

TISSUE PAPER MATERIAL AND TISSUE PAPER PRODUCT

TECHNICAL FIELD

The present disclosure relates to a single-ply tissue paper material, to a single-ply tissue
5 paper product, and to a multi-ply tissue paper product, comprising at least one non-wood
tissue ply comprising non-wood cellulose pulp fibres.

BACKGROUND

Tissue paper materials find extensive use in modern society. Toilet paper, and paper
10 towels such as hand towels or household (kitchen) towels, facial tissues, tissue
handkerchiefs, napkins, and industrial wipes are staple items of commerce. These
products are typically made from papermaking pulp comprising wood fibres, such as
hardwood and softwood fibres.

15 In the following, a "tissue paper product" relates to an absorbent paper product based on
cellulose wadding which is also called tissue paper material or tissue paper base-sheet in
this field of technology.

Tissue paper material is defined as a soft absorbent paper material having a low basis
weight, of for example 8 to 45 g/m², preferably 10 to 35 g/m² per ply. The total basis
20 weight of multi-ply tissue paper products may preferably be up to a maximum of 110 g/m²,
more preferably to a maximum of 80 g/m². Its density is typically below 0.6 g/cm³,
preferably below 0.30 g/cm³ and more preferably in the range of 0.02 g/cm³ and
0.20 g/cm³. The production of tissue paper material is distinguished from conventional
paper production, e.g. printing paper production, by its relatively low basis weight and
25 relatively high tensile energy absorption index (see ISO 12625-4). Conventional paper
and tissue paper also differ in general with regard to the modulus of elasticity that
characterises the stress/strain properties of these generally planar products as a material
parameter.

The fibres contained in the tissue paper are mainly cellulosic fibres, such as pulp fibres
30 from chemical pulp (e.g. Kraft or sulphite), or mechanical pulp (e.g. ground wood, thermo
mechanical pulp, chemo-mechanical pulp and/or chemo- thermo-mechanical pulp
/CTMP). Pulps derived from both deciduous (hardwood) and coniferous (softwood) can be

used. Fibres may also come from non-wood plants e.g. cereal, bamboo, jute, or sisal. The fibres or a portion of the fibres may be recycled fibres, which may belong to any or all of the above categories. The fibres can be treated with additives, e.g. fillers, softeners, such as, but not limited to, quaternary ammonium compounds and binders, conventional dry-
5 strength agents, temporary wet strength agents or wet-strength agents, in order to facilitate the original paper making or to adjust the properties thereof.

Tissue paper products in particular for use as hygiene- or wiping products primarily include all kinds of tissue paper materials including dry-creped tissue paper material, wet-creped tissue paper material, NTT (flat), TAD-paper material (Through Air Drying), tissue
10 paper material based on structured or textured technologies such as ATMOS, NTT (textured), UCTAD, eTAD, QRT, PrimeLineTEX etc. and cellulose or pulp-wadding, or combinations, laminates or mixtures thereof. Typical properties of these hygiene- and wiping products include the ability to absorb tensile stress energy, their drapability, good textile-like flexibility, properties which are frequently referred to as bulk softness, a high
15 surface softness and a high specific volume with a perceptible thickness. A liquid absorbency as high as possible and, depending on the application, a suitable wet and dry strength as well as an appealing visual appearance of the outer product's surfaces are desired. These properties, among others, allow these hygiene and wiping products to be used, for example, as cleaning wipes such as windscreen cleaning wipes, industrial
20 wipes, kitchen paper or the like; as sanitary products such as for example bathroom tissue, handkerchiefs, household towels, towels and the like; as cosmetic wipes such as for example facials and as serviettes or napkins, just to mention some of the products that can be used. Furthermore, the hygiene- and wiping products can be dry, moist, wet, printed or pre-treated in any manner. In addition, the hygiene- and wiping products may
25 be folded, interleaved or individually placed, stacked or rolled, connected or not, in any suitable manner.

The products described above can be used for personal and household use as well as commercial and industrial use. They are adapted to absorb fluids, remove dust, and for other cleaning purposes.

30 If tissue paper material is to be made out of pulp, the process essentially comprises a forming step that includes a headbox- and a forming wire section, and a drying section, e.g. including through air drying or conventional drying on a Yankee cylinder. The production process can also include a crepe process for tissue paper and, finally, typically a monitoring and winding area.

