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(71) Applicant: **ANHEUSER-BUSCH INBEV S.A.** [BE/BE]; Grand Place 1, 1000 Brussels (BE).

(72) Inventors: **BUJA, Federico**; Brouwerijplein 1, 3000 Leuven (BE). **THOMPSON, Keenan**; Brouwerijplein 1, 3000 Leuven (BE). **MERISALO, Jarno-Petteri**; Brouwerijplein 1, 3000 Leuven (BE).

(74) Agent: **GORDON, Kirsteen**; Marks & Clerk LLP, 15 Fetter Lane, London EC4A 1BW (GB).

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(54) Title: PACKAGING FROM AGRICULTURAL PLANT FIBRES

(57) Abstract: A composition for making paperboard or paper comprising agricultural plant fibres and paperboard, paper and packaging made therefrom.

PACKAGING FROM AGRICULTURAL PLANT FIBRES

FIELD OF THE INVENTION

The present invention is directed to compositions, in particular pulp compositions, comprising agricultural plant fibres and recycled wood fibres. The present invention is also directed to methods of making these compositions, paperboard or paper comprising or obtained from these compositions, the use of these compositions in making paperboard, paper or packaging, and packaging comprising or prepared from the compositions of the present invention.

BACKGROUND

Pulp and paperboard/paper production based on wood fibre is a highly resource intensive and polluting industry. The vast majority of pulp for paperboard/paper making is prepared from a combination of both softwood and hardwood fibres, which can be virgin fibres or recycled fibres. Fibres originating from woodlands and tree plantations have a devastating impact on the environment in various ways, such as a loss of biodiversity and biomass above and below ground biota (which is one of Earth's main CO_2 sinks), soil erosion, floods and climate change. Also, the processing of turning wood into virgin fibers has an additional negative impact on CO_2 emissions because roughly 80% of the CO_2 stored in trees ends up being released in the waste stream and consumption of wood (e.g., burning of wood, production of paper or other products).

Besides wood fibre, the primary inputs into the paperboard and paper making process are water, energy and chemicals. The energy cost of paperboard and paper production represents 10-40% of total manufacturing cost and is an important factor influencing profitability of a mill operation. Manufacturing pulp and paperboard/paper requires a substantial amount of water since it is used in all major process stages. The benchmark for water usage within pulp and mills ranges between 64,352 and 113,562 liters/ton of paperboard/paper. Within the pulping process, most methods use sulfur and chlorine compounds to increase pulp quality and yield, resulting in NOx and SOx emissions such as dimethyl sulfide (DMS), dimethyl disulfide (DMDS), and methyl mercaptan. Aside from odor nuisance in the mills and surroundings, oxidized sulphur contributes to the large-scale acidification of soil, which negatively affects vegetation and biodiversity. Although

methods to control chemical balance are applied, many modern mills still have difficulties controlling sulfidity.

Meanwhile, alternative, non-wood fibres from agricultural sources can deliver fibres of suitable quality for the production of paperboard and paper. Barley is one of the four main ingredients in beer, along with water, yeast and hops. Wheat is also commonly used in beer production. However, only the grains of the barley and wheat plants are used in the brewing process. After the barley or wheat is harvested, there is an abundance of straw leftover as a by-product or co-product, which has a high fibre content. Making use of the straw fibres creates value from a by-product/co-product which is often left to decay, burnt, or sold as low value animal bedding. These straw fibres have been shown to be suitable for pulp and paper production (see, for example, WO 99/18285 A1). However, the resulting paper often does not have the physical and mechanical properties (such as tensile strength and tear strength) needed for secondary packaging such as packaging for beer bottles or cans, which requires the package to carry relatively high weight and where liquid from condensation or spillages can affect the integrity of the packaging.

In view of the above, there is a need in the art for compositions derived from alternative raw materials for use in making paperboard, paper and packaging in order to reduce the environmental impact of production. There is also a need for paperboard and paper derived from alternative raw materials that has improved physical and mechanical properties. Additionally, many alternative fibres are not able to withstand the high pressure, temperature and intensive mechanical processing used for processing wood fibres to make paperboard or paper. Accordingly, methods of producing paperboard and paper from alternative raw materials that have reduced water and energy consumption and reduced use of chemicals are needed.

SUMMARY OF THE INVENTION

In a first aspect, the present invention is directed to composition, preferably a pulp composition comprising:

a first component comprising agricultural plant fibres; and,

a second component comprising recycled wood fibres.

In a second aspect, the present invention is directed to a method of making a composition of the present invention, comprising the step of: mixing a first component comprising agricultural plant fibres and a second component comprising recycled wood fibres.

In a third aspect, the present invention is directed to paperboard or paper comprising the composition of the present invention.

In a fourth aspect, the present invention is directed to paperboard or paper prepared from the composition of the present invention.

In a fifth aspect, the present invention is directed to use of a composition as defined herein in the manufacture of paperboard, paper or packaging.

