.	Dahoma Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH T1	12.28	6.78	10.30	9.88	13.93	19.84
DAH T2	11.88	5.14	9.71	9.21	14.24	21.77
DAH T3	11.05	5.09	8.67	8.22	15.12	23.21
DAH T4	11.52	5.85	9.91	8.72	14.73	22.68
DAH T5	12.83	5.58	10.61	10.32	13.23	17.26
DAH T6	11.41	5.58	9.27	8.95	5.79	6.78

Appendix 12b: Summary of basic statistics of the E M C of Dahoma with RH of the various saturated salt solutions

	Dahoma Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.83	5.67	9.74	9.22	14.33	20.97
Std Dev	0.65	0.62	0.70	0.77	0.68	2.17
Minimum	11.05	5.09	8.67	8.22	13.23	17.26
Maximum	12.83	6.78	10.61	10.32	15.12	23.21
Count	6	6	6	6	6	6
95% C. L.	0.68	0.65	0.74	0.81	0.72	2.28

Appendix 12c: EMC data for Dahoma with RH of the various saturated solutions

Sample no.	Dahoma Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH R1	13.16	6.77	10.40	10.28	13.35	17.76
DAH R2	11.80	5.75	9.33	8.86	14.38	21.70
DAH R3	12.09	6.39	9.81	9.50	13.74	19.16
DAH R4	11.96	6.15	9.57	9.13	14.08	19.69
DAH R5	11.88	6.34	9.79	9.23	13.94	19.95
DAH R6	12.83	7.23	10.72	10.31	13.26	17.28

Appendix 12d: Summary of basic statistics of the E M C of Dahoma with RH of the various saturated salt solutions

	Dahoma Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	12.29	6.44	9.94	9.55	13.79	19.26
Std Dev	0.57	0.51	0.52	0.61	0.43	1.60
Minimum	11.80	5.75	9.33	8.86	13.26	17.28
Maximum	13.16	7.23	10.72	10.31	14.38	21.70
Count	6	6	6	6	6	6
95% C. L.	0.59	0.54	0.55	0.64	0.45	1.68

Appendix 13a: EMC data for Kusia with RH of the various saturated solutions

Sample no.	Kusia Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS T1	12.69	7.11	10.94	10.51	12.69	17.02
KUS T2	11.19	7.56	11.43	10.99	15.26	21.21
KUS T3	12.43	6.45	10.73	10.66	12.60	16.54
KUS T4	13.11	7.17	10.93	10.83	12.86	16.98
KUS T5	13.14	7.09	11.07	10.76	12.80	17.75
KUS T6	13.05	7.11	11.09	10.76	12.81	17.87

Appendix 13b: Summary of basic statistics of the E M C of Kusia with RH of the various saturated salt solutions

	Kusia Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	12.60	7.08	11.03	10.75	13.17	17.89
Std Dev	0.74	0.36	0.23	0.16	1.03	1.70
Minimum	11.19	6.45	10.73	10.51	12.60	16.54
Maximum	13.14	7.56	11.43	10.99	15.26	21.21
Count	6	6	6	6	6	6
95% C. L.	0.78	0.38	0.24	0.17	1.08	1.78

Appendix 13c: EMC data for Kusia with RH of the various saturated solutions

Sample no.	Kusia Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS R1	13.45	7.06	10.93	10.72	12.80	17.62
KUS R2	13.48	7.09	10.82	10.72	12.78	17.17
KUS R3	13.64	7.12	11.00	10.78	12.81	17.32
KUS R4	13.75	7.18	11.01	10.79	12.92	17.42
KUS R5	13.61	7.19	10.88	10.67	12.81	17.33
KUS R6	13.56	7.06	10.86	10.57	12.74	17.23

Appendix 13d: Summary of basic statistics of the E M C of Kusia with RH of the various saturated salt solutions

	Kusia Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	13.58	7.12	10.92	10.71	12.81	17.35
Std Dev	0.11	0.06	0.08	0.08	0.06	0.16
Minimum	13.45	7.06	10.82	10.57	12.74	17.17
Maximum	13.75	7.19	11.01	10.79	12.92	17.62
Count	6	6	6	6	6	6
95% C. L.	0.12	0.06	0.08	0.08	0.06	0.17

Appendix 14a: EMC data for Danta (Tangential) with RH of the various saturated solutions

Sample no.	Danta Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN T1	11.35	9.51	11.58	-	14.07	16.65
DAN T2	11.84	9.79	11.81	-	14.17	16.71
DAN T3	11.55	9.84	11.85	-	13.99	16.65
DAN T4	11.88	9.74	11.79	-	14.18	16.80
DAN T5	11.45	9.53	11.60	-	13.90	17.09
DAN T6	11.12	9.39	11.49	-	14.19	17.26

Appendix 14b: Summary of basic statistics of the E M C of Danta (Tangential) with RH of the various saturated salt solutions

	Danta Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.53	9.63	11.69	-	14.08	16.86
Std Dev	0.29	0.18	0.15	-	0.12	0.26
Minimum	11.12	9.39	11.49	-	13.90	16.65
Maximum	11.88	9.84	11.85	-	14.19	17.26
Count	6	6	6	-	6	6
95% C. L.	0.31	0.19	0.16	-	0.12	0.27

Appendix 14c: EMC data for Danta with RH of the various saturated solutions

Sample no.	Danta Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN R1	11.94	9.78	11.98	-	14.20	16.96
DAN R2	12.00	9.71	11.82	-	14.17	17.04
DAN R3	11.31	9.68	11.76	-	14.05	17.61
DAN R4	11.79	9.80	11.82	-	14.17	17.38
DAN R5	12.36	10.24	12.19	-	14.60	18.53
DAN R6	11.95	9.84	11.91	-	14.24	18.49

Appendix 14d: Summary of basic statistics of the E M C of Danta with RH of the various saturated salt solutions

	Danta Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.89	9.84	11.91	-	14.24	17.67
Std Dev	0.34	0.20	0.16	-	0.19	0.69
Minimum	11.31	9.68	11.76	-	14.05	16.96
Maximum	12.36	10.24	12.19	-	14.60	18.53
Count	6	6	6	-	6	6
95% C. L.	0.36	0.21	0.16	-	0.20	0.73

Appendix 15a: EMC data for *Celtis mildbraedii* with RH of the various saturated Solutions

Sample no.	Celtis mildbraedii Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM T1	14.54	9.36	17.00	13.35	15.31	18.46
CEM T2	12.04	7.13	11.16	10.85	14.16	19.13
CEM T3	11.50	7.19	10.76	10.72	17.95	17.95
CEM T4	11.49	7.21	10.65	10.52	12.23	18.15
CEM T5	11.79	7.32	11.01	10.78	12.46	18.80
CEM T6	11.64	7.33	10.86	10.76	12.42	18.56

Appendix 15b: Summary of basic statistics of the E M C of *Celtis mildbraedii* with RH of the various saturated salt solution

	Celtis mildbraedii Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	12.17	7.59	11.91	11.16	14.09	18.51
Std Dev	1.18	0.87	2.50	1.08	2.25	0.43
Minimum	11.49	7.13	10.65	10.52	12.23	17.95
Maximum	14.54	9.36	17.00	13.35	17.95	19.13
Count	6	6	6	6	6	6
95% C. L.	1.24	0.91	2.63	1.13	2.36	0.45

Appendix 15c: EMC data for *Celtis mildbraedii* with RH of the various saturated solutions

Sample no.	*Celtis mildbraedii* Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM R1	11.96	7.36	11.04	10.70	12.84	19.15
CEM R2	12.26	7.82	11.13	11.13	13.05	19.04
CEM R3	12.06	7.62	11.14	11.07	12.94	18.37
CEM R4	11.97	7.58	11.36	11.05	12.74	18.38
CEM R5	12.45	7.85	11.55	11.28	13.09	18.83
CEM R6	11.88	7.49	11.24	10.98	12.72	18.51

Appendix 15d: Summary of basic statistics of the E M C of *Celtis mildbraedii* with RH of the various saturated salt solutions

	Celtis mildbraedii Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	12.10	7.62	11.24	11.04	12.90	18.71
Std Dev	0.22	0.19	0.19	0.19	0.16	0.34
Minimum	11.88	7.36	11.04	10.70	12.72	18.37
Maximum	12.45	7.85	11.55	11.28	13.09	19.15
Count	6	6	6	6	6	6
95% C. L.	0.23	0.20	0.19	0.20	0.16	0.36

Appendix 16a: EMC data for *Celtis zenkeri* with RH of the various saturated solutions

Sample no.	*Celtis zenkeri* Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEZ T1	11.16	5.25	8.79	8.43	14.99	22.23
CEZ T2	12.43	5.20	10.25	9.73	14.05	19.65
CEZ T3	12.76	6.60	10.29	9.84	15.00	21.74
CEZ T4	13.19	7.53	11.03	10.52	13.06	17.93
CEZ T5	12.27	6.26	9.89	9.54	13.94	19.56
CEZ T6	12.43	6.47	9.83	9.48	14.28	19.96

Appendix 16b: Summary of basic statistics of the E M C of *Celtis zenkeri* with RH of the various saturated salt solutions

	Celtis zenkeri Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	12.37	6.22	10.01	9.59	14.22	20.18
Std Dev	0.68	0.88	0.74	0.68	0.73	1.58
Minimum	11.16	5.20	8.79	8.43	13.06	17.93
Maximum	13.19	7.53	11.03	10.52	15.00	22.23
Count	6	6	6	6	6	6
95% C. L.	0.71	0.93	0.77	0.71	0.76	1.65

Appendix 16c: EMC data for *Celtis zenkeri* with RH of the various saturated solutions

Sample no.	*Celtis zenkeri* Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEZ R1	12.83	7.40	10.83	10.47	12.88	16.81
CEZ R2	13.19	6.44	9.82	9.29	14.16	20.02
CEZ R3	13.19	7.67	10.96	10.57	13.25	17.82
CEZ R4	12.44	7.06	10.57	10.10	13.08	17.35
CEZ R5	13.20	7.48	10.89	10.61	13.00	17.21
CEZ R6	12.82	7.02	10.45	10.06	13.65	18.08

Appendix 16d: Summary of basic statistics of the E M C of *Celtis zenkeri* with RH of the various saturated salt solutions

	Celtis zenkeri Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	12.94	7.18	10.59	10.18	13.34	17.88
Std Dev	0.31	0.44	0.42	0.50	0.48	1.14
Minimum	12.44	6.44	9.82	9.29	12.88	16.81
Maximum	13.20	7.67	10.96	10.61	14.16	20.02
Count	6	6	6	6	6	6
95% C. L.	0.32	0.46	0.44	0.52	0.51	1.20

Appendix 17a: EMC data for Essia with RH of the various saturated solutions

Sample no.	Essia Tangential Equilibrium Moisture Content %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS T1	10.98	8.33	10.83	-	13.07	18.21
ESS T2	10.90	7.98	10.57	-	13.05	17.81
ESS T3	11.15	8.35	10.85	-	13.20	17.85
ESS T4	10.87	8.08	10.70	-	12.89	17.83
ESS T5	11.03	8.29	8.29	-	13.08	17.71
ESS T6	11.11	8.30	10.91	-	13.19	17.63

Appendix 17b: Summary of basic statistics of the E M C of Essia with RH of the various saturated salt solutions

	Essia Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.01	8.22	10.36	-	13.08	17.84
Std Dev	0.11	0.15	1.02	-	0.11	0.20
Minimum	10.87	7.98	8.29	-	12.89	17.63
Maximum	11.15	8.35	10.91	-	13.20	18.21
Count	6	6	6	-	6	6
95% C. L.	0.12	0.16	1.07	-	0.12	0.21

Appendix 17c: EMC data for Essia with RH of the various saturated solutions

Sample no.	Essia Radial Equilibrium Moisture Content %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS R1	11.35	8.36	10.87	-	12.91	18.50
ESS R2	11.36	8.41	10.86	-	13.20	18.45
ESS R3	11.40	8.52	11.05	-	13.37	18.42
ESS R4	10.73	8.28	10.76	-	13.12	17.51
ESS R5	11.23	8.50	10.90	-	13.39	19.02
ESS R6	10.32	8.43	11.00	-	13.25	13.25

Appendix 17d: Summary of basic statistics of the E M C of Essia with RH of the various saturated salt solutions

	Essia Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.06	8.42	10.91	-	13.21	17.53
Std Dev	0.44	0.09	0.10	-	0.18	2.15
Minimum	10.32	8.28	10.76	-	12.91	13.25
Maximum	11.40	8.52	11.05	-	13.39	19.02
Count	6	6	6	-	6	6
95% C. L.	0.46	0.09	0.11	-	0.19	2.26