Tissue paper material can be formed by placing the fibres, in an oriented or random manner, on one or between two endless continuously rotating wires or felts of a paper making machine while simultaneously removing water.

Further dewatering and drying the formed primary fibrous web occur in one or more steps
5 by mechanical and thermal means until a final dry-solid content of usually about 90 to 99% has been reached.

In case of creped tissue paper material making, this stage is followed by the crepe process which influences the properties of the finished tissue paper product in conventional processes. The conventional dry crepe process involves creping on a
10 usually 3.0 to 6.5 m diameter drying cylinder, the so-called Yankee cylinder, by means of a crepe doctor blade with the aforementioned final dry-solids content of the raw tissue paper. Wet creping can be used as well, if lower demands are made of the tissue quality. The creped, finally dry raw tissue paper material, the so-called base tissue, is then available for further processing into the tissue paper product.

15 Instead of the conventional tissue making process described above, the use of a modified technique is possible in which an improvement in specific volume is achieved by a special kind of drying which leads to an improvement in the e.g. caliper, bulk, softness, etc. of the tissue paper material. This process, which exists in a variety of subtypes, is herein generally termed the structured tissue technique. Examples of structured tissue
20 techniques are TAD ATMOS®, NTT(textured), UCTAD, eTAD, QRT, PrimeLineTex etc.

The processing step from the tissue paper material to the finished tissue paper product occurs in processing machines (converting machines) which include operations such as unwinding the tissue paper material (base tissue), calendering of the tissue, laminating, printing or embossing.

25 Several plies may be combined together by a combining operation of a chemical nature (e.g. by adhesive bonding), or of a mechanical nature (e.g. by knurling or so-called edge-embossing), or a combination of both. Examples of such process steps for combining plies together will be described in more detail in the below.

Further, the processing to finished tissue paper product may involve e.g. longitudinal cut,
30 folding, cross cut etc. Moreover, individual tissue paper products may be positioned and brought together to form stacks, which may be individually packaged. Such processing

steps may also include application of substances like scents, lotions, softeners or other chemical additives.

When several plies are combined together using adhesive bonding, a film of adhesive is deposited over some or all of the surface of at least one of the plies, then the adhesive-
5 treated surface is placed in contact with the surface of at least one other ply.

When several plies are combined together using mechanical bonding, the plies may be combined by knurling, by compression, by edge-embossing, union embossing and/or ultrasonic.

Mechanical and adhesive bonding may also be combined to combine several plies
10 together to form a multi-ply product.

Embossing is to change the shape of a sheet from flat to shaped, so that there are areas that are raised and/or recessed from the rest of the surface. It therefore constitutes a deformation of the previously relatively flat sheet, and results in a ply having a particular relief. The thickness of the ply or of the multiple plies is in most cases increased after
15 embossing compared with its initial thickness.

An embossing process is carried out between an embossing roll and an anvil roll. The embossing roll can have protrusions or depressions on its circumferential surface leading to embossed protrusions/depressions in the paper web. Anvil rolls may be softer than the corresponding embossing roll and may consist of rubber, such as natural rubber, or
20 plastic materials, paper or steel. If the anvil roll is made of a softer material like rubber, a contact area/nip can be formed between the embossing roll (e.g. steel roll) and the anvil roll by the deformation of the softer roll.

By embossing, a pattern can be applied to a tissue paper fulfilling a decorative and/or functional purpose.

25 A functional purpose may be to improve the properties of the hygiene paper product, that is, the embossment may improve the product thickness, absorbency, bulk, softness etc.

A functional purpose may also be to provide a joint to another ply in a multi-ply product.

Tissue paper products display a number of physical properties which are of importance for their use for example as toilet paper, hand towels, kitchen towels, facial tissues,
30 handkerchiefs, napkins, wipe or the like. Examples of such properties are their strength, softness, and absorbency (primarily for aqueous systems). These physical properties are

generally tuned for addressing common consumer demand in view of the intended use of the tissue paper product.

For example, tissue paper products need to retain their strength at least for a time period
5 of use e.g. for wiping liquids or moisture.

For example, it is desired that tissue paper products have an absorbency so as to be suitable for their purpose such as for wiping liquids or moisture, cleaning etc.