In a sixth aspect, the present invention is directed to a method of preparing paperboard, paper or packaging comprising:

(i) mixing a composition as defined in any one of claims 1 to 15 and/or in any one of claims 1 to 19 with an alkaline agent and applying heat,
(ii) removing lignin, optionally by sieving;
(iii) washing to produce a pulp;
(iv) mixing the pulp with water to make a pulp slurry;
(v) distributing the pulp slurry onto a moving continuous screen;
(vi) draining water from the pulp slurry;
(vii) pressing and drying the pulp slurry to make paperboard or paper; and
(viii) rolling the paperboard or paper into rolls.

In a seventh aspect, the present invention is directed to packaging comprising the composition of the present invention.

In an eighth aspect, the present invention is directed to packaging prepared from the composition of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Definitions

Agricultural plant fibres: Agricultural plants include all non-wood plants, such as cereal plants. Agricultural plant fibres may be from or derived from any part of the non-wood plant, such as the stem, bark or skin, leaves or fruit. Preferably the fibres are derived from the stem or stalk, which may be known as straw.

Recycled wood fibres: Recycled wood fibres are non-virgin wood fibres. Recycled wood fibres are divided into a number of grades depending on the origin of the wood fibres and their relative contents. Recycled paper grades are defined by, for example, the Confederation of European Paper Industries' (Cepi) EN 643 standard.

Group 1 according to EN 643 (Ordinary Grades) includes, corrugated paper and board wastes, Old Corrugated Containers (OCC) and Unsold Magazines. Corrugated paper and board wastes may contain used paper and board packaging that may be made up of a minimum of 80% of corrugated board, the rest being other paper and board products. Old Corrugated Containers (OCC) may comprise used boxes and sheets of corrugated board of various qualities and 10% of other packaging papers and boards. OCC may alternatively comprise used boxes and sheets of corrugated board of various qualities and 5% of other packaging papers and boards. Group 2 according to EN 643 (Medium Grades) includes, for example, unsold newspapers, sorted office paper and white wood-free books. Group 3 according to EN 643 (High Grades) includes, for example, wood-free binders, white wood-free letters, white heavily printed multiply board, and white woodfree shavings. Group 4 according to EN 643 (Kraft Grades) includes, for example, unused corrugated material, used/unused kraft sacks with polycoated papers. Group 5 according to EN 643 (Special Grades) includes, for example, mixed recovered paper and board, liquid board packaging, and labels.

Softwood fibres: Softwood fibres are virgin wood fibres and may comprise any softwood fibres known in the art, for example fibres from pine, spruce and/or coniferous trees.

Hardwood fibres: Hardwood fibres are virgin wood fibres and may comprise any hardwood fibres known in the art, for example, fibres from aspen, birch and/or eucalyptus trees.

Paperboard: Paperboard refers to a paper-based material that comprise fibres from sources such as agricultural plants and wood. Typically, paperboard is thicker than paper. Paperboard includes but is not limited to material such as card, cardboard, folding boxboard, carton board, folding carton, containerboard and linerboard. Generally, paperboard has a grammage above 250 g/m^2.

Paper: Paper refers to material that comprises fibres from sources such as agricultural plants and wood. Generally, paper has a grammage below 250 g/m^2.

Fibre dimensions: Various fibre dimensions are recited herein, e.g. fibre length, fibre width. Wherever such dimensions are given, the values recited are average values. Preferably the values relate to dry fibres.

As used herein, weight percentages (wt%) are based on the total weight of the composition, unless otherwise specified.

The compositions of the present invention

Most paperboard or paper is a mixture of hardwood and softwood fibres, each giving different characteristics. Agricultural plant stalk fibres from, for example, barley and wheat have physical characteristics that fall between hardwood and softwood and are superior to recycled wood fibre. Other advantageous characteristics of pulps made from agricultural plant fibres, in particular cereal plant fibres, especially barley & wheat, include:

- A longer fibre length than hardwood pulps. The fibres of the compositions of the present invention additionally have a higher length:diameter ratio compared to hardwood and softwood fibres. These characteristics improve the tensile strength, breaking strain and fracture toughness of the dry paperboard and paper and are especially important for wet web strength.
- Lower fibre coarseness (fiber mass per unit length) compared to other non-wood pulps. This property is usually employed for characterization of the fibre cross section. A low coarseness means there are more fibers per unit mass of pulp and a higher number of bonds per unit fiber length at a given sheet density.

- Lower lignin content. Lignin is removed during the pulping process and cereal plant fibres allow lower lignin contents to be achieved.

The present invention uses these advantageous properties in its compositions for the production of high-quality paperboard and paper.

In addition to the above, most available pulping processes tend to reduce the fibre length. The agricultural plant fibres (e.g. cereal fibres) present in the compositions of the invention typically have a longer fibre length than those produced in conventional pulping processes. Preferably the agricultural plants fibres (e.g. cereal fibres) are prepared in a pulping process that uses milder conditions to preserve fibre length. This ensures the pulp quality is high, and leads to improved mechanical performance and durability of the end product.