Appendix 18a: EMC data for Wawabima with RH of the various saturated solutions

Sample no.	Wawabima Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW T1	11.19	8.67	11.22	-	13.75	19.50
WAW T2	10.90	8.60	11.09	-	13.61	19.24
WAW T3	11.10	8.66	11.22	-	13.77	19.85
WAW T4	11.10	8.59	11.29	-	13.87	19.48
WAW T5	10.99	8.57	11.17	-	13.67	18.71
WAW T6	10.93	8.68	11.23	-	13.67	18.68

Appendix 18b: Summary of basic statistics of the E M C of Wawabima with RH of the various saturated salt solutions

Sample no	Wawabima Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.04	8.63	11.20	-	13.72	19.24
Std Dev	0.12	0.05	0.07	-	0.09	0.47
Minimum	10.90	8.57	11.09	-	13.61	18.68
Maximum	11.19	8.68	11.29	-	13.87	19.85
Count	6	6	6	-	6	6
95% C. L.	0.12	0.05	0.07	-	0.10	0.49

Appendix 18c: EMC data for Wawabima with RH of the various saturated solutions

Sample no.	Wawabima Radial Equilibrium Moisture Content ,%					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW R1	11.01	8.98	11.42	-	13.89	19.30
WAW R2	11.77	9.08	11.47	-	13.99	20.29
WAW R3	11.94	8.98	11.43	-	13.91	19.91
WAW R4	11.94	8.72	11.14	-	13.73	18.60
WAW R5	12.05	8.94	11.37	-	13.89	19.82
WAW R6	12.05	8.77	11.38	-	13.78	19.27

Appendix 18d: Summary of basic statistics of the E M C of Wawabima with RH of the various saturated salt solutions

	Wawabima Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.79	8.91	11.37	-	13.87	19.53
Std Dev	0.40	0.14	0.12	-	0.09	0.60
Minimum	11.01	8.72	11.14	-	13.73	18.60
Maximum	12.05	9.08	11.47	-	13.99	20.29
Count	6	6	6	-	6	6
95% C. L.	0.42	0.14	0.12	-	0.10	0.63

Appendix 19a: EMC data for Afina with RH of the various saturated solutions

Sample no.	Afina Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
AFN T1	11.42	9.44	11.51	-	13.85	16.74
AFN T2	11.55	9.50	11.52	-	13.93	16.80
AFN T3	11.59	9.56	11.56	-	14.00	17.19
AFN T4	11.76	9.46	11.55	-	13.97	17.35
AFN T5	11.60	9.41	11.48	-	13.85	17.76
AFN T6	11.46	9.58	11.58	-	13.99	17.99

Appendix 19b: Summary of basic statistics of the E M C of Afina with RH of the various saturated salt solutions

	Afina Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.56	9.49	11.53	-	13.93	17.31
Std Dev	0.12	0.07	0.04	-	0.07	0.50
Minimum	11.42	9.41	11.48	-	13.85	16.74
Maximum	11.76	9.58	11.58	-	14.00	17.99
Count	6	6	6	-	6	6
95% C. L.	0.13	0.07	0.04	-	0.07	0.53

Appendix 19c: EMC data for Afina with RH of the various saturated solutions

Sample no.	Afina Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
AFN R1	11.53	9.42	11.37	-	13.69	16.35
AFN R2	11.57	9.47	11.39	-	13.59	16.33
AFN R3	11.61	9.75	11.67	-	13.74	16.27
AFN R4	11.38	9.57	11.48	-	13.66	16.44
AFN R5	11.22	9.52	11.40	-	13.62	16.25
AFN R6	10.78	9.26	11.14	-	13.54	16.50

Appendix 19d: Summary of basic statistics of the E M C of Afina with RH of the various saturated salt solutions

	Afina Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	11.35	9.50	11.41	-	13.64	16.36
Std Dev	0.31	0.16	0.17	-	0.07	0.10
Minimum	10.78	9.26	11.14	-	13.54	16.25
Maximum	11.61	9.75	11.67	-	13.74	16.50
Count	6	6	6	-	6	6
95% C. L.	0.33	0.17	0.18		0.08	0.10

Appendix 20a: EMC data for Ananta with RH of the various saturated solutions

Sample no.	Ananta Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA T1	12.83	11.05	12.00	-	13.72	15.81
ANA T2	12.90	11.13	12.04	-	13.78	16.19
ANA T3	12.89	11.12	12.02	-	13.79	13.79
ANA T4	13.32	11.37	12.36	-	14.15	16.45
ANA T5	13.38	11.42	12.43	-	14.25	16.87
ANA T6	12.69	11.00	11.93	-	13.55	15.85

Appendix 20b: Summary of basic statistics of the E M C of Ananta with RH of the various saturated salt solutions

	Ananta Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	13.00	11.18	12.13	-	13.87	15.83
Std Dev	0.28	0.17	0.21	-	0.27	1.07
Minimum	12.69	11.00	11.93	-	13.55	13.79
Maximum	13.38	11.42	12.43	-	14.25	16.87
Count	6	6	6	-	6	6
95% C. L.	0.29	0.18	0.22	-	0.28	1.13

Appendix 20c: EMC data for Ananta with RH of the various saturated solutions

Sample no.	Ananta Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA R1	13.27	11.60	12.57	-	14.37	17.76
ANA R2	13.05	11.37	12.35	-	14.08	17.35
ANA R3	12.86	11.08	12.11	-	13.82	17.53
ANA R4	12.82	11.01	12.00	-	13.71	16.71
ANA R5	13.04	11.41	12.38	-	14.38	17.65
ANA R6	12.97	11.16	12.10	-	13.84	17.30

Appendix 20d: Summary of basic statistics of the E M C of Ananta with RH of the various saturated salt solutions

	Ananta Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	13.00	11.27	12.25	-	14.03	17.38
Std Dev	0.16	0.23	0.22	-	0.29	0.37
Minimum	12.82	11.01	12.00	-	13.71	16.71
Maximum	13.27	11.60	12.57	-	14.38	17.76
Count	6	6	6	-	6	6
95% C. L.	0.17	0.24	0.23	-	0.31	0.39

Appendix 21a: EMC data for Kaku with RH of the various saturated solutions

Sample no.	Kaku Tangential Equilibrium Moisture Content %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK T1	13.83	12.03	13.02	-	14.86	18.06
KAK T2	13.46	11.73	12.67	-	14.60	18.00
KAK T3	13.50	11.77	12.75	-	14.58	17.58
KAK T4	13.27	11.57	12.46	-	14.31	17.19
KAK T5	13.42	11.80	12.66	-	14.63	17.96
KAK T6	13.22	11.76	12.61	-	14.35	17.22

Appendix 21b: Summary of basic statistics of the E M C of Kaku with RH of the various saturated salt solutions

	Kaku Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	13.45	11.78	12.70	-	14.56	17.67
Std Dev	0.22	0.15	0.19	-	0.20	0.40
Minimum	13.22	11.57	12.46	-	14.31	17.19
Maximum	13.83	12.03	13.02	-	14.86	18.06
Count	6	6	6	-	6	6
95% C. L.	0.23	0.16	0.20	-	0.21	0.42

Appendix 21c: Summary of basic statistics of the E M C of Kaku with RH of the various saturated salt solutions

Sample no	Kaku Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK R1	13.30	11.41	12.37	-	14.35	17.83
KAK R2	13.51	11.58	12.46	-	14.39	17.33
KAK R3	13.81	11.85	12.77	-	14.76	18.02
KAK R4	13.38	11.77	12.70	-	14.61	17.63
KAK R5	13.45	11.79	12.68	-	14.57	17.61
KAK R6	12.36	11.10	12.04	-	13.79	16.80

Appendix 21d: Summary of basic statistics of the E M C of Kaku with RH of the various saturated salt solutions

	Kaku Radial Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1031	1030	1032	-	1037	1034
Std Dev	28	26	25	-	25	25
Minimum	985	985	987	-	993	991
Maximum	1059	1056	1057	-	1063	1059
Count	6	6	6	-	6	6
95% C. L.	29	27	27	-	26	26

Appendix 22a: Shrinkage data for Dahoma with RH of the various saturated solutions

Sample no	Dahoma Tangential Shrinkage %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH T1	3.65	1.59	2.68	2.49	3.42	4.78
DAH T2	3.17	1.59	2.47	2.32	3.48	5.07
DAH T3	3.19	1.28	2.24	2.12	3.34	4.98
DAH T4	3.40	1.44	2.48	2.26	3.51	4.85
DAH T5	3.39	1.62	2.59	2.56	3.30	4.12
DAH T6	3.32	1.17	2.13	2.15	3.35	4.42

Appendix 22b: Summary of basic statistics of the shrinkage of Dahoma with RH of the various saturated salt solutions

	Dahoma Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.35	1.45	2.43	2.32	3.40	4.70
Std Dev	0.17	0.19	0.21	0.18	0.08	0.36
Minimum	3.17	1.17	2.13	2.12	3.30	4.12
Maximum	3.65	1.62	2.68	2.56	3.51	5.07
Count	6	6	6	6	6	6
95% C. L.	0.18	0.20	0.22	0.19	0.09	0.38

Appendix 22c: Shrinkage data for Dahoma with RH of the various saturated solutions

Sample no	Dahoma Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH R1	3.42	1.75	2.60	2.61	3.41	4.55
DAH R2	3.79	1.63	2.73	2.55	3.31	5.07
DAH R3	3.57	1.30	2.28	2.17	2.76	4.15
DAH R4	3.17	1.33	2.18	2.12	3.06	4.66
DAH R5	2.92	1.19	2.09	2.01	2.85	2.85
DAH R6	3.13	1.54	2.27	2.24	2.82	3.78

Appendix 22d: Summary of basic statistics of the shrinkage of Dahoma with RH of the various saturated salt solutions

	Dahoma Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.33	1.46	2.36	2.28	3.03	4.18
Std Dev	0.32	0.21	0.25	0.24	0.27	0.79
Minimum	2.92	1.19	2.09	2.01	2.76	2.85
Maximum	3.79	1.75	2.73	2.61	3.41	5.07
Count	6	6	6	6	6	6
95% C. L.	0.34	0.22	0.26	0.26	0.29	0.83

Appendix 22e: Shrinkage data for Dahoma with RH of the various saturated solutions

Sample no	Longitudinal Shrinkage %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH T1	0.11	0.04	0.07	0.06	0.09	0.14
DAH T2	0.12	0.06	0.09	0.07	0.11	0.17
DAH T3	0.14	0.01	0.05	0.03	0.15	0.18
DAH T4	0.14	0.03	0.04	0.04	0.10	0.14
DAH T5	0.37	0.09	0.21	0.22	0.21	0.25
DAH T6	0.21	0.08	0.28	0.27	0.23	0.30

Sample no	Longitudinal Shrinkage %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH R1	0.27	0.06	0.16	0.14	0.13	0.24
DAH R2	0.07	0.02	0.03	0.04	0.03	0.12
DAH R3	0.20	0.05	0.09	0.05	0.08	0.11
DAH R4	0.24	0.05	0.05	0.06	0.07	0.16
DAH R5	0.05	0.04	0.09	0.03	0.08	0.18
DAH R6	0.35	0.09	0.14	0.16	0.15	0.34

Appendix 22f: Summary of basic statistics of the shrinkage of Dahoma with RH of the various saturated salt solutions

	Dahoma Longitudinal Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.19	0.05	0.11	0.10	0.12	0.19
Std Dev	0.10	0.03	0.08	0.08	0.06	0.07
Minimum	0.05	0.01	0.03	0.03	0.03	0.11
Maximum	0.37	0.09	0.28	0.27	0.23	0.34
Count	12	12	12	12	12	12
95% C. L.	0.07	0.02	0.05	0.05	0.04	0.05

Appendix 23a: Shrinkage data for Kusia with RH of the various saturated solutions

Sample no	Kusia Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS T1	1.96	0.09	1.29	3.22	1.73	3.37
KUS T2	3.69	1.82	2.88	2.72	3.89	5.80
KUS T3	3.92	2.07	3.07	2.99	3.54	4.90
KUS T4	3.93	2.03	3.06	3.05	3.53	4.77
KUS T5	4.14	1.93	3.24	3.08	3.71	5.34
KUS T6	4.05	1.93	3.11	2.91	3.50	5.18

Appendix 23b: Summary of basic statistics of the shrinkage of Kusia with RH of the various saturated salt solutions

	Kusia Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.95	1.99	3.11	2.99	3.65	5.22
Std Dev	0.15	0.12	0.15	0.17	0.16	0.37
Minimum	3.69	1.82	2.88	2.72	3.50	4.77
Maximum	4.14	2.14	3.31	3.22	3.89	5.80
Count	6	6	6	6	6	6
95% C. L.	0.16	0.12	0.16	0.18	0.16	0.39