10 At the same time, there are requirements regarding tactile properties such as softness as tissue paper products may be intended to come in intimate contact with the body and skin. Accordingly, it is desired that tissue paper products shall exhibit sufficient softness in order to ensure consumer's comfort.

15 However, some of the desired physical properties of tissue paper products are generally conflicting properties. One example is strength and softness. Often, as strength in a tissue paper product rises, the softness declines.

Hence, it is desired to provide a tissue paper product providing a good balance between
20 required properties. For example, it is desired to provide a tissue paper product achieving a satisfactory balance between softness and strength or to provide a tissue paper product achieving a satisfactory absorption, strength and/or softness.

Further, there is a desire to reduce the consumption of wood fibre to produce tissue paper
25 products. This desire is advocated by e.g. rising costs for wood fibre, concerns involving sustainable forest management, and other environmental reasons such as carbon foot print.

To this end, attempts have been made to replace some or all of the wood fibre in tissue
30 paper products with for example recycled fibres and/or with non-wood fibres. However, since the fibre content in the pulp will naturally impact the above-mentioned physical properties of the resulting tissue paper material, the replacement of virgin wood fibres with other fibres in the pulp is not uncomplicated.

Thus, there is a need for improvement and/or alternatives for tissue paper products in view of one or more of the above-mentioned desires.

SUMMARY

- 5 An object of the present invention is to fulfill said need for improvement and/or alternatives.

To this end, it is proposed herein to use non-wood cellulose pulp fibres in tissue paper materials and tissue paper products.

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The non-wood cellulose pulp fibres may be chemical pulp fibres.

- Optionally, the non-wood cellulose pulp fibres may be never-dried fibres. "Never-dried" means herein that the fibres have not been subject to drying before use in the tissue
15 making process. It is believed that the non-wood cellulose pulp fibres being never-dried may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

- Optionally, the non-wood cellulose pulp fibres contain at least 15% hemicellulose. It is
20 believed that such a hemicellulose content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

- Optionally, the non-wood cellulose pulp fibres contain no more than 15 % lignin. For example, the non-wood cellulose pulp fibres may contain no more than 12 % lignin. In yet
25 another example, the non-wood cellulose pulp fibres may contain no more than 10% lignin. It is believed that such a lignin content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

- For example, the non-wood cellulose pulp fibres may contain at least 15% hemicellulose
30 and no more than 15 % lignin, such as no more than 12 % lignin or no more than 10% lignin.

Optionally, the non-wood cellulose pulp fibres are pre-treated, to obtain the desired amounts of lignin and/or hemicellulose.

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Further, the non-wood cellulose pulp fibres may have a relatively low average fibre length.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1700 μm .

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Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1200 μm .

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1000 μm .

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 900 μm .

15 For example, the non-wood cellulose pulp fibres may have an average fibre length in the range of 750 to 1000 μm .

Further, it is believed that the non-wood cellulose pulp fibres having a relatively high breaking length, may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products. The breaking length is the initial breaking length of the non-wood cellulose pulp fibres as measured on the non-wood cellulose pulp fibres after the pulping process.

Optionally, the non-wood cellulose fibres have a breaking length of more than 3000 m, such as more than 5000 m.

For example, the non-wood cellulose fibres may have a breaking length of more than 3000 m and an average fibre length of less than 1700 μm , such as less than 1200 μm , less than 1000 μm or less than 900 μm .

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For example, the non-wood cellulose fibres may have a breaking length of more than 5000 m and an average fibre length of less than 1700 μm , such as less than 1200 μm , less than 1000 μm or less than 900 μm .

Also, it is believed that the non-wood cellulose pulp fibres having a relatively high ratio between breaking length, and average fibre length may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

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Optionally, the non-wood cellulose fibres have a breaking length/average fibre length of more than 3.7.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio
10 of more than 4.0.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5.

15 For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5, such as more than 5.5 or more than 6.5.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7 such as more than 4 and an average fibre length of less than
20 1700 µm, such as less than 1200 µm, less than 1000 µm, or less than 900 µm.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5, such as more than 5.5 or more than 6.5 and an average fibre length of less than 1700 µm, such as less than 1200 µm, less than 1000 µm, or less than
25 900 µm.