In one aspect, the present invention is directed to a composition, preferably a pulp composition, for making paperboard or paper comprising:

a first component comprising agricultural plant fibres; and,

a second component comprising recycled wood fibres.

The agricultural plant from which the fibres are derived may be, for example, one or more selected from the group consisting of barley, wheat, rye, rice, sorghum, millet, corn, hemp, flax, bagasse, cotton, bamboo, sisal, sabai, jute, ramie and reed.

Preferably the agricultural plant is a cereal plant. The cereal plant may be any of those known to the skilled person and may be, for example, one or more selected from the group consisting of barley, wheat, rye, rice, sorghum, millet, and corn. Preferably, the cereal plant may be one or more selected from the group consisting of barley, wheat, and rice, more preferably barley or wheat, especially barley. Preferably, the cereal plant fibres comprise cereal plant stalk fibres, which may also be known as straw fibres.

The recycled wood fibres may be one or more selected from the group consisting of recycled softwood fibres, and recycled hardwood fibres.

The composition of the present invention can accommodate the presence of significant amounts of recycled fibres, without compromising the mechanical performance of its end products, due to the presence of the agricultural plant fibres, in particular cereal plant fibres, and especially barely or wheat fibres.

Optionally the composition further comprises virgin wood fibres. The compositions of the present invention may comprise virgin wood fibres in an amount of 0% to 30% by weight, more preferably 5% to 20% by weight, and still more preferably 5% to 10% by weight, based on the total weight of the composition. It is generally preferred to minimize the amount of virgin wood fibres present. Hence particularly preferred compositions of the invention are substantially free of virgin wood fibres, e.g. they comprise less than 5%, and more preferably less than 3% and still more preferably 0% by weight of virgin wood fibres, based on the total weight of the composition.

Recycled wood fibres present in the compositions of the present invention may be from Group 1, 2, 3 or 4, according to EN 643. Preferably the recycled wood fibres are from Group 1. For example the recycled wood fibres may be from Group 1.04 (supermarket corrugated paper and board), i.e. used paper and board packaging containing a minimum of 70% corrugated board, the rest being solid board and wrapping papers. The recycled wood fibres may also be from Group 1.05 (old corrugated containers), i.e. used boxes and sheets of corrugated board of various qualities. Preferred recycled wood fibres comprise (e.g. consist of) old corrugated container (OCC) fibres.

Recycled wood fibres present in the compositions of the present invention have a length between 0.1 mm and 3 mm, preferably from 1 mm to 2 mm, for example 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, or 2 mm.

Particularly preferred recycled wood fibres comprise (e.g. consist of) old corrugated container (OCC) fibres. The length of the OCC fibres may be between 0.1 mm and 3 mm, preferably from 1 mm to 2 mm, for example 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, or 2 mm.

The compositions of the present invention may comprise agricultural plant fibres in any amount. Preferably, compositions of the present invention may comprise agricultural

plant fibres in an amount of up to 95% by weight based on the total weight of the composition, preferably up to 75%, preferably up to 50%, preferably from 5% to 45% by weight based on the total weight of the composition, more preferably 10% to 30% by weight based on the total weight of the composition, for example, 10, 12, 14, 16, 18, 20, 22, 24, 25, 26, 28 or 30% by weight based on the total weight of the composition. The second component may be present in an amount such that the total amount of the first and second components adds up to 100%. Preferably, compositions of the present invention may comprise wood fibres, preferably recycled wood fibres, in an amount of at least 5% by weight based on the total weight of the composition, preferably at least 25%, preferably at least 50%, preferably from 55% to 95% by weight based on the total weight of the composition, more preferably 70% to 90% by weight based on the total weight of the composition.

In a particular embodiment, the composition comprises:

a first component comprising barley fibres or wheat fibres, in an amount of from 10 to 30% by weight based on the total weight of the composition; and,

a second component comprising old corrugated container (OCC) fibres in an amount of from 70 to 90% by weight based on the total weight of the composition.

In this embodiment, the ratio of the first component to the second component may be from 1:10 to 1.5:1 by weight, preferably from 1:5 to 1:2 by weight. Additionally, the barley or wheat fibres may have an average fibre length of from 0.8 to 1.1 mm, an average fibre width of from 8 to 18 μm, and the composition may have a lignin content of 8% to 14% by weight. The present inventors have discovered that this embodiment has ideal mechanical properties for use in paperboard for secondary or tertiary packaging, such as folding cartons for baskets.