Appendix 23c: Shrinkage data for Kusia with RH of the various saturated solutions

Sample no	Kusia Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS R1	2.05	0.79	1.59	1.50	1.99	2.83
KUS R2	2.02	0.75	1.43	1.37	1.68	2.11
KUS R3	2.39	1.08	1.76	1.61	2.07	3.12
KUS R4	2.04	0.58	1.13	1.11	1.66	2.41
KUS R5	1.93	0.81	1.59	1.53	1.81	2.67
KUS R6	2.17	0.80	1.37	1.27	1.69	2.49

Appendix 23d: Summary of basic statistics of the shrinkage of Kusia with RH of the various saturated salt solutions

	Kusia Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	2.10	0.80	1.48	1.40	1.82	2.68
Std Dev	0.16	0.16	0.22	0.18	0.18	0.26
Minimum	1.93	0.58	1.13	1.11	1.66	2.41
Maximum	2.39	1.08	1.76	1.61	2.07	3.12
Count	6	6	6	6	6	6
95% C. L.	0.17	0.17	0.23	0.19	0.18	0.27

Appendix 23e: Shrinkage data for Kusia with RH of the various saturated solutions

Sample no	Longitudinal Shrinkage %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS T1	0.13	0.08	0.10	0.12	0.15	0.16
KUS T2	0.20	0.10	0.18	0.14	0.28	0.26
KUS T3	0.12	0.05	0.07	0.05	0.15	0.16
KUS T4	0.13	0.07	0.80	0.08	0.15	0.18
KUS T5	0.11	0.02	0.06	0.05	0.17	0.20
KUS T6	0.22	0.05	0.05	0.02	0.18	0.19

Appendix 23e: Shrinkage data for Kusia with RH of the various saturated solutions

Sample no	Longitudinal Shrinkage % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS R1	0.19	0.09	0.13	0.14	0.23	0.25
KUS R2	0.18	0.11	0.18	0.15	0.20	0.20
KUS R3	0.10	0.03	0.05	0.06	0.17	0.20
KUS R4	0.21	0.11	0.14	0.15	1.66	0.26
KUS R5	0.23	0.13	0.14	0.13	0.19	0.20
KUS R6	0.17	0.07	0.13	0.12	0.18	0.20

Appendix 23f: Summary of basic statistics of the shrinkage of Kusia with RH of the various saturated salt solutions

	Kusia Longitudinal Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.17	0.08	0.17	0.11	0.19	0.21
Std Dev	0.04	0.03	0.20	0.06	0.04	0.03
Minimum	0.10	0.03	0.05	0.04	0.15	0.16
Maximum	0.23	0.13	0.80	0.23	0.28	0.26
Count	12	12	12	12	12	12
95% C. L.	0.03	0.02	0.13	0.04	0.03	0.02

Appendix 24a: Shrinkage data for Danta with RH of the various saturated solutions

Sample no	Danta Tangential Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN T1	2.90	2.19	2.81	-	3.25	4.06
DAN T2	3.29	2.56	3.13	-	3.81	4.72
DAN T3	3.39	2.78	3.22	-	3.88	4.67
DAN T4	3.82	2.99	3.56	-	4.25	5.11
DAN T5	2.87	2.06	2.62	-	3.33	4.25
DAN T6	2.96	2.36	2.83	-	3.36	4.36

Appendix 24b: Summary of basic statistics of the shrinkage of Danta with RH of the various saturated salt solutions

	Danta Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.20	2.49	3.03	-	3.65	4.53
Std Dev	0.37	0.36	0.34	-	0.39	0.38
Minimum	2.87	2.06	2.62	-	3.25	4.06
Maximum	3.82	2.99	3.56	-	4.25	5.11
Count	6	6	6	-	6	6
95% C. L.	0.39	0.37	0.36	-	0.41	0.40

Appendix 24c: Shrinkage data for Danta with RH of the various saturated solutions

	Danta Radial Shrinkage, %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN R1	3.14	2.43	2.93	-	3.54	4.50
DAN R2	3.31	2.47	2.94	-	3.63	4.51
DAN R3	3.14	2.49	2.98	-	3.71	4.82
DAN R4	2.72	2.02	2.62	-	3.29	4.37
DAN R5	3.36	2.62	3.02	-	3.72	3.72
DAN R6	3.47	2.52	3.03	-	3.67	4.89

Appendix 24d: Summary of basic statistics of the shrinkage of Danta with RH of the various saturated salt solutions

	Danta Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.19	2.42	2.92	-	3.59	4.47
Std Dev	0.26	0.21	0.15	-	0.16	0.42
Minimum	2.72	2.02	2.62	-	3.29	3.72
Maximum	3.47	2.62	3.03	-	3.72	4.89
Count	6	6	6	-	6	6
95% C. L.	0.28	0.22	0.16	-	0.17	0.44

Appendix 24e: Shrinkage data for Danta with RH of the various saturated solutions

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN T1	0.18	0.11	0.18	-	0.20	0.20
DAN T2	0.15	0.09	0.13	-	0.17	0.17
DAN T3	0.14	0.10	0.16	-	0.16	0.18
DAN T4	0.12	0.04	0.11	-	0.14	0.15
DAN T5	0.20	0.14	0.18	-	0.21	0.23
DAN T6	0.19	0.09	0.09	-	0.14	0.15

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN R1	0.13	0.04	0.11	-	0.13	0.13
DAN R2	0.18	0.15	0.12	-	0.13	0.14
DAN R3	0.09	0.09	0.15	-	0.15	0.15
DAN R4	0.12	0.06	0.15	-	0.14	0.14
DAN R5	0.15	0.10	0.15	-	0.17	0.17
DAN R6	0.16	0.14	0.14	-	0.17	0.17

Appendix 24f: Summary of basic statistics of the shrinkage of Danta with RH of the various saturated salt solutions

	Danta Longitudinal Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.15	0.09	0.14	-	0.16	0.16
Std Dev	0.03	0.04	0.03	-	0.03	0.03
Minimum	0.09	0.04	0.09	-	0.13	0.13
Maximum	0.20	0.15	0.18	-	0.21	0.23
Count	12	12	12	-	12	12
95% C. L.	0.02	0.02	0.02	-	0.02	0.02

Appendix 25a: Shrinkage data for *Celtis mildbraedii* with RH of the various saturated solutions

Sample no	*Celtis mildbraedii* Tangential Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM T1	4.28	2.63	2.74	2.66	3.18	3.18
CEM T2	3.38	1.80	2.98	3.00	3.55	5.54
CEM T3	3.21	1.91	2.67	2.66	3.21	4.95
CEM T4	3.27	1.90	2.83	2.77	3.41	5.22
CEM T5	3.51	2.43	3.18	2.97	3.20	5.23
CEM T6	3.16	1.88	2.77	2.66	5.05	5.05

Appendix 25b: Summary of basic statistics of the shrinkage of *Celtis mildbraedii* with RH of the various saturated salt solutions

	Celtis mildbraedii Tangential Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.47	2.09	2.86	2.54	3.60	4.86
Std Dev	0.42	0.35	0.19	0.20	0.73	0.85
Minimum	3.16	1.80	2.67	2.31	3.18	3.18
Maximum	4.28	2.63	3.18	2.73	5.05	5.54
Count	6	6	6	6	6	6
95% C. L.	0.44	0.36	0.20	0.21	0.76	0.89

Appendix 25c: Shrinkage data for *Celtis mildbraedii* with RH of the various saturated solutions

Sample no	Celtis mildbraedii Radial Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM R1	1.99	0.95	1.68	1.62	2.19	3.49
CEM R2	2.21	1.14	1.79	1.71	2.12	3.25
CEM R3	2.09	0.94	1.71	1.67	1.87	2.86
CEM R4	1.87	0.98	1.66	1.54	1.89	2.75
CEM R5	2.00	0.98	1.58	1.45	1.95	2.92
CEM R6	1.91	1.00	1.64	1.52	1.93	2.83

Appendix 25d: Summary of basic statistics of the shrinkage of *Celtis mildbraedii* with RH of the various saturated salt solutions

	Celtis mildbraedii Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	2.01	1.00	1.67	2.63	1.99	3.02
Std Dev	0.12	0.07	0.07	0.21	0.13	0.29
Minimum	1.87	0.94	1.58	2.36	1.87	2.75
Maximum	2.21	1.14	1.79	2.88	2.19	3.49
Count	6	6	6	6	6	6
95% C. L.	0.13	0.08	0.07	0.22	0.14	0.30

Appendix 25e: Shrinkage data for *Celtis mildbraedii* with RH of the various saturated salt solutions

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM T1	0.21	0.17	0.19	0.17	0.18	0.18
CEM T2	0.16	0.06	0.07	0.06	0.15	0.17
CEM T3	0.15	0.07	0.12	0.11	0.14	0.14
CEM T4	0.16	0.08	0.10	0.09	0.12	0.13
CEM T5	0.14	0.10	0.10	0.10	0.15	0.21
CEM T6	0.16	0.08	0.09	0.11	0.17	0.17

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM R1	0.12	0.08	0.06	0.05	0.19	0.22
CEM R2	0.27	0.21	0.25	0.23	0.25	0.26
CEM R3	0.15	0.03	0.07	0.07	0.16	0.22
CEM R4	0.08	0.04	0.05	0.04	0.14	0.18
CEM R5	0.28	0.09	0.18	0.17	0.22	0.24
CEM R6	0.12	0.03	0.10	0.10	0.17	0.18

Appendix 25f: Summary of basic statistics of the shrinkage of *Celtis mildbraedii* with RH of the various saturated salt solutions

	Celtis mildbraedii Longitudinal Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_4 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.16	0.09	0.11	0.11	0.17	0.19
Std Dev	0.06	0.06	0.06	0.06	0.04	0.04
Minimum	0.08	0.03	0.05	0.04	0.12	0.13
Maximum	0.28	0.21	0.25	0.23	0.25	0.26
Count	12	12	12	12	12	12
95% C. L.	0.04	0.04	0.04	0.04	0.02	0.03

Appendix 26a: Shrinkage data for *Celtis zenkeri* with RH of the various saturated salt solutions

	Celtis zenkeri Tangential Shrinkage, %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_4 (43)	NaCl (76)	$CuSO_4$ (98)
CEZ T1	3.11	1.26	2.30	2.31	3.53	5.90
CEZ T2	2.87	1.51	2.51	2.42	3.00	5.14
CEZ T3	3.79	1.83	2.89	2.72	3.02	5.06
CEZ T4	3.48	2.00	2.94	2.73	3.33	4.84
CEZ T5	3.58	1.76	2.77	2.72	3.62	5.10
CEZ T6	2.94	1.30	2.38	2.35	3.15	4.33

Appendix 26b: Summary of basic statistics of the shrinkage of *Celtis zenkeri* with RH of the various saturated salt solutions

	Celtis zenkeri Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_4 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.30	1.61	2.63	2.54	3.27	5.06
Std Dev	0.38	0.30	0.27	0.20	0.26	0.51
Minimum	2.87	1.26	2.30	2.31	3.00	4.33
Maximum	3.79	2.00	2.94	2.73	3.62	5.90
Count	6	6	6	6	6	6
95% C. L.	0.39	0.32	0.29	0.21	0.27	0.53

Appendix 26c: Summary of basic statistics of the shrinkage of *Celtis zenkeri* with RH of the various saturated salt solutions

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Celtis zenkeri Radial Shrinkage %					
CEZ R1	3.45	1.67	2.66	2.78	3.17	4.55
CEZ R2	3.17	1.69	2.53	2.42	3.35	5.07
CEZ R3	3.40	1.82	2.74	2.77	3.43	4.60
CEZ R4	3.61	1.80	3.00	2.88	3.49	4.94
CEZ R5	3.35	1.81	2.58	2.57	3.05	4.12
CEZ R6	3.15	1.57	2.59	2.36	3.07	4.34

Appendix 26d: Shrinkage data for *Celtis zenkeri* with RH of the various saturated salt solutions

	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Celtis zenkeri Radial Shrinhage, %					
Mean	3.36	1.73	2.68	2.63	3.26	4.60
Std Dev	0.17	0.10	0.17	0.21	0.19	0.36
Minimum	3.15	1.57	2.53	2.36	3.05	4.12
Maximum	3.61	1.82	3.00	2.88	3.49	5.07
Count	6	6	6	6	6	6
95% C. L.	0.18	0.11	0.18	0.22	0.20	0.38

Appendix 26e: Shrinkage data for *Celtis zenkeri* with RH of the various saturated salt solutions