For comparison, it may be mentioned that different types of conventional hardwood and softwood pulps display lower breaking length/average fibre length ratios, than those suggested in the above for the non-wood cellulose fibres. This applies also to examples of
30 never-dried hardwood and softwood pulps. Average ratios as calculated for different types of hardwood and softwood pulps are indicated in the table in the below.

Type of pulps	Average ratio
BEK	2.4
BHK	2.0
BSK	1.0
BSS	0.6
NBHK	2.3
NBSK	1.2
Never-dried HW	0.9
Never-dried SW	1.0

(BEK – Bleached Eucalyptus Pulp, BHK – Bleached Hardwood Kraft, BSK – Bleached Softwood Kraft, BSS – Bleached Softwood Sulfite, Northern Bleached Hardwood Kraft, Northern Bleached Softwood Kraft. The never-dried Hardwood (HW) and Softwood (SW) are sulfite.)

Also, several types of previously used non-wood cellulose pulp fibres have been found to display lower breaking length/average fibre length ratio than what is proposed in the above. For example, tested samples of dried bagasse fibre pulp was found to have an average ratio of 2.6, dried bamboo fibre pulp an average ratio of 1.2 and dried wheat fibre pulp an average ratio of 3.5.

For example, the non-wood cellulose fibres may be never-dried non-wood cellulose pulp fibres and the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7, such as more than 4.0 or more than 4.5.

For example, the non-wood cellulose fibres may be never-dried non-wood cellulose pulp fibres and the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5, such as more than 5.5 or more than 6.5.

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The non-wood cellulose pulp fibres as proposed herein may be used together with hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

As mentioned in the above, optionally, a portion of or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibres.

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Optionally, the non-wood cellulose fibres are used with softwood cellulose pulp fibres. In this case, a portion of or all softwood cellulose fibres may be never-dried softwood cellulose pulp fibres.

- 5 For example, the softwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried softwood cellulose pulp fibres.

Optionally, the non-wood cellulose fibres are used with hardwood cellulose pulp fibres. In this case, a portion of or all hardwood cellulose fibres may be never-dried hardwood
10 cellulose pulp fibres.

For example, the hardwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried hardwood cellulose pulp fibres.

- 15 Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by treatment by a non-pressurised process.

Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by treatment by a process with no use of sulfur.

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For example, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described EP 2 048281 A1, EP 2 247781 B1, US20130129573 A1, EP 2 034 090 A1, US20110281298 A1, and/or US20130129573 A1.

- 25 Additionally or alternatively, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described in WO2020264311 A1, WO2020264322 A1, US20190091643 A1, US2592983.

For example, the non-wood cellulose pulp fibres may be achieved by the Phoenix Process
30 TM, of Sustainable Fiber Technologies Inc.

It will be understood that the features as discussed in the above as being contributing to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products may be used separately or in different combinations.

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Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct.

Optionally, the non-wood cellulose pulp fibres are derived from a member of the Poaceae family. For example, the non-wood cellulose pulp fibres may be derived from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, *Arundo donax*, miscanthus, bamboo, and/or sorghum. Another example of a member of the Poaceae family is sugar cane, from which non-wood cellulose pulp fibres may be derived, for example from sugar cane bagasse.

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Optionally, the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family. For example, the non-wood cellulose pulp fibres may be derived from hemp and/or hop.

15 Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproducts. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of the members of the Poaceae family and/or Cannabaceae family such as exemplified in the above, i.e. including agricultural waste or byproducts from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop. In another example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.

25 Optionally, the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass, succulents, alfalfa (belongs to the family Fabaceae.), flax straw (belongs to the family Linaceae), palm fruits (*Elaeis* or *Arecaceae*), and/or avocado (*Lauraceae*).

30 Optionally, the non-wood cellulose pulp fibres are derived from one or more of wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, *Arundo donax*, miscanthus, bamboo, sorghum, banana harvest residue, pineapple residue, nut shell waste, sugar-cane bagasse, industrial hemp, and/or members of the Cannabaceae family, kenaf, switchgrass, succulents, alfalfa, corn stover, and flax straw.

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Optionally, the non-wood cellulose pulp fibres are derived from wheat straw, oat straw, barley straw, and/or rye grass. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of wheat straw, oat straw, barley straw, and/or rye grass.