A ratio of the first component to the second component may be from 1:15 to 2:1 by weight, preferably from 1:10 to 1.5:1 by weight, for example, 1:9, 1:8, 1:7, 1:6, 1:5, 1:4, 1:3, 1:2 or 1.5:1 by weight. In preferred compositions, wherein the first component comprises barley or wheat fibres and the second component comprises recycled wood fibres such as OCC, the ratio of the first component to the second component may be from 1:9 to 1:4 by weight. In other preferred compositions wherein the first component comprises barley or wheat fibres and the second component comprises recycled wood

fibres such as OCC, the ratio of the first component to the second component may be from 1:10 to 1.5:1, preferably from 1:5 to 1:2 by weight. The present inventors have discovered that including barley or wheat straw in these amounts significantly improves the strength of the paperboard or paper, in particular when recycled fibres are used. In these compositions, the barley or wheat fibres preferably have an average fibre length of from 0.8 to 1.1 mm, an average fibre width of from 8 to 18 µm, and the composition has a lignin content of 8% to 14% by weight.

The average length of the agricultural plant fibres is preferably at least 0.5 mm, preferably from 0.5 to 5 mm, more preferably from 0.6 to 2 mm, more preferably 0.8 to 1.1 mm, for example, 0.8, 0.9, 1.0, or 1.1 mm. The average length of the agricultural plant fibres may also be from 0.5 mm to 1 mm, for example 0.5, 0.6, 0.7, 0.8, 0.9, or 1 mm.

The average width or average diameter of the agricultural plant fibres is preferably from 5 to 30 µm, preferably from 8 to 18 µm, for example, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, or 18 µm.

The ratio of the average length to the average width of the agricultural plant fibres is preferably from 50:1 to 500:1, preferably from 60:1 to 200:1, more preferably from 75:1 to 150:1, more preferably from 100:1 to 120:1, for example, 100:1, 105:1, 110:1, 115:1, or 120:1.

The coarseness of the agricultural plant fibres is preferably less than 1 mg/m, preferably less than 0.9 mg/m, more preferably less than 0.1 mg/m.

The α-cellulose of the agricultural plant fibres is not particularly limited and the agricultural plant fibres may comprise α-cellulose in an amount of from 15 to 40% by weight, preferably from 19 to 35% by weight, more preferably 31 to 34% by weight, for example 31, 32, 33, 34% by weight.

The amount of lignin in the agricultural plant fibres is not particularly limited and the agricultural plant fibres may comprise lignin in an amount less than 20% by weight, preferably from 1 to 15% by weight, more preferably 5 to 15% by weight, for example, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15% by weight.

In particularly preferred compositions of the present invention, the first component may comprise barley fibres or wheat fibres; and, the second component comprises recycled wood fibres. In compositions in which the first component comprises barley or wheat fibres; and, the second component comprises recycled fibres such as OCC, the barley or wheat fibres may be present in an amount of up to 50% by weight based on the total weight of the composition, preferably from 10 to 30%. The present inventors have discovered that including barley or wheat straw in these amounts significantly improves the strength of the paperboard or paper when recycled fibres are used. In these compositions, the barley or wheat fibres preferably have an average fibre length of from 0.8 to 1.1 mm, an average fibre width of from 8 to 18 μm, and the composition has a lignin content of 8% to 14% by weight.

The compositions of the present invention may further comprise water, e.g. to bring the total weight of the composition to 100 wt%. The water content of the composition may depend on the papermaking process in which it is used. For example, the water content of the composition may up to 96% by weight, preferably from 75% to 96%, particularly at the wet end of the papermaking machine. The water content of a dried composition may be up to 25% by weight, more preferably from 4% to 20%, more preferably from 7% to 15%.

The compositions of the present invention may further comprise additives that those skilled in the art of papermaking may include in compositions for making paperboard and paper. Examples of suitable additives include sizing agents such as alkyl ketene dimers (AKD), alum, albietic acid, and/or alkenyl succinic anhydride (ASA); silicas; pigments and dyes such as titanium dioxide zinc oxide and/or casein; non-ionic, cationic or anionic retention aids; adhesives; acidity regulators such as calcium carbonate; bleaches; fillers such as barium sulfate; binders; and, bonding agents such as carboxymethyl cellulose. Preferably the total amount of additives present in the composition is 0.1 to 20 wt%, more preferably 0.2 to 10 wt%, and more preferably 0.5 to 5 wt%.

In a further aspect, the present invention is directed to a method of making a composition as described above, comprising the steps of: mixing a first component comprising

agricultural plant fibres, and a second component comprising recycled wood fibres. Mixing may be achieved by any conventional method known in the art.

In a further aspect, the present invention is directed to a paperboard or paper prepared from the compositions as described above.

In a further aspect, the present invention is directed to paperboard or paper comprising the compositions as described above.

The paperboard or paper of the present invention may be obtained from the compositions of the present invention using conventional methodology. The paperboard or paper of the present invention may be derived from the compositions of the present invention. Generally speaking, the paperboard or paper is obtained or derived from the compositions of the invention by conventional methodology, which comprises removal of water (and other solvents) present in the, e.g. pulp composition.

The grammage of the paperboard or paper of the present invention is preferably at least 90 g/m^2, preferably from 100 to 800 g/m^2, preferably from 250 to 450 g/m^2, preferably from 310 to 450 g/m^2, more preferably from 310 to 390 g/m^2, for example, 310, 320, 330, 340, 350, 360, 370, 380, or 390.