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Longitudinal Shrinkage %					
CEZ T1	0.13	0.03	0.13	0.12	0.12	0.18
CEZ T2	0.13	0.10	0.14	0.09	0.14	0.18
CEZ T3	0.14	0.10	0.13	0.08	0.15	0.19
CEZ T4	0.10	0.02	0.10	0.10	0.11	0.19
CEZ T5	0.11	0.05	0.09	0.05	0.10	0.17
CEZ T6	0.22	0.15	0.12	0.06	0.25	0.32

Appendix 26e: Shrinkage data for *Celtis zenkeri* with RH of the various saturated salt solutions (continued)

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Longitudinal Shrinkage %					
CEZ R1	0.09	0.02	0.07	0.11	0.08	0.14
CEZ R2	0.18	0.13	0.17	0.14	0.19	0.22
CEZ R3	0.11	0.08	0.08	0.10	0.08	0.22
CEZ R4	0.06	0.04	0.15	0.11	0.09	0.15
CEZ R5	0.14	0.12	0.14	0.14	0.17	0.18
CEZ R6	0.12	0.10	0.15	0.14	0.15	0.19

Appendix 26f: Summary of basic statistics of the shrinkage of *Celtis zenkeri* with RH of the various saturated salt solutions

	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Celtis zenkeri Longitudinal Shrinkage, %					
Mean	0.12	0.08	0.12	0.10	0.13	0.19
Std Dev	0.04	0.04	0.03	0.03	0.05	0.05
Minimum	0.06	0.02	0.07	0.05	0.08	0.14
Maximum	0.22	0.15	0.17	0.14	0.25	0.32
Count	12	12	12	12	12	12
95% C. L.	0.03	0.03	0.02	0.02	0.03	0.03

Appendix 27a: Shrinkage data for *Celtis zenkeri* with RH of the various saturated salt solutions

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Essia Tangential Shrinkage, %					
ESS T1	2.45	1.56	2.34	-	3.16	5.43
ESS T2	3.35	2.03	2.97	-	4.02	6.17
ESS T3	1.92	0.94	1.60	-	2.69	4.69
ESS T4	1.94	1.00	1.78	-	2.77	4.99
ESS T5	2.46	1.78	2.25	-	3.22	4.99
ESS T6	2.88	1.98	2.79	-	3.71	5.88

Appendix 27b: Summary of basic statistics of the shrinkage of Essia with RH of the various saturated salt solutions

	Essia Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	2.50	1.55	2.29	-	3.26	5.36
Std Dev	0.55	0.48	0.54	-	0.52	0.57
Minimum	1.92	0.94	1.60	-	2.69	4.69
Maximum	3.35	2.03	2.97	-	4.02	6.17
Count	6	6	6	-	6	6
95% C. L.	0.58	0.50	0.56	-	0.55	0.60

Appendix 27c: Shrinkage data for Essia with RH of the various saturated salt solutions

	Essia Radial Shrinkage, %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS R1	1.62	1.03	1.62	-	2.05	3.22
ESS R2	2.60	2.20	2.47	-	3.03	4.01
ESS R3	1.89	1.12	1.77	-	2.41	3.63
ESS R4	1.69	1.18	1.63	-	2.15	3.05
ESS R5	1.97	1.39	1.94	-	2.44	3.95
ESS R6	2.04	1.59	2.16	-	2.67	3.84

Appendix 27d: Summary of basic statistics of the shrinkage of Essia with RH of the various saturated salt solutions

	Essia Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1.97	1.42	1.93	-	2.46	3.62
Std Dev	0.35	0.43	0.33	-	0.35	0.40
Minimum	1.62	1.03	1.62	-	2.05	3.05
Maximum	2.60	2.20	2.47	-	3.03	4.01
Count	6	6	6	-	6	6
95% C. L.	0.37	0.46	0.35	-	0.37	0.42

Appendix 27e: Shrinkage data for Essia with RH of the various saturated salt solutions

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS T1	0.21	0.07	0.15	-	0.27	0.37
ESS T2	0.27	0.24	0.22	-	0.33	0.43
ESS T3	0.18	0.17	0.16	-	0.37	0.42
ESS T4	0.28	0.17	0.17	-	0.29	0.39
ESS T5	0.09	0.06	0.10	-	0.17	0.28
ESS T6	0.11	0.06	0.08	-	0.16	0.16

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS R1	0.11	0.09	0.15	-	0.25	0.33
ESS R2	0.15	0.11	0.14	-	0.21	0.24
ESS R3	0.18	0.12	0.17	-	0.25	0.28
ESS R4	0.17	0.15	0.18	-	0.18	0.19
ESS R5	0.18	0.05	0.11	-	0.15	0.18
ESS R6	0.13	0.11	0.17	-	0.21	0.30

Appendix 27f: Summary of basic statistics of the shrinkage of Essia with RH of the various saturated salt solutions

	Essia Longitudinal Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.17	0.12	0.15	-	0.24	0.30
Std Dev	0.06	0.06	0.04	-	0.07	0.09
Minimum	0.09	0.05	0.08	-	0.15	0.16
Maximum	0.28	0.24	0.22	-	0.37	0.43
Count	12	12	12	-	12	12
95% C. L.	0.04	0.04	0.03	-	0.04	0.06

Appendix 28a: Shrinkage data for Wawabima with RH of the various saturated salt solutions

Sample no	Wawabima Tangential Shrinkage %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW T1	2.72	1.89	2.81	-	3.82	6.03
WAW T2	3.39	2.45	3.09	-	4.20	6.51
WAW T3	2.60	2.11	2.85	-	3.92	6.28
WAW T4	2.91	2.08	2.97	-	3.84	6.10
WAW T5	2.90	1.92	2.85	-	3.73	5.79
WAW T6	2.73	1.99	2.88	-	3.75	5.73

Appendix 28b: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Wawabima Tangential Equilibrium Moisture Content, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	730	724	730	-	731	741
Std Dev	16	16	15	-	15	16
Minimum	707	701	707	-	711	717
Maximum	750	744	749	-	754	760
Count	6	6	6	-	6	6
95% C. L.	16	16	16	-	15	17

Appendix 28c: Shrinkage data for Wawabima with RH of the various saturated salt solutions

Sample no	Wawabima Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW R1	2.04	1.62	2.19	-	2.93	4.35
WAW R2	2.11	1.49	2.02	-	2.75	4.17
WAW R3	2.24	1.50	1.93	-	2.72	4.04
WAW R4	2.14	1.51	2.08	-	2.73	3.76
WAW R5	2.27	1.55	2.28	-	2.90	4.55
WAW R6	2.11	1.54	1.92	-	2.56	4.01

Appendix 28d: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Longitudinal Shrinkage %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	761	752	758	-	762	771
Std Dev	38	36	35	-	38	38
Minimum	707	701	707	-	711	717
Maximum	835	822	825	-	834	846
Count	12	12	12	-	12	12
95% C. L.	24	23	22	-	24	24

Appendix 28e: Shrinkage data for Wawabima with RH of the various saturated salt solutions

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW T1	0.25	0.18	0.17	-	0.21	0.25
WAW T2	0.16	0.14	0.14	-	0.19	0.19
WAW T3	0.17	0.14	0.13	-	0.18	0.19
WAW T4	0.24	0.20	0.22	-	0.19	0.19
WAW T5	0.30	0.23	0.25	-	0.26	0.28
WAW T6	0.24	0.20	0.20	-	0.25	0.27

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW R1	0.08	0.06	0.07	-	0.11	0.11
WAW R2	0.13	0.07	0.09	-	0.11	0.11
WAW R3	0.16	0.11	0.13	-	0.16	0.16
WAW R4	0.09	0.04	0.04	-	0.12	0.13
WAW R5	0.06	0.04	0.02	-	0.08	0.08
WAW R6	0.11	0.03	0.04	-	0.09	0.10

Appendix 28f: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Longitudinal Shrinkage %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	761	752	758	-	762	771
Std Dev	38	36	35	-	38	38
Minimum	707	701	707	-	711	717
Maximum	835	822	825	-	834	846
Count	12	12	12	-	12	12
95% C. L.	24	23	22	-	24	24

Appendix 29a: Shrinkage data for Afina with RH of the various saturated salt solutions

	Afina Tangential Shrinkage, %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
AFN T1	3.76	2.88	3.48	-	4.23	5.17
AFN T2	3.81	2.79	3.36	-	4.10	5.13
AFN T3	3.93	2.84	3.54	-	4.29	5.46
AFN T4	3.78	2.84	3.61	-	4.35	5.66
AFN T5	3.66	2.71	3.33	-	4.06	5.43
AFN T6	3.50	2.81	3.42	-	4.18	5.47

Appendix 29b: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Afina Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.74	2.81	3.45	-	4.20	5.39
Std Dev	0.15	0.06	0.11	-	0.11	0.20
Minimum	3.50	2.71	3.33	-	4.06	5.13
Maximum	3.93	2.88	3.61	-	4.35	5.66
Count	6	6	6	-	6	6
95% C. L.	0.16	0.06	0.11	-	0.12	0.21

Appendix 29c: Shrinkage data for Afina with RH of the various saturated salt solutions

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Afina Radial Shrinkage, %					
AFN R1	2.03	1.48	1.97	-	2.37	2.88
AFN R2	2.01	1.50	1.93	-	2.33	2.96
AFN R3	2.30	1.75	2.19	-	2.63	3.31
AFN R4	2.06	1.48	1.96	-	2.41	3.07
AFN R5	1.92	1.44	1.86	-	2.37	2.96
AFN R6	2.08	1.49	1.98	-	2.34	2.96

Appendix 29d: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Afina Radial Shrinkage, %					
Mean	2.07	1.52	1.98	-	2.41	3.02
Std Dev	0.13	0.11	0.11	-	0.11	0.15
Minimum	1.92	1.44	1.86	-	2.33	2.88
Maximum	2.30	1.75	2.19	-	2.63	3.31
Count	6	6	6	-	6	6
95% C. L.	0.13	0.12	0.12	-	0.12	0.16

Appendix 29e: Shrinkage data for Afina with RH of the various saturated salt solutions

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Longitudinal Shrinkage %					
AFN T1	0.20	0.09	0.14	-	0.18	0.19
AFN T2	0.18	0.10	0.18	-	0.23	0.26
AFN T3	0.16	0.07	0.04	-	0.09	0.12
AFN T4	0.22	0.06	0.16	-	0.18	0.21
AFN T5	0.21	0.12	0.13	-	0.15	0.16
AFN T6	0.29	0.19	0.19	-	0.27	0.30

Appendix 29e: Shrinkage data for Afina with RH of the various saturated salt solutions (continued)

Sample no	Longitudinal Shrinkage % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
AFN R1	0.13	0.03	0.10	-	0.13	0.14
AFN R2	0.11	0.06	0.15	-	0.16	0.20
AFN R3	0.10	0.02	0.12	-	0.18	0.28
AFN R4	0.21	0.15	0.20	-	0.24	0.25
AFN R5	0.11	0.05	0.17	-	0.22	0.24
AFN R6	0.27	0.18	0.27	-	0.27	0.27

Appendix 29f: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Afina Longitudinal Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.18	0.09	0.15	-	0.19	0.22
Std Dev	0.06	0.06	0.06	-	0.06	0.06
Minimum	0.10	0.02	0.04	-	0.09	0.12
Maximum	0.29	0.19	0.27	-	0.27	0.30
Count	12	12	12	-	12	12
95% C. L.	0.04	0.04	0.04	-	0.04	0.04

Appendix 30a: Shrinkage data for Ananta with RH of the various saturated salt solutions

Sample no	Ananta Tangential Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA T1	2.86	2.44	2.66	-	3.18	3.84
ANA T2	3.01	2.44	2.78	-	3.24	3.94
ANA T3	3.08	2.58	2.87	-	3.33	4.19
ANA T4	3.54	2.97	3.26	-	3.70	4.70
ANA T5	3.75	3.27	3.59	-	4.22	5.29
ANA T6	2.90	2.43	2.69	-	3.20	3.80

Appendix 30b: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Ananta Tangential Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.19	2.69	2.98	-	3.48	4.29
Std Dev	0.37	0.35	0.37	-	0.41	0.59
Minimum	2.86	2.43	2.66	-	3.18	3.80
Maximum	3.75	3.27	3.59	-	4.22	5.29
Count	6	6	6	-	6	6
95% C. L.	0.38	0.37	0.39	-	0.43	0.62

Appendix 30c Shrinkage data for Ananta with RH of the various saturated salt solutions

	Ananta Radial Shrinkage, %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA R1	3.57	3.05	3.25	-	3.78	5.01
ANA R2	2.96	2.96	2.72	-	3.22	4.25
ANA R3	3.06	2.60	2.85	-	3.35	4.67
ANA R4	2.98	2.45	2.45	-	3.11	4.12
ANA R5	2.74	2.36	2.63	-	3.23	4.38
ANA R6	2.34	1.68	1.90	-	2.26	3.04

Appendix 30d: Summary of basic statistics of the shrinkage of Wawabima with RH of the various saturated salt solutions

	Ananta Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	2.94	2.52	2.63	-	3.16	4.25
Std Dev	0.40	0.50	0.45	-	0.50	0.67
Minimum	2.34	1.68	1.90	-	2.26	3.04
Maximum	3.57	3.05	3.25	-	3.78	5.01
Count	6	6	6	-	6	6
95% C. L.	0.42	0.52	0.47	-	0.52	0.71

Appendix 30e: Shrinkage data for Ananta with RH of the various saturated salt solutions

Sample no	Longitudinal Shrinkage % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA T1	0.25	0.22	0.24	-	0.27	0.30
ANA T2	0.35	0.29	0.30	-	0.36	0.36
ANA T3	0.34	0.30	0.30	-	0.30	0.31
ANA T4	0.19	0.18	0.19	-	0.21	0.22
ANA T5	0.22	0.21	0.22	-	0.22	0.23
ANA T6	0.31	0.26	0.30	-	0.31	0.35

Sample no	Longitudinal Shrinkage % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA R1	0.24	0.21	0.22	-	0.26	0.26
ANA R2	0.16	0.11	0.13	-	0.16	0.16
ANA R3	0.20	0.19	0.19	-	0.24	0.27
ANA R4	0.30	0.28	0.28	-	0.32	0.37
ANA R5	0.18	0.16	0.18	-	0.18	0.20
ANA R6	0.22	0.11	0.15	-	0.22	0.39

Appendix 30f: Summary of basic statistics of the shrinkage of Ananta with RH of the various saturated salt solutions

	Ananta Longitudinal Shrinkage, % Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.25	0.21	0.22	-	0.25	0.29
Std Dev	0.06	0.07	0.06	-	0.06	0.07
Minimum	0.16	0.11	0.13	-	0.16	0.16
Maximum	0.35	0.30	0.30	-	0.36	0.39
Count	12	12	12	-	12	12
95% C. L.	0.04	0.04	0.04	-	0.04	0.05

Appendix 31a: Shrinkage data for Kaku with RH of the various saturated salt solutions

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Kaku Tangential Shrinkage, %					
KAK T1	4.75	3.99	4.26	-	4.93	6.25
KAK T2	4.77	4.13	4.38	-	5.12	6.76
KAK T3	4.48	3.90	4.16	-	4.85	6.24
KAK T4	4.86	4.15	4.48	-	5.18	5.18
KAK T5	4.86	4.21	4.59	-	5.20	5.20
KAK T6	4.73	4.13	4.36	-	5.02	6.42

Appendix 31b: Summary of basic statistics of the shrinkage of Kaku with RH of the various saturated salt solutions

	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Kaku Tangential Shrinkage, %					
Mean	4.74	4.08	4.37	-	5.05	6.01
Std Dev	0.14	0.12	0.15	-	0.14	0.66
Minimum	4.48	3.90	4.16	-	4.85	5.18
Maximum	4.86	4.21	4.59	-	5.20	6.76
Count	6	6	6	-	6	6
95% C. L.	0.15	0.12	0.16	-	0.15	0.70

Appendix 31c: Shrinkage data for Kaku with RH of the various saturated salt solutions

Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
	Kaku Radial Shrinkage, %					
KAK R1	3.31	2.73	3.13	-	3.69	4.76
KAK R2	3.61	2.91	3.26	-	3.92	4.98
KAK R3	3.36	2.76	3.02	-	3.54	4.64
KAK R4	4.00	3.34	3.58	-	4.13	5.42
KAK R5	3.24	2.74	2.98	-	3.50	4.52
KAK R6	4.52	3.97	4.38	-	4.72	6.35

Appendix 31d: Summary of basic statistics of the shrinkage of Kaku with RH of the various saturated salt solutions

	Kaku Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.67	3.08	3.39	-	3.92	5.11
Std Dev	0.50	0.50	0.53	-	0.46	0.69
Minimum	3.24	2.73	2.98	-	3.50	4.52
Maximum	4.52	3.97	4.38	-	4.72	6.35
Count	6	6	6	-	6	6
95% C. L.	0.52	0.52	0.56	-	0.49	0.72

Appendix 31e: Shrinkage data for Kaku with RH of the various saturated salt solutions

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK T1	0.20	0.16	0.16	-	0.20	0.22
KAK T2	0.19	0.17	0.18	-	0.22	0.23
KAK T3	0.21	0.15	0.16	-	0.23	0.25
KAK T4	0.19	0.17	0.17	-	0.21	0.24
KAK T5	0.14	0.06	0.12	-	0.16	0.16
KAK T6	0.16	0.09	0.13	-	0.17	0.18

	Longitudinal Shrinkage %					
Sample no	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK R1	0.28	0.26	0.27	-	0.32	0.33
KAK R2	0.12	0.11	0.12	-	0.17	0.17
KAK R3	0.19	0.16	0.16	-	0.20	0.21
KAK R4	0.22	0.19	0.21	-	0.21	0.25
KAK R5	0.16	0.15	0.16	-	0.20	0.21
KAK R6	0.21	0.16	0.17	-	0.20	0.20

Appendix 31f: Summary of basic statistics of the shrinkage of Kaku with RH of the various saturated salt solutions

	Kaku Radial Shrinkage, %					
	Initial (12.5)	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	3.67	3.08	3.39	-	3.92	5.11
Std Dev	0.50	0.50	0.53	-	0.46	0.69
Minimum	3.24	2.73	2.98	-	3.50	4.52
Maximum	4.52	3.97	4.38	-	4.72	6.35
Count	6	6	6	-	6	6
95% C. L.	0.52	0.52	0.56	-	0.49	0.72

Appendix 32a: Dimensional change data for Dahoma with RH of the various saturated solutions

Sample no.	Dahoma Tangential Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH T1	2.10	1.11	0.92	1.06	1.42
DAH T2	1.61	0.89	0.00	1.26	1.65
DAH T3	1.94	0.97	0.03	1.33	1.70
DAH T4	1.99	1.05	0.01	1.32	1.38
DAH T5	1.79	0.98	-0.03	0.91	1.24
DAH T6	2.18	0.97	0.02	1.30	1.11

Appendix 32b: Summary of basic statistics of the Dimensional Change of Dahoma with RH of the various saturated salt solutions

	Dahoma Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1.93	1.00	0.16	1.17	1.42
Std Dev	0.21	0.08	0.37	0.23	0.23
Minimum	1.61	0.89	-0.03	0.74	1.11
Maximum	2.18	1.11	0.92	1.33	1.70
Count	6	6	6	6	6.00
95% C. L.	0.22	0.08	0.39	0.25	0.24

Appendix 32c: Dimensional change data for Dahoma with RH of the various saturated solutions

Sample no.	Dahoma Radial Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAH R1	1.70	0.87	0.01	0.96	1.18
DAH R2	2.20	1.12	-0.28	0.87	1.82
DAH R3	2.29	0.99	-0.11	0.79	1.43
DAH R4	1.86	0.86	0.35	1.10	1.66
DAH R5	1.75	0.91	0.08	0.98	1.53
DAH R6	1.61	0.75	0.01	0.81	1.18

Appendix 32d: Summary of basic statistics of the Dimensional Change of Dahoma with RH of the various saturated salt solutions

	Dahoma Radial Dimensional Change %					
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1.90	0.92	0.01	0.92	1.47
Std Dev	0.28	0.13	0.21	0.12	0.26
Minimum	1.61	0.75	-0.28	0.79	1.18
Maximum	2.29	1.12	0.35	1.10	1.82
Count	6	6	6	6	6
95% C. L.	0.29	0.13	0.22	0.12	0.27

Appendix 33a: Dimensional change data for Kusia with RH of the various saturated solutions

Sample no.	Kusia Tangential Dimensional Change, %				
	LiCl (12)	$MgCl_2$(33)	K_2CO_3(43)	NaCl (76)	$CuSO_4$(98)
KUS T1	1.87	1.19	-0.13	0.54	1.66
KUS T2	1.91	1.08	-0.15	1.21	1.98
KUS T3	1.88	1.02	-0.08	0.57	1.41
KUS T4	1.94	1.05	-0.01	0.50	1.29
KUS T5	2.26	1.34	-0.10	0.66	1.69
KUS T6	2.15	1.20	-0.10	0.61	1.74

Appendix 33b: Summary of basic statistics of the Dimensional Change of Kusia with RH of the various saturated salt solutions

	Kusia Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	2.00	1.15	-0.10	0.68	1.63
Std Dev	0.16	0.12	0.05	0.26	0.25
Minimum	1.87	1.02	-0.15	0.50	1.29
Maximum	2.26	1.34	-0.01	1.21	1.98
Count	6.00	6.00	6	6.00	6.00
95% C. L.	0.17	0.13	0.05	0.28	0.26

Appendix 33c: Dimensional change data for Kusia with RH of the various saturated Solutions

Sample no.	Kusia Radial Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KUS R1	1.27	0.80	0.06	0.50	0.85
KUS R2	1.28	0.68	-0.04	0.32	0.88
KUS R3	1.33	0.69	-0.16	0.47	1.07
KUS R4	1.47	0.56	-0.02	0.55	0.77
KUS R5	1.13	0.79	-0.06	0.38	0.88
KUS R6	1.38	0.57	-0.10	0.42	0.82

Appendix 23d: Summary of basic statistics of the Dimensional Change of Kusia with RH of the various saturated salt solutions

	Kusia Radial Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1.31	0.68	-0.05	0.44	0.88
Std Dev	0.11	0.10	0.07	0.09	0.10
Minimum	1.13	0.56	-0.16	0.32	0.77
Maximum	1.47	0.80	0.06	0.55	1.07
Count	6	6	6	6	6
95% C. L.	0.12	0.11	0.08	0.09	0.11

Appendix 34a: Dimensional change data for Danta with RH of the various saturated solutions

Sample no.	Danta Radial Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN T1	0.73	0.64	-	0.45	0.83
DAN T2	0.74	0.58	-	0.71	0.94
DAN T3	0.63	0.46	-	0.63	0.82
DAN T4	0.85	0.59	-	0.71	0.90
DAN T5	0.83	0.57	-	0.68	0.95
DAN T6	0.62	0.48	-	0.66	1.04

Appendix 34b: Summary of basic statistics of the Dimensional Change of Danta with RH of the various saturated salt solutions

	Danta Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.73	0.55	-	0.64	0.91
Std Dev	0.10	0.07	-	0.10	0.08
Minimum	0.62	0.46	-	0.45	0.82
Maximum	0.85	0.64	-	0.71	1.04
Count	6	6	-	6	6
95% C. L.	0.10	0.08	-	0.10	0.08

Appendix 34c: Dimensional change data for Danta with RH of the various saturated solutions

Sample no.	Danta Radial Dimensional Change ,%				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
DAN R1	0.73	0.52	-	0.63	0.99
DAN R2	0.86	0.54	-	0.71	2.10
DAN R3	0.67	0.51	-	0.75	1.15
DAN R4	0.72	0.60	-	0.70	1.11
DAN R5	0.75	0.41	-	0.72	1.25
DAN R6	0.98	0.53	-	0.66	1.27

Appendix 35a: Dimensional change data for *Celtis mildbraedii* with RH of the various saturated solutions

Sample no.	*Celtis mildbraedii* Tangential Dimensional Change ,%				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEM T1	1.27	0.80	0.06	0.50	0.85
CEM T2	1.28	0.68	-0.04	0.32	0.88
CEM T3	1.33	0.69	-0.16	0.47	1.07
CEM T4	1.47	0.56	-0.02	0.55	0.77
CEM T5	1.13	0.79	-0.06	0.38	0.88
CEM T6	1.38	0.57	-0.10	0.42	0.82

Appendix 35b: Summary of basic statistics of the Dimensional Change of *Celtis mildbraedii* with RH of the various saturated salt solutions

	Celtis mildbraedii Tangential Dimensional Change %				
	$LiCl$ (12)	$MgCl_2$ (33)	K_2CO_3 (43)	$NaCl$ (76)	$CuSO_4$ (98)
Mean	1.41	0.78	-0.04	0.53	1.95
Std Dev	0.22	0.36	0.05	0.15	0.14
Minimum	1.10	0.12	-0.10	0.24	1.80
Maximum	1.70	1.21	0.04	0.66	2.10
Count	6	6	6	6	6
95% C. L.	0.23	0.38	0.05	0.16	0.14

Appendix 35c: Dimensional change data for *Celtis mildbraedii* with RH of the various saturated solutions