The thickness of the paperboard or paper of the present invention is preferably from 200 to 1200 µm, preferably from 300 to 1000 µm, preferably 400 µm to 700 µm, preferably from 400 µm to 550 µm, for example 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, or 550 µm, preferably from 450 µm to 550 µm, more preferably from 450 µm to 500 µm, for example, 450, 460, 470, 480, 490, or 500 µm.

The paperboard or paper of the present invention may have at least one, preferably two, and still more preferably all, of the following properties:

Tensile strength (MD) dry of at least 15 kN/m, preferably from 20 to 50 kN/m, more preferably 30 to 40 kN/m for example 30, 35, or 40 kN/m;

Tensile strength (CD) dry of at least 7 kN/m, preferably at least 8 kN/m, preferably 10 to 20 kN/m, for example 10, 12, 14, 16, 18, or 20 kN/m;

Tear strength (MD) dry of 2,500 to 10,000 Nm, preferably 3,000 to 7,000 Nm, more preferably 3,500 to 4,500 Nm; and/or

Tear strength (CD) dry of 3,000 to 12,000 Nm, preferably from 4,000 to 7,000 Nm.

The paperboard or paper of the present invention may have at least one, preferably two, and still more preferably all, of the following properties:

Tensile strength (MD) wet of at least 5 kN/m, preferably from 5 to 30 kN/m, more preferably from 15 to 25 kN/m for example 15, 20, or 25 kN/m;

Tensile strength (CD) wet of at least 4 kN/m, preferably 6 to 20 kN/m, more preferably 7 to 15 kN/m for example 7, 8, 9, 10, 11, 12, 13, 14, or 15 kN/m;

Tear strength (MD) wet of 1,000 to 10,000 Nm, preferably 2,500 to 7,000 Nm, more preferably 3,000 to 6000 Nm; and/or

Tear strength (CD) wet of 1,000 to 7,500 Nm, preferably from 4,000 to 7,000 Nm.

The water absorbancy of the paperboard or paper may be up to 50 g/m^2 measured according to the COBB 60 method, optionally 0.5 to 40 g/m^2, optionally 20 to 35 g/m^2.

In a further aspect, the present invention is directed to a method of preparing paperboard, paper or packaging comprising:

(i) mixing a composition as defined in any one of claims 1 to 15 and/or in any one of claims 1 to 19 with an alkaline agent and applying heat,
(ii) removing lignin, optionally by sieving;
(iii) washing to produce a pulp;
(iv) mixing the pulp with water to make a pulp slurry and optionally adding additives;
(v) distributing the pulp slurry onto a moving continuous screen;
(vi) draining water from the pulp slurry;
(vii) pressing and drying the pulp slurry to make paperboard or paper; and
(viii) rolling the paperboard or paper into rolls.

Optionally the paperboard or paper is folded to make packaging. Accordingly, the packaging may comprise or be prepared from the paperboard or paper described hereinabove.

In a further aspect, the present invention is directed to use of a composition as described above in the manufacture of paperboard, paper or packaging.

In a further aspect, the present invention is directed to packaging comprising the composition as described above.

In a further aspect, the present invention is directed to packaging prepared from the composition according to any one of the preceding claims.

The packaging of the present invention can be any type of packaging but is preferably primary, secondary, or tertiary packaging. Preferably the packaging is secondary or tertiary packaging suitable for beverage containers, such as regular slotted containers, crates, folding cartons for (including but not limited to) baskets, wraparound packages, neck-through wraparound packages, cluster wraparound packages, open and closed baskets, trays, fully enclosed packs, fridge packs, suitcases, top clusters, rings, clips, top clips, moulded fibre, sleeves, fibre hi-cones, or box partitions. Preferably the packaging is folding cartons for baskets.

EXAMPLES

The present invention will now be further exemplified with reference to the following examples. The present invention is in no way limited to the given examples.

Methods of measurement

The following methods were used to measure the parameters described in Table 1.

Fibre coarseness – measured according to ISO 9184-6:1994.

Paperboard Grammage - measured according to ISO 536/TAPPI 410.

Paperboard Thickness – measured according to ISO 186/TAPPI 400.

Paperboard Water absorption (Cobb60) – measured according to ISO 535/TAPPI 441.

Paperboard Tensile strength Machine Direction (MD) and Cross Direction (CD) Dry – measured according to ISO 1924/TAPPI 494.

Paperboard Tensile strength Machine Direction (MD) and Cross Direction (CD) Wet – measured according to ISO 1924/TAPPI 494 with 1 minute immersion.

Paperboard Tear strength Machine Direction (MD) and Cross Direction (CD) Dry – measured according to ISO 1974/TAPPI 414.

Paperboard Tear strength Machine Direction (MD) and Cross Direction (CD) Wet – measured according to ISO 1974/TAPPI 414 with 3 minutes immersion.

Pulp preparation

The compositions of the Examples were prepared by combining barley straw fibres or wheat straw fibres with either recycled wood fibres (OCC) or softwood fibres in the amounts recited in row 2 of Table 1 below. These compositions were processed into a

pulp by combining the raw materials in a digester under alkaline conditions with heat applied depending on the raw materials used. Lignin was removed in the process to separate the fibres with minimal mechanical action. The pulp was then washed to remove residual chemicals.

Paperboard preparation

The paperboard of the Examples was made by refining the pulp and mixing it with water and other additives (including alkyl ketene dimer (AKD) or alkenyl succinic anhydride (ASA)) to make a pulp slurry. The head-box of the paperboard machine (Fourdrinier mill or cylinder mill) distributed the slurry onto a moving continuous screen, drained water from the slurry, passed the wet paperboard sheet through presses and driers, and rolled the paperboard into rolls. Coatings such as wax or a clay-based coating were applied if needed.

Table 1 presents data on the physical parameters of paperboard made using the compositions of the present invention (see Example 1 to 7). These data demonstrate that the paperboard of the present invention performs at least as well as a commercial paperboard made entirely from virgin wood fibres (Reference Example 1), with the additional advantage that it is at least partially, if not entirely, made from recycled or waste material. The paperboard of the present invention is ideal for use in secondary packaging such as packaging for beer bottles or cans, which requires the package to carry relatively high weight and where liquid from condensation or spillages can affect the integrity of the packaging.

Performance testing

Folded baskets for carrying beverage containers were prepared from paperboard by methods known in the art involving die-cutting the paperboard, folding it to the desired shape and gluing.

Dynamic performance testing

Ten randomly-selected baskets were tested to determine handle strength by repeatedly "dropping" a basket held by a grasping device a defined distance (at least 38 mm at an acceleration of 5G). The number of "drops" before the package tears or breaks is counted. Dry conditions indicate that the package has been conditioned for 24 hours at 23°C and 50% relative humidity prior to testing. Wet conditions indicate that the basket

is soaked under a 25 mm head of tap water at 23°C for 3 minutes prior to testing in addition to the conditioning indicated for the dry conditions. Tropical conditions indicate that the basket was conditioned at 38°C and 90% relative humidity prior to testing.

Static performance testing

The strength of ten randomly-selected baskets was measured by pulling the handle of the basket, which is held by a grasping device, at 100 mm/minute until the basket tears or breaks. The maximum pulling force to the nearest 0.1 N is recorded. In order to pass the test, the maximum pulling force must be no less than 3x the weight of the basket. Dry conditions indicate that the package was conditioned for 24 hours at 23°C and 50% relative humidity prior to testing. Wet conditions indicate that the basket is soaked under a 25 mm head of tap water at 23°C for 3 minutes prior to testing in addition to the conditioning indicated for the dry conditions. Tropical conditions indicate that the basket was conditioned at 38°C and 90% relative humidity prior to testing.

TABLE 1	Ref Ex 1	Ref Ex 2	Ref Ex 3	Ref Ex 4	Ref Ex 5	Ref Ex 6	Ex 1	Ex 2	Ex 3	Ex 4	Ex 5	Ex 6	Ex 7
	100% virgin wood fibres	100% Softwood	25% barley + 75% Softwood	50% barley + 50% softwood	100% OCC	100% OCC	10% Barley + 90% OCC	20% Barley + 80%OCC	30% Barley + 70% OCC	20% wheat + 80% OCC	20% wheat + 80% OCC + Mid-level coating & Wax	20% wheat + 80% OCC	20% wheat + 80% OCC
Additive	N/A	AKD	AKD	AKD	AKD	AKD	AKD	AKD	AKD	ASA	ASA	AKD	AKD
Fibre type	Virgin wood fibres	Virgin wood fibres	Virgin wood + barley straw fibres	Virgin wood + barley straw fibres	OCC fibres	OCC fibres	OCC + barley straw fibres	OCC + barley straw fibres	OCC + barley straw fibres	OCC + wheat straw fibres	OCC + wheat straw fibres	OCC + wheat straw fibres	OCC + wheat straw fibres
Grammage (g/m^2)	359	327	399	350	353	393	348	348	358	360	384	396	352
Caliper (mil)	23.1	16	19.9	17.5	18.4	20	18.3	17.7	17.6	24	24	19.3	17.4
Thickness (µm)	600	399	505.0	480.0	467.9	500.1	465.0	450.0	447.0	477.2	485.3	497.5	441.1
COBB60 (g/m^2) - Inside	30	30	37.0	49.0	21.2	36	22.6	21.9	22.3	25.1	0.8	30	29
Tensile strength MD Dry (kN/m)	22.9	39.0	32.4	38.5	36.3	17.5	35.7	35.5	35.7	24.5	24.1	17.5	16.0
Tensile strength MD Wet (kN/m)	12.1	25.8	15.6	21.9	20.5	6.5	21.4	21.5	21.2	9.4	19.1	7.1	5.5
Tensile strength CD Dry (kN/m)	12.4	12.9	12.9	11.9	10.8	8.7	10.7	10.5	10.6	14.24	15.43	8.9	7.5
Tensile strength CD Wet (kN/m)	7.0	9.0	6.6	6.8	7.2	3.6	7.5	6.9	7.2	5.8	10.7	3.8	3.1
Tear strength MD Dry (Nm)	7239	8472	6252	6122	3532	3495	3738	3744	3667	4098	4246	3392	2625