Sample no.	*Celtis mildbraedii* Radial Dimensional Change, %				
	$LiCl$ (12)	$MgCl_2$ (33)	K_2CO_3 (43)	$NaCl$ (76)	$CuSO_4$ (98)
CEM R1	1.05	0.73	-0.06	0.58	1.33
CEM R2	1.09	0.66	-0.08	0.42	1.15
CEM R3	1.17	0.78	-0.04	0.20	1.02
CEM R4	0.90	0.67	-0.11	0.36	0.87
CEM R5	1.03	0.60	-0.13	0.51	0.99
CEM R6	0.92	0.64	-0.12	0.42	0.92

Appendix 35d: Summary of basic statistics of the Dimensional Change of *Celtis mildbraedii* with RH of the various saturated salt solutions

	Celtis mildbraedii Radial Dimensional Change %				
	$LiCl$ (12)	$MgCl_2$ (33)	K_2CO_3 (43)	$NaCl$ (76)	$CuSO_4$ (98)
Mean	1.02	0.68	-0.09	0.42	1.05
Std Dev	0.10	0.06	0.04	0.13	0.17
Minimum	0.90	0.60	-0.13	0.20	0.87
Maximum	1.17	0.78	-0.04	0.58	1.33
Count	6	6	6	6	6
95% C. L.	0.11	0.07	0.04	0.14	0.18

Appendix 36a: Dimensional change data for *Celtis zenkeri* with RH of the various saturated solutions

Sample no.	*Celtis zenkeri* Tangential Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEZ T1	1.88	1.06	0.01	1.32	2.45
CEZ T2	1.38	1.02	0.06	0.98	2.20
CEZ T3	2.00	1.09	0.01	0.37	2.10
CEZ T4	1.51	0.96	-0.13	0.66	1.57
CEZ T5	1.85	1.03	-0.05	1.09	1.54
CEZ T6	1.66	1.09	-0.03	0.90	1.22

Appendix 36b: Summary of basic statistics of the Dimensional Change of *Celtis zenkeri* with RH of the various saturated salt solutions

	Celtis zenkeri Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1.71	1.04	-0.02	0.89	1.85
Std Dev	0.24	0.05	0.07	0.33	0.47
Minimum	1.38	0.96	-0.13	0.37	1.22
Maximum	2.00	1.09	0.06	1.32	2.45
Count	6	6	6	6	6
95% C. L.	0.25	0.05	0.07	0.35	0.49

Appendix 36c: Dimensional change data for *Celtis zenkeri* with RH of the various saturated solutions

Sample no.	*Celtis zenkeri* Radial Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
CEZ R1	1.81	1.01	0.12	0.66	1.42
CEZ R2	1.50	0.86	0.73	1.02	1.78
CEZ R3	1.62	0.94	0.03	0.75	1.21
CEZ R4	1.84	1.22	-0.12	0.88	1.50
CEZ R5	1.57	0.80	-0.03	0.70	1.30
CEZ R6	1.61	1.05	-0.24	0.81	1.32

Appendix 36d: Summary of basic statistics of the Dimensional Change of *Celtis zenkeri* with RH of the various saturated salt solutions

	Celtis zenkeri Radial Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	1.66	0.98	0.08	0.80	1.42
Std Dev	0.14	0.15	0.34	0.13	0.20
Minimum	1.50	0.80	-0.24	0.66	1.21
Maximum	1.84	1.22	0.73	1.02	1.78
Count	6	6	6	6	6
95% C. L.	0.14	0.16	0.36	0.14	0.21

Appendix 37a: Dimensional change data for Essia with RH of the various saturated solutions

Sample no.	Essia Tangential Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ESS T1	0.90	0.79	-	0.73	2.35
ESS T2	1.35	0.96	-	0.91	2.23
ESS T3	0.99	0	-	0.75	2.05
ESS T4	0.95	0.79	-	0.86	2.29
ESS T5	0.70	0.48	-	0.85	1.83
ESS T6	0.92	0.83	-	0.63	2.25

Appendix 37b: Summary of basic statistics of the Dimensional Change of Essia with RH of the various saturated salt solutions

	Essia Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.97	0.75	-	0.79	2.17
Std Dev	0.21	0.16	-	0.10	0.19
Minimum	0.70	0.48	-	0.63	1.83
Maximum	1.35	0.96	-	0.91	2.35
Count	6	6	-	6	6
95% C. L.	0.22	0.17	-	0.11	0.20

Appendix 37c: Dimensional change data for Essia with RH of the various saturated solutions

Sample no	Essia Radial Dimensional Change %				
	LiCl	$MgCl_2$	K_2CO_3	NaCl	$CuSO_4$
ESS R1	0.60	0.60	-	0.35	1.19
ESS R2	0.41	0.28	-	0.41	1.02
ESS R3	0.78	0.66	-	0.46	1.25
ESS R4	0.51	0.45	-	0.40	0.91
ESS R5	0.59	0.56	-	0.42	1.55
ESS R6	0.46	0.58	-	0.43	1.20

Appendix 37d: Summary of basic statistics of the Dimensional Change of Essia with RH of the various saturated salt solutions

	Essia Radial Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.56	0.52	-	0.41	1.19
Std Dev	0.13	0.14	-	0.04	0.22
Minimum	0.41	0.28	-	0.35	0.91
Maximum	0.78	0.66	-	0.46	1.55
Count	6	6	-	6	6
95% C. L.	0.14	0.14	-	0.04	0.23

Appendix 38a: Dimensional change data for Wawabima with RH of the various saturated solutions

Sample no.	Wawabima Tangential Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW T1	0.84	0.94	-	0.87	2.30
WAW T2	0.97	0.65	-	0.89	2.41
WAW T3	0.50	0.75	-	0.92	2.46
WAW T4	0.85	0.91	-	0.77	2.35
WAW T5	1.00	0.95	-	0.84	2.14
WAW T6	0.75	0.91	-	0.82	2.06

Appendix 38b: Summary of basic statistics of the Dimensional Change of Wawabima with RH of the various saturated salt solutions

	Wawabima Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.82	0.85	-	0.85	2.29
Std Dev	0.18	0.12	-	0.05	0.16
Minimum	0.50	0.65	-	0.77	2.06
Maximum	1.00	0.95	-	0.92	2.46
Count	6	6	-	6	6
95% C. L.	0.19	0.13	-	0.06	0.16

Appendix 38c: Dimensional change data for Wawabima with RH of the various saturated solutions

Sample no.	Wawabima Radial Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
WAW R1	0.43	0.58	-	0.59	1.47
WAW R2	0.63	0.54	-	0.53	1.46
WAW R3	0.75	0.43	-	0.51	1.36
WAW R4	0.64	0.58	-	0.49	1.06
WAW R5	0.73	0.74	-	0.56	1.69
WAW R6	0.58	0.47	-	0.37	1.49

Appendix 38d: Summary of basic statistics of the Dimensional Change of Wawabima with RH of the various saturated salt solutions

	Wawabima Radial Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.62	0.56	-	0.51	1.42
Std Dev	0.12	0.11	-	0.08	0.21
Minimum	0.43	0.43	-	0.37	1.06
Maximum	0.75	0.74	-	0.59	1.69
Count	6	6	-	6	6
95% C. L.	0.12	0.11	-	0.08	0.22

Appendix 39a: Dimensional change data for Afina with RH of the various saturated solutions

Sample no.	Afina Tangential Dimensional Change, %				
	$LiCl$ (12)	$MgCl_2$ (33)	K_2CO_3 (43)	$NaCl$ (76)	$CuSO_4$ (98)
AFN T1	0.91	0.62	-	1.43	2.36
AFN T2	1.05	0.58	-	0.77	1.08
AFN T3	1.01	0.60	-	0.78	1.23
AFN T4	0.97	0.80	-	0.76	1.37
AFN T5	0.98	0.64	-	0.75	1.43
AFN T6	0.70	0.62	-	0.79	1.35

Appendix 39b: Summary of basic statistics of the Dimensional Change of Afina with RH of the various saturated salt solutions

	Afina Tangential Dimensional Change %				
	$LiCl$ (12)	$MgCl_2$ (33)	K_2CO_3 (43)	$NaCl$ (76)	$CuSO_4$ (98)
Mean	0.94	0.64	-	0.88	1.47
Std Dev	0.12	0.08	-	0.27	0.46
Minimum	0.70	0.58	-	0.75	1.08
Maximum	1.05	0.80	-	1.43	2.36
Count	6	6	-	6	6
95% C. L.	0.13	0.08	-	0.28	0.48

Appendix 39c: Dimensional change data for Afina (Radial) with RH of the various saturated solutions

Sample no.	Afina Radial Dimensional Change, %				
	$LiCl$ (12)	$MgCl_2$ (33)	K_2CO_3 (43)	$NaCl$ (76)	$CuSO_4$ (98)
AFN R1	0.56	0.50	-	0.41	0.52
AFN R2	0.53	0.44	-	0.41	0.64
AFN R3	0.55	0.44	-	0.45	0.70
AFN R4	0.59	0.49	-	0.45	0.68
AFN R5	0.49	0.42	-	0.52	0.60
AFN R6	0.60	0.50	-	0.36	0.63

Appendix 39d: Summary of basic statistics of the Dimensional Change of Afina (Radial) with RH of the various saturated salt solutions

	Afina Radial Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.55	0.46	-	0.44	0.63
Std Dev	0.04	0.03	-	0.05	0.06
Minimum	0.49	0.42	-	0.36	0.52
Maximum	0.60	0.50	-	0.52	0.70
Count	6	6	-	6	6
95% C. L.	0.04	0.03	-	0.06	0.07

Appendix 40a: Dimensional change data for Ananta with RH of the various saturated solutions

Sample no.	Ananta Tangential Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA T1	0.43	0.22	-	0.54	0.67
ANA T2	0.59	0.35	-	0.82	1.54
ANA T3	0.52	0.31	-	0.47	0.89
ANA T4	0.59	0.30	-	0.45	1.04
ANA T5	0.50	0.33	-	0.66	1.12
ANA T6	0.49	0.27	-	0.52	0.62

Appendix 40b: Summary of basic statistics of the Dimensional Change of Ananta with RH of the various saturated salt solutions

	Ananta Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.52	0.30	-	0.58	0.98
Std Dev	0.06	0.05	-	0.14	0.34
Minimum	0.43	0.22	-	0.45	0.62
Maximum	0.59	0.35	-	0.82	1.54
Count	6	6	-	6	6
95% C. L.	0.06	0.05	-	0.15	0.35

Appendix 40c: Dimensional change data for Ananta with RH of the various saturated solutions

Sample no.	Ananta Radial Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
ANA R1	0.53	0.21	-	0.54	1.28
ANA R2	0.42	0.17	-	0.52	1.06
ANA R3	0.47	0.25	-	0.52	1.36
ANA R4	0.54	0.28	-	0.40	1.04
ANA R5	0.39	0.28	-	0.62	1.18
ANA R6	0.67	0.23	-	0.36	0.80

Appendix 40d: Summary of basic statistics of the Dimensional Change of Ananta with RH of the various saturated salt solutions

	Ananta Radial Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.51	0.24	-	0.49	1.12
Std Dev	0.10	0.04	-	0.10	0.20
Minimum	0.39	0.17	-	0.36	0.80
Maximum	0.67	0.28	-	0.62	1.36
Count	6	6	-	6	6
95% C. L.	0.11	0.05	-	0.10	0.21

Appendix 41a: Dimensional change data for Kaku with RH of the various saturated solutions

Sample no.	Kaku Tangential Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK T1	0.79	0.29	-	0.70	1.39
KAK T2	0.67	0.26	-	0.78	1.72
KAK T3	0.60	0.28	-	0.99	1.46
KAK T4	0.74	0.34	-	0.73	1.36
KAK T5	0.67	0.40	-	0.63	1.89
KAK T6	0.63	0.24	-	0.69	1.48

Appendix 41b: Summary of basic statistics of the Dimensional Change of Kaku with RH of the various saturated salt

	Kaku Tangential Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.69	0.30	-	0.75	1.55
Std Dev	0.07	0.06	-	0.12	0.21
Minimum	0.60	0.24	-	0.63	1.36
Maximum	0.79	0.40	-	0.99	1.89
Count	6	6	-	6	6
95% C. L.	0.07	0.06	-	0.13	0.22

Appendix 41c: Dimensional change data for Kaku with RH of the various saturated solutions

Sample no.	Kaku Radial Dimensional Change, %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
KAK R1	0.60	0.42	-	0.58	1.11
KAK R2	0.72	0.36	-	0.69	1.10
KAK R3	0.61	0.26	-	0.53	1.14
KAK R4	0.68	0.25	-	0.57	1.34
KAK R5	0.89	0.25	-	0.53	1.06
KAK R6	0.83	0.42	-	0.36	1.71

Appendix 41d: Summary of basic statistics of the Dimensional Change of Kaku with RH of the various saturated salt

	Kaku Radial Dimensional Change %				
	LiCl (12)	$MgCl_2$ (33)	K_2CO_3 (43)	NaCl (76)	$CuSO_4$ (98)
Mean	0.72	0.33	-	0.54	1.24
Std Dev	0.12	0.08	-	0.11	0.25
Minimum	0.60	0.25	-	0.36	1.06
Maximum	0.89	0.42	-	0.69	1.71
Count	6	6	-	6	6
95% C. L.	0.12	0.09	-	0.11	0.26

Appendix 42a: Dimensional Difference data for Dahoma with relative humidity of the various saturated salt solutions

Sample no.	Dahoma Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
DAH T1	1.12	0.93	1.90	3.36	0.76	2.21	1.44
DAH T2	0.90	0.74	1.96	3.67	1.05	2.75	1.68
DAH T3	0.98	0.86	2.13	3.89	1.14	2.88	1.73
DAH T4	1.07	0.85	2.14	3.57	1.06	2.48	1.40
DAH T5	0.99	0.96	1.73	2.60	0.74	1.60	0.85
DAH T6	0.98	1.00	2.26	3.41	1.27	2.40	1.12

Appendix 42b: Summary of basic statistics of the Dimensional Difference data for Dahoma with relative humidity of the various saturated salt solutions

	Dahoma Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	1.01	0.89	2.02	3.42	1.00	2.39	1.37
Std Dev	0.08	0.09	0.20	0.44	0.21	0.46	0.33
Minimum	0.90	0.74	1.73	2.60	0.74	1.60	0.85
Maximum	1.12	1.00	2.26	3.89	1.27	2.88	1.73
Count	6	6	6	6	6	6	6
C. L. 95%	0.08	0.10	0.20	0.47	0.22	0.48	0.35

Appendix 42c: Dimensional Difference data for Dahoma with relative humidity of the various saturated salt solutions

Sample no.	Dahoma Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
DAH R1	0.88	0.89	1.72	2.93	0.83	2.04	1.20
DAH R2	1.14	0.95	1.74	3.63	0.60	2.46	1.85
DAH R3	1.00	0.89	1.50	2.97	0.49	1.95	1.45
DAH R4	0.87	0.81	1.78	3.49	0.90	2.60	1.69
DAH R5	0.92	0.84	1.70	3.28	0.78	2.34	1.55
DAH R6	0.75	0.72	1.32	2.33	0.57	1.57	0.99

Appendix 42d: Summary of basic statistics of the Dimensional Difference data for Dahoma with relative humidity of the various saturated salt solutions

	Dahoma Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.93	0.85	1.63	3.11	0.69	2.16	1.46
Std Dev	0.13	0.08	0.18	0.47	0.17	0.38	0.32
Minimum	0.75	0.72	1.32	2.33	0.49	1.57	0.99
Maximum	1.14	0.95	1.78	3.63	0.90	2.60	1.85
Count	6	6	6	6	6	6	6
C. L. 95%	0.14	0.08	0.19	0.49	0.17	0.40	0.33

Appendix 43a: Dimensional Difference data for Kusia with relative humidity of the various saturated salt solutions

Sample no.	Kusia Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
KUS T1	1.21	1.08	1.67	3.39	0.46	2.16	1.69
KUS T2	1.09	0.94	2.16	4.23	1.06	3.10	2.02
KUS T3	1.03	0.94	1.52	2.98	0.49	1.93	1.44
KUS T4	1.06	1.05	1.55	2.87	0.49	1.80	1.30
KUS T5	1.36	1.19	1.86	3.61	0.56	2.29	1.72
KUS T6	1.20	1.01	1.62	3.42	0.41	2.18	1.77

Appendix 43b: Summary of basic statistics of the Dimensional Difference data for Kusia with relative humidity of the various saturated salt solutions

	Kusia Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	1.16	1.03	1.73	3.42	0.58	2.24	1.66
Std Dev	0.12	0.09	0.24	0.49	0.24	0.46	0.26
Minimum	1.03	0.94	1.52	2.87	0.41	1.80	1.30
Maximum	1.36	1.19	2.16	4.23	1.06	3.10	2.02
Count	6	6	6	6	6	6	6
C. L. 95%	0.13	0.10	0.25	0.51	0.25	0.48	0.27

Appendix 43c: Dimensional Difference data for Kusia with relative humidity of the various saturated salt solutions

Sample no.	Kusia Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
KUS R1	0.81	0.72	1.22	2.10	0.41	1.28	0.86
KUS R2	0.69	0.63	0.95	1.85	0.26	1.15	0.89
KUS R3	0.70	0.54	1.02	2.11	0.32	1.40	1.08
KUS R4	0.57	0.54	1.10	1.88	0.53	1.31	0.77
KUS R5	0.79	0.73	1.02	1.91	0.22	1.11	0.89
KUS R6	0.58	0.48	0.90	1.73	0.32	1.15	0.82

Appendix 43d: Summary of basic statistics of the Dimensional Difference data for Kusia with relative humidity of the various saturated salt solutions

	Kusia Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.69	0.61	1.03	1.93	0.34	1.23	0.89
Std Dev	0.10	0.10	0.12	0.15	0.11	0.11	0.11
Minimum	0.57	0.48	0.90	1.73	0.22	1.11	0.77
Maximum	0.81	0.73	1.22	2.11	0.53	1.40	1.08
Count	6	6	6	6	6	6	6
95% C. L.	0.11	0.11	0.12	0.16	0.12	0.12	0.11

Appendix 44a: Dimensional Difference data for Danta with relative humidity of the various saturated salt solutions

Sample no.	Danta Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
DAN T1	0.65	-	1.10	1.95	0.45	1.30	0.84
DAN T2	0.58	-	1.30	2.26	0.71	1.67	0.95
DAN T3	0.46	-	1.15	1.98	0.69	1.52	0.89
DAN T4	0.59	-	1.31	2.23	0.71	1.63	0.91
DAN T5	0.58	-	1.32	2.29	0.74	1.70	0.96
DAN T6	0.48	-	1.04	2.09	0.55	1.61	1.05

Appendix 44b: Summary of basic statistics of the Dimensional Difference data for Danta with relative humidity of the various saturated salt solutions

	Danta Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.56	-	1.20	2.13	0.64	1.57	0.93
Std Dev	0.07	-	0.12	0.15	0.11	0.15	0.07
Minimum	0.46	-	1.04	1.95	0.45	1.30	0.84
Maximum	0.65	-	1.32	2.29	0.74	1.70	1.05
Count	6	-	6	6	6	6	6
95% C. L.	0.08	-	0.13	0.15	0.12	0.16	0.07

Appendix 44c: Dimensional Difference data for Danta with relative humidity of the various saturated salt solutions

Sample no.	Danta Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
DAN R1	0.52	-	1.16	2.17	0.63	1.64	1.00
DAN R2	0.49	-	1.20	2.14	0.71	1.64	0.93
DAN R3	0.51	-	1.26	2.45	0.75	1.93	1.17
DAN R4	0.60	-	1.32	2.46	0.71	1.84	1.13
DAN R5	0.41	-	1.14	2.43	0.73	2.01	1.27
DAN R6	0.53	-	1.20	2.50	0.66	1.95	1.28

Appendix 44d: Summary of basic statistics of the Dimensional Difference data for Danta with relative humidity of the various saturated salt solutions

	Danta Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.51	-	1.21	2.36	0.70	1.84	1.13
Std Dev	0.06	-	0.07	0.16	0.04	0.16	0.14
Minimum	0.41	-	1.14	2.14	0.63	1.64	0.93
Maximum	0.60	-	1.32	2.50	0.75	2.01	1.28
Count	6	-	6	6	6	6	6
95% C. L.	0.07	-	0.07	0.17	0.05	0.17	0.15

Appendix 45a: Dimensional Difference data for *Celtis mildbraedii* with relative humidity of the various saturated salt solutions

Sample no.	*Celtis mildbraedii* Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
CEM T1	0.96	0.88	1.42	3.56	0.45	2.57	2.11
CEM T2	1.22	1.24	1.82	3.96	0.59	2.71	2.11
CEM T3	0.78	0.77	1.34	3.20	0.56	2.40	1.83
CEM T4	0.95	0.89	1.56	3.50	0.60	2.53	1.92
CEM T5	0.77	0.55	0.79	2.95	0.02	2.17	2.14
CEM T6	0.91	0.80	1.46	3.34	0.54	2.41	1.85

Appendix 45b: Summary of basic statistics of the Dimensional Difference data for *Celtis mildbraedii* with relative humidity of the various saturated salt solutions

	Celtis mildbraedii Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.93	0.86	1.40	3.42	0.46	2.46	1.99
Std Dev	0.16	0.23	0.34	0.35	0.22	0.19	0.14
Minimum	0.77	0.55	0.79	2.95	0.02	2.17	1.83
Maximum	1.22	1.24	1.82	3.96	0.60	2.71	2.14
Count	6	6	6	6	6	6	6
95% C. L.	0.17	0.24	0.36	0.36	0.23	0.19	0.15

Appendix 45c: Dimensional Difference data for *Celtis mildbraedii* with relative humidity of the various saturated salt solutions

Sample no.	*Celtis mildbraedii* Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
CEM R1	0.74	0.68	1.26	2.63	0.52	1.88	1.35
CEM R2	0.66	0.58	1.01	2.18	0.34	1.51	1.17
CEM R3	0.78	0.74	0.95	1.98	0.16	1.19	1.03
CEM R4	0.68	0.57	0.93	1.82	0.25	1.13	0.88
CEM R5	0.61	0.47	0.99	2.00	0.38	1.39	1.00
CEM R6	0.65	0.53	0.95	1.89	0.30	1.23	0.93

Appendix 45d: Summary of basic statistics of the Dimensional Difference data for *Celtis mildbraedii* with relative humidity of the various saturated salt solutions

	Celtis mildbraedii Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.69	0.59	1.01	2.08	0.33	1.39	1.06
Std Dev	0.06	0.10	0.13	0.29	0.12	0.28	0.17
Minimum	0.61	0.47	0.93	1.82	0.16	1.13	0.88
Maximum	0.78	0.74	1.26	2.63	0.52	1.88	1.35
Count	6	6	6	6	6	6	6
95% C. L.	0.07	0.10	0.13	0.31	0.13	0.29	0.18

Appendix 46a: Dimensional Difference data for *Celtis zenkeri* with relative humidity of the various saturated salt solutions

Sample no.	*Celtis zenkeri* Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
CEZ T 1	1.07	1.08	2.36	4.93	1.27	3.82	2.51
CEZ T 2	1.03	0.94	1.87	3.83	0.83	2.77	2.25
CEZ T 3	1.10	0.92	1.23	3.40	0.13	2.28	2.14
CEZ T 4	0.97	0.75	1.37	2.99	0.40	2.00	1.60
CEZ T 5	1.04	0.98	1.93	3.52	0.88	2.46	1.56
CEZ T 6	1.11	1.08	1.91	3.17	0.80	2.05	1.24

Appendix 46b: Summary of ~~basic~~ statistics of the Dimensional Difference data for *Celtis zenkeri* with relative humidity of the various saturated salt solutions

	Celtis zenkeri Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	1.05	0.96	1.78	3.64	0.72	2.56	1.88
Std Dev	0.05	0.12	0.41	0.69	0.40	0.68	0.49
Minimum	0.97	0.75	1.23	2.99	0.13	2.00	1.24
Maximum	1.11	1.08	2.36	4.93	1.27	3.82	2.51
Count	6	6	6	6	6	6	6
C. L. 95%	0.05	0.13	0.43	0.73	0.42	0.71	0.51

Appendix 46c: Dimensional Difference data for *Celtis zenkeri* with relative humidity of the various saturated salt solutions

Sample no.	*Celtis zenkeri* Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
CEZ R 1	1.02	1.14	1.55	3.01	0.52	1.98	1.44
CEZ R 2	0.87	0.73	1.72	3.56	0.85	2.67	1.81
CEZ R 3	0.95	0.98	2.70	3.95	0.72	1.95	1.22
CEZ R 4	1.23	1.11	1.75	3.30	0.51	2.04	1.52
CEZ R 5	0.78	0.77	1.27	2.41	0.49	1.61	1.12
CEZ R 6	1.05	0.81	1.55	2.90	0.49	1.83	1.33

Appendix 46d: Summary of basic statistics of the Dimensional Difference data for *Celtis zenkeri* with relative humidity of the various saturated salt solutions