Tear strength MD Wet (Nm)	3702	7598	5688	5675	4007	2134	4158	3910	4097	3714	4593	2263	1865
Tear strength CD Dry (Nm)	6338	8232	6726	6858	4779	3925	4980	4745	5174	5055	4814	3774	3002
Tear strength CD Wet (Nm)	3855	8319	5688	7130	4709	2384	4929	4795	4839	3957	5063	2484	2015

Table 2

Testing Finished Baskets	Conditions	Example 7		Example 6		Reference Example 6	
		350 gsm		400 gsm		400 gsm	
		Min.	Avg.	Min.	Avg.	Min.	Avg.
Dynamic (# of drops)	Dry	>200	>200	>200	>200	>200	>200
	Wet	35	68	77	126	61	156
	Tropical	88	186	>200	>200	>200	>200
Static (X* pack weight)	Dry	5.3	5.6	6.2	6.7	5.3	6
	Wet	3.4	3.9	4.1	4.7	3.9	4.3
	Tropical	3.8	4.2	4.6	4.9	4.5	4.9

CLAIMS:

1. A composition, preferably a pulp composition, comprising:
a first component comprising agricultural plant fibres; and,
a second component comprising recycled wood fibres.

2. The composition according to claim 1, wherein the agricultural plant fibres are cereal plant fibres.

3. The composition according to claim 2, wherein the cereal plant is one or more selected from the group consisting of barley, wheat, rye, rice, sorghum, millet, and corn, preferably wherein the cereal plant is barley or wheat.

4. The composition according to any one of the preceding claims, wherein the recycled wood fibres are one or more selected from the group consisting of recycled softwood fibres and recycled hardwood fibres.

5. The composition according to any one of the preceding claims, wherein the recycled wood fibres comprise old corrugated container (OCC) fibres.

6. The composition according to any one of the preceding claims comprising agricultural plant fibres in an amount of up to 50% by weight based on the total weight of the composition, preferably from 5% to 45% by weight based on the total weight of the composition, more preferably 10% to 30% by weight based on the total weight of the composition.

7. The composition according to any one of the preceding claims, wherein a ratio of the first component to the second component is from 1:15 to 2:1 by weight, preferably from 1:10 to 1.5:1 by weight.

8. The composition according to any one of the preceding claims, wherein the average length of the agricultural plant fibres is at least 0.5 mm, preferably from 0.5 to 5 mm, more preferably from 0.6 to 2 mm, more preferably 0.8 to 1.1 mm.

9. The composition according to any one of the preceding claims, wherein the average width of the agricultural plant fibres is from 5 to 30 µm, preferably from 8 to 18 µm.

10. The composition according to any one of the preceding claims, wherein a ratio of the length to the width of the agricultural plant fibres is from 50:1 to 200:1, preferably from 75:1 to 150:1, more preferably from 100:1 to 120:1

11. The composition according to any one of the preceding claims, wherein the coarseness of the agricultural plant fibres is less than 1 mg/m, preferably less than 0.9 mg/m, more preferably less than 0.1 mg/m.

12. The composition according to any one of the preceding claims, wherein the agricultural plant fibres comprise α-cellulose in an amount of from 15 to 40% by weight, preferably from 19 to 35% by weight, more preferably 31 to 34% by weight.

13. The composition according to any one of the preceding claims, wherein the agricultural plant fibres comprise lignin in an amount less than 20% by weight, preferably from 5 to 15% by weight.

14. The composition according to any one of the preceding claims, wherein the first component comprises (e.g. consists of) barley fibres or wheat fibres; and, the second component comprises recycled wood fibres, and wherein the barley or wheat fibres are present in an amount of from 10 to 30% by weight based on the total weight of the composition.

15. The composition according to any one of the preceding claims, wherein:

the first component comprises barley fibres or wheat fibres, in an amount of from 10 to 30% by weight based on the total weight of the composition; and,

the second component comprises old corrugated container (OCC) fibres in an amount of from 70 to 90% by weight based on the total weight of the composition.

16. The composition according to claim 15, wherein the ratio of the first component to the second component may be from 1:10 to 1.5:1 by weight, preferably from 1:5 to 1:2 by weight.

17. The composition according to claim 15 or 16, wherein the barley or wheat fibres have an average fibre length of from 0.8 to 1.1 mm, an average fibre width of from 8 to 18 µm, and the composition has a lignin content of 8% to 14% by weight.