	Celtis zenkeri Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.98	0.92	1.76	3.19	0.60	2.01	1.41
Std Dev	0.16	0.18	0.49	0.54	0.15	0.36	0.24
Minimum	0.78	0.73	1.27	2.41	0.49	1.61	1.12
Maximum	1.23	1.14	2.70	3.95	0.85	2.67	1.81
Count	6	6	6	6	6	6	6
C. L. 95%	0.17	0.19	0.52	0.56	0.16	0.38	0.26

Appendix 47a: Dimensional Difference data for Essia with relative humidity of the various saturated salt solutions

Sample no.	Essia Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
ESS T1	0.80	0.90	1.65	4.09	0.84	3.27	2.40
ESS T2	0.97	1.15	2.07	4.41	1.10	3.41	2.28
ESS T3	0.67	1.03	1.80	3.93	1.12	3.24	2.10
ESS T4	0.80	0.94	1.82	4.20	1.01	3.38	2.34
ESS T5	0.48	0.63	1.49	3.38	1.01	2.89	1.86
ESS T6	0.84	1.16	1.80	4.15	0.96	3.28	2.30

Appendix 47b: Summary of basic statistics of the Dimensional Difference data for Essia with relative humidity of the various saturated salt solutions

	Essia Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.76	0.97	1.77	4.03	1.01	3.24	2.22
Std Dev	0.17	0.20	0.19	0.35	0.10	0.18	0.20
Minimum	0.48	0.63	1.49	3.38	0.84	2.89	1.86
Maximum	0.97	1.16	2.07	4.41	1.12	3.41	2.40
Count	6	6	6	6	6	6	6
95% C. L.	0.18	0.21	0.20	0.37	0.11	0.19	0.21

Appendix 47c: Dimensional Difference data for Essia with relative humidity of the various saturated salt solutions

Sample no.	Essia Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
ESS R1	0.60	0.69	1.04	2.26	0.44	1.65	1.21
ESS R2	0.28	0.44	0.85	1.89	0.57	1.60	1.03
ESS R3	0.66	0.86	1.32	2.61	0.66	1.93	1.27
ESS R4	0.46	0.59	0.99	1.92	0.53	1.46	0.92
ESS R5	0.51	0.66	1.08	2.67	0.56	2.14	1.57
ESS R6	0.58	0.67	1.11	2.34	0.53	1.75	1.22

Appendix 47d: Summary of basic statistics of the Dimensional Difference data for Essia with relative humidity of the various saturated salt solutions

	Essia Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.51	0.65	1.07	2.28	0.55	1.76	1.20
Std Dev	0.14	0.14	0.16	0.33	0.07	0.25	0.22
Minimum	0.28	0.44	0.85	1.89	0.44	1.46	0.92
Maximum	0.66	0.86	1.32	2.67	0.66	2.14	1.57
Count	6	6	6	6	6	6	6
95% C. L.	0.14	0.14	0.16	0.35	0.07	0.26	0.24

Appendix 48a: Dimensional Difference data for Wawabima with relative humidity of the various saturated salt solutions

Sample no.	Wawabima Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
WAW T1	0.95	1.12	2.01	4.41	1.05	3.43	2.35
WAW T2	0.66	0.93	1.83	4.35	1.16	3.67	2.47
WAW T3	0.76	0.94	1.88	4.44	1.11	3.66	2.52
WAW T4	0.92	1.05	1.83	4.28	0.91	3.34	2.41
WAW T5	0.96	1.02	1.87	4.11	0.91	3.12	2.19
WAW T6	0.91	1.00	1.83	3.97	0.91	3.02	2.10

Appendix 48b: Summary of basic statistics of the Dimensional Difference data for Wawabima with relative humidity of the various saturated salt solutions

	Wawabima Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.86	1.01	1.88	4.26	1.01	3.37	2.34
Std Dev	0.12	0.07	0.07	0.19	0.12	0.27	0.16
Minimum	0.66	0.93	1.83	3.97	0.91	3.02	2.10
Maximum	0.96	1.12	2.01	4.44	1.16	3.67	2.52
Count	6	6	6	6	6	6	6
95% C. L.	0.13	0.08	0.07	0.20	0.12	0.28	0.17

Appendix 48c: Dimensional Difference data for Wawabima with relative humidity of the various saturated salt solutions

Sample no.	Wawabima Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
WAW R1	0.58	0.74	1.35	2.85	0.76	2.26	1.49
WAW R2	0.54	0.76	1.30	2.80	0.75	2.25	1.48
WAW R3	0.44	0.73	1.25	2.65	0.81	2.20	1.38
WAW R4	0.58	0.75	1.25	2.34	0.67	1.75	1.07
WAW R5	0.74	0.83	1.39	3.14	0.65	2.38	1.72
WAW R6	0.47	0.67	1.05	2.57	0.58	2.09	1.55

Appendix 48d: Summary of basic statistics of the Dimensional Difference data for Wawabima with relative humidity of the various saturated salt solutions

	Wawabima Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.56	0.75	1.26	2.72	0.70	2.15	1.45
Std Dev	0.11	0.05	0.12	0.27	0.09	0.22	0.22
Minimum	0.44	0.67	1.05	2.34	0.58	1.75	1.07
Maximum	0.74	0.83	1.39	3.14	0.81	2.38	1.72
Count	6	6	6	6	6	6	6
95% C. L.	0.11	0.05	0.13	0.29	0.09	0.23	0.23

Appendix 49a: Dimensional Difference data for Afina with relative humidity of the various saturated salt solutions

Sample no.	Afina Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
AFN T1	0.62	-	1.45	2.42	0.82	1.79	0.96
AFN T2	0.58	-	1.36	2.47	0.78	1.87	1.09
AFN T3	0.60	-	1.39	2.65	0.79	2.04	1.24
AFN T4	0.81	-	1.58	2.99	0.77	2.17	1.39
AFN T5	0.65	-	1.41	2.88	0.76	2.22	1.45
AFN T6	0.62	-	1.42	2.81	0.79	2.18	1.37

Appendix 49b: Summary of basic statistics of the Dimensional Difference data for Afina with relative humidity of the various saturated salt solutions

	Afina Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.65	-	1.44	2.71	0.78	2.04	1.25
Std Dev	0.08	-	0.08	0.23	0.02	0.18	0.19
Minimum	0.58	-	1.36	2.42	0.76	1.79	0.96
Maximum	0.81	-	1.58	2.99	0.82	2.22	1.45
Count	6	-	6	6	6	6	6
95% C. L.	0.09	-	0.08	0.24	0.02	0.19	0.20

Appendix 49c: Dimensional Difference data for Afina with relative humidity of the various saturated salt solutions

Sample no.	Afina Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
AFN R1	0.50	-	0.92	1.45	0.41	0.94	0.88
AFN R2	0.44	-	0.85	1.51	0.42	1.06	0.65
AFN R3	0.45	-	0.90	1.61	0.45	1.16	0.70
AFN R4	0.49	-	0.95	1.64	0.46	1.14	0.68
AFN R5	0.43	-	0.95	1.56	0.53	1.13	0.60
AFN R6	0.50	-	0.87	1.51	0.37	1.01	0.64

Appendix 49d: Summary of basic statistics of the Dimensional Difference data for Afina with relative humidity of the various saturated salt solutions

	Afina Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensiona l Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.47	-	0.91	1.55	0.44	1.07	0.69
Std Dev	0.03	-	0.04	0.07	0.05	0.09	0.10
Minimum	0.43	-	0.85	1.45	0.37	0.94	0.60
Maximum	0.50	-	0.95	1.64	0.53	1.16	0.88
Count	6	-	6	6	6	6	6
95% C. L.	0.03	-	0.04	0.08	0.06	0.09	0.10

Appendix 50a: Dimensional Difference data for Ananta with relative humidity of the various saturated salt solutions

Sample no.	Ananta Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
ANA T1	0.22	-	0.77	1.45	0.54	1.22	0.68
ANA T2	0.35	-	0.83	1.56	0.47	1.21	0.73
ANA T3	0.31	-	0.78	1.68	0.47	1.37	0.90
ANA T4	0.30	-	0.76	1.82	0.46	1.51	1.05
ANA T5	0.34	-	1.00	2.14	0.66	1.80	1.13
ANA T6	0.28	-	0.80	1.43	0.52	1.15	0.63

Appendix 50b: Summary of basic statistics of the Dimensional Difference data for Kaku with relative humidity of the various saturated salt solutions

	Ananta Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.30	-	0.82	1.68	0.52	1.38	0.85
Std Dev	0.05	-	0.09	0.27	0.08	0.24	0.21
Minimum	0.22	-	0.76	1.43	0.46	1.15	0.63
Maximum	0.35	-	1.00	2.14	0.66	1.80	1.13
Count	6	-	6	6	6	6	6
95% C. L.	0.05	-	0.09	0.28	0.08	0.26	0.22

Appendix 50c: Dimensional Difference data for Ananta with relative humidity of the various saturated salt solutions

Sample no.	Ananta Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
ANA R1	0.21	-	0.75	2.06	0.55	1.85	1.30
ANA R2	0.17	-	0.70	1.78	0.53	1.61	1.07
ANA R3	0.25	-	0.78	2.17	0.53	1.91	1.38
ANA R4	0.28	-	0.69	1.74	0.40	1.46	1.05
ANA R5	0.28	-	0.91	2.12	0.62	1.83	1.20
ANA R6	0.23	-	0.60	1.40	0.36	1.17	0.80

Appendix 50d: Summary of basic statistics of the Dimensional Difference data for Ananta with relative humidity of the various saturated salt solutions

	Ananta Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.24	-	0.74	1.88	0.50	1.64	1.13
Std Dev	0.04	-	0.10	0.29	0.10	0.29	0.21
Minimum	0.17	-	0.60	1.40	0.36	1.17	0.80
Maximum	0.28	-	0.91	2.17	0.62	1.91	1.38
Count	6	-	6	6	6	6	6
95% C. L.	0.05	-	0.11	0.31	0.10	0.30	0.22

Appendix 51a: Dimensional Difference data for Kaku with relative humidity of the various saturated salt solutions

Sample no.	Kaku Tangential Dimensional Difference from LiCl (12%) to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
KAK T1	0.29	-	0.99	2.42	0.70	2.12	1.41
KAK T2	0.26	-	1.05	2.82	0.79	2.56	1.75
KAK T3	0.28	-	1.00	2.49	0.72	2.21	1.48
KAK T4	0.34	-	1.08	2.48	0.74	2.13	1.38
KAK T5	0.40	-	1.04	2.98	0.64	2.57	1.93
KAK T6	0.25	-	0.94	2.45	0.69	2.20	1.50

Appendix 51b: Summary of basic statistics of the Dimensional Difference data for Kaku with relative humidity of the various saturated salt solutions

	Kaku Tangential Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.30	-	1.02	2.61	0.71	2.30	1.58
Std Dev	0.06	-	0.05	0.24	0.05	0.21	0.22
Minimum	0.25	-	0.94	2.42	0.64	2.12	1.38
Maximum	0.40	-	1.08	2.98	0.79	2.57	1.93
Count	6	-	6	6	6	6	6
95% C. L.	0.06	-	0.05	0.25	0.05	0.22	0.23

Appendix 51c: Dimensional Difference data for Kaku with relative humidity of the various saturated salt solutions

Sample no.	Kaku Radial Dimensional Difference from LiCl (12%) to				Dimensional Difference from MgCl2 (33%) to		Dimensional Difference from NaCl (76%) to
	33%	43%	76%	98%	76%	98%	98%
KAK R1	0.42	-	1.00	2.13	0.58	1.71	1.12
KAK R2	0.36	-	1.06	2.18	0.69	1.81	1.11
KAK R3	0.26	-	0.80	1.96	0.54	1.70	1.16
KAK R4	0.25	-	0.82	2.19	0.57	1.94	1.36
KAK R5	0.26	-	0.79	1.87	0.53	1.61	1.07
KAK R6	0.43	-	0.79	2.54	0.36	2.11	1.74

Appendix 51d: Summary of basic statistics of the Dimensional Difference data for Kaku with relative humidity of the various saturated salt solutions

	Kaku Radial Dimensional Difference from 12% to				Dimensional Difference from 33% to		Dimensional Difference from 76% to
	33%	43%	76%	98%	76%	98%	98%
Mean	0.33	-	0.88	2.15	0.55	1.81	1.26
Std Dev	0.08	-	0.12	0.23	0.11	0.18	0.26
Minimum	0.25	-	0.79	1.87	0.36	1.61	1.07
Maximum	0.43	-	1.06	2.54	0.69	2.11	1.74
Count	6	-	6	6	6	6	6
95% C. L.	0.09	-	0.13	0.24	0.11	0.19	0.27