18. The composition according to any one of the preceding claims wherein the agricultural plant fibres are straw fibres.

19. The composition according to any one of the preceding claims, further comprising one or more additives, preferably wherein the additive is selected from the group consisting of: sizing agents such as alkyl ketene dimers (AKD), alum, albietic acid, and/or alkenyl succinic anhydride (ASA); silicas; pigments and dyes such as titanium dioxide zinc oxide and/or casein; non-ionic, cationic or anionic retention aids; adhesives; acidity regulators such as calcium carbonate; bleaches; fillers such as barium sulfate; binders; and, bonding agents such as carboxymethyl cellulose.

20. A method of making a composition as claimed in any one of claims 1 to 19, comprising the step of: mixing a first component comprising agricultural plant fibres and a second component comprising recycled wood fibres.

21. Paperboard or paper comprising the composition according to any one of claims 1 to 19.

22. Paperboard or paper prepared from the composition according to any one of claims 1 to 19.

23. Paperboard or paper as claimed in claim 21 or 22, which has a grammage of at least 90 g/m^2, preferably from 100 to 800 g/m^2, preferably from 250 to 450 g/m^2, more preferably from 310 to 450 g/m^2, more preferably from 310 to 390 g/m^2; and/or, a thickness of from 400 µm to 700 µm, preferably from 400 µm to 550 µm, preferably from 450 µm to 550 µm, more preferably from 450 µm to 500 µm.

24. Paperboard or paper as claimed in any one of claims 21 to 23, which has at least one, preferably two, and still more preferably all, of the following properties:

Tensile strength (MD) dry of at least 15 kN/m, preferably from 20 to 50 kN/m, more preferably 30 to 40 kN/m;

Tensile strength (CD) dry of at least 7 kN/m, preferably at least 8 kN/m, preferably 10 to 20 kN/m;

Tear strength (MD) dry of 2,500 to 10,000 Nm, preferably 3,000 to 7,000 Nm, more preferably 3,500 to 4,500 Nm; and/or

Tear strength (CD) dry of 3,000 to 12,000 Nm, preferably from 4,000 to 7,000 Nm.

25. Use of a composition as defined in any one of claims 1 to 19 in the manufacture of paperboard, paper or packaging.

26. A method of preparing paperboard, paper or packaging comprising:

(i) mixing a composition as defined in any one of claims 1 to 19 with an alkaline agent and applying heat,

(ii) removing lignin, optionally by sieving;

(iii) washing to produce a pulp;

(iv) mixing the pulp with water to make a pulp slurry;

(v) distributing the pulp slurry onto a moving continuous screen;

(vi) draining water from the pulp slurry;

(vii) pressing and drying the pulp slurry to make paperboard or paper; and

(viii) rolling the paperboard or paper into rolls.

27. Packaging comprising the composition according to any one of claims 1 to 19.

28. Packaging prepared from the composition according to any one of claims 1 to 19.

29. Packaging comprising the paperboard or paper according to any one of claims 21 to 24.

30. Packaging prepared from the paperboard or paper according to any one of claims 21 to 24.

31. Packaging as claimed in any one of claims 27 to 30, which is packaging for beverage containers, preferably folding cartons for baskets, wraparound packages, neck-through wraparound packages, cluster wraparound packages, open and closed baskets, trays, fully enclosed packs, fridge packs, suitcases, top clusters, rings, clips, top clips, moulded fibre, sleeves, fibre hi-cones, or box partitions, more preferably folding cartons for baskets or folding cartons for wraparound packages.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/056953

A. CLASSIFICATION OF SUBJECT MATTER
INV. D21H11/12 D21H11/14 D21C3/02 D21C1/06 D21C5/02
D21H27/10 D21H15/00
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
D21H D21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Román Gutiérrez Alma Delia Delia ET AL: "Reuse of Barley Straw for Handmade Paper Production", , 11 March 2021 (2021-03-11), XP093054574, DOI: 10.20944/preprints202103.0307.v1 Retrieved from the Internet: URL:https://www.preprints.org/manuscript/202103.0307/v1 [retrieved on 2023-06-14] figure 1; tables 1, 3 paragraphs [02.2], [03.5], [0003], [03.1], [0001] abstract	1-4, 6-25, 27-31

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[x] Further documents are listed in the continuation of Box C.
[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Billet, Aina

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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Aguilar-Rivera Noé: "Sustainable Sugarcane Bagasse Cellulose for Papermaking" In: "Advanced Engineering Materials and Modeling", 12 August 2016 (2016-08-12), John Wiley & Sons, Inc., Hoboken, NJ, USA, XP093013058, ISBN: 978-1-119-24246-8 pages 121-163, DOI: 10.1002/9781119242567.ch4, Retrieved from the Internet: URL:http://api.wiley.com/onlinelibrary/tdm/v1/articles/10.1002%2F9781119242567.ch4> paragraph [02.4]; table 1 paragraphs [0003], [03.5]; figure 2 paragraph [02.2]; table 3 -----	1,4,5, 20-22, 24-31
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