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For example, the non-wood cellulose pulp fibres may be derived from wheat straw, such as from agricultural waste or byproducts of wheat.

Optionally, the non-wood cellulose pulp fibres are derived from residues from sugar
10 production. For example, the non-wood cellulose pulp fibres may be residues from beet.

Optionally, the non-wood cellulose pulp fibres are derived from sugarcane bagasse.

Optionally, the non-wood cellulose pulp fibres are derived from agave. For example, the
15 non-wood cellulose pulp fibres may be derived from residues from agave syrup production or derived from agave bagasse.

Although the present disclosure relates primarily to tissue paper made of non-wood fibres, it is understood that the non-wood cellulose pulp fibres as described herein may also find
20 use in other applications e.g. in wound care, in absorbent articles, for example diapers, sanitary napkins, and incontinence articles, in beauty care, and/or in nonwoven materials and products.

Herein, the non-wood cellulose pulp fibres as described in the above are proposed to be
25 used to form a non-wood tissue ply, comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the non-wood tissue ply.
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Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an
35 amount of at least 30% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the non-wood tissue ply.

- 5 Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 20 to 50% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 25 to 35% by dry weight of the non-wood tissue ply.

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Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight of the non-wood tissue ply.

- 15 Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight of the non-wood tissue ply.

Optionally, the non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

- 20 Optionally, the non-wood tissue ply further comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the tissue paper ply.

- 25 Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 95/5.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 90/10.

- 30 Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 80/20.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be greater than or equal to 0/100.

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For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be in the range of 70/30 to 30/70.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the
5 non-wood tissue ply may be in the range of 60/40 to 40/60.

Optionally, said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply. In other words, at least some non-wood cellulose pulp fibres may be found in all parts of the ply, e.g. in all layers of the ply. The non-wood cellulose pulp fibres need not
10 be uniformly distributed, but may be a result of e.g. stratified distribution of the non-wood cellulose pulp fibres. For example, the non-wood cellulose pulp fibres may be homogeneously distributed in the ply. In another example, the non-wood cellulose pulp fibres may be heterogeneously distributed in the ply.

15 Optionally, when said non-wood tissue ply comprises two or more layers, at least one layer of the non-wood tissue ply comprises non-wood fibres. For example, said at least one layer maybe an outer layer of the non-wood tissue ply.

Optionally, when said non-wood tissue ply comprises two or more layers, each out of said
20 two or more layers may comprise non-wood fibres.

Optionally, the non-wood tissue ply is produced by conventional wet press technology (CWP). By "is produced" means that the tissue paper material has been manufactured using conventional wet press technology, i.e. the tissue paper material is a CWP tissue
25 paper material. For example, the tissue paper material may be a dry crepe tissue paper material.

Optionally, the non-wood tissue ply is produced by structured tissue technology. By "is produced" means that the tissue paper material has been manufactured using structured
30 tissue technology, i.e. the tissue paper material is a structured tissue paper material.

Optionally, the non-wood tissue ply is produced by TAD (Through Air Drying) technology.

Optionally, the non-wood tissue ply is produced by ATMOS technology.

Optionally, the non-wood tissue ply is produced by UCTAD technology.

35 Optionally, the non-wood tissue ply is produced by textured NTT technology.

Optionally, the non-wood tissue ply is produced by eTAD technology, such as Advantage eTAD technology from Valmet.

Optionally, the non-wood tissue ply is produced by QRT technology.

Optionally, the non-wood tissue ply is produced by PrimeLine TEX technology.

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In accordance with the invention, there is provided tissue paper materials and tissue paper products including the non-wood tissue ply as described in the above with the non-wood cellulose pulp fibres as described in the above.

10 Thus, in a first aspect, there is provided a single-ply tissue paper material according to claim 1.

Thus, there is provided a single-ply tissue paper material having a basis weight less than 40 gsm and a GMT tensile strength of at least 60 N/m, the tissue paper material
15 comprising a non-wood tissue ply. The non-wood tissue ply comprises non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the tissue paper material.

Optionally, the tissue paper material has a GMT tensile strength of at least 70 N/m.
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Optionally, the tissue paper material has a GMT tensile strength of at least 80 N/m.

Optionally, the tissue paper material has a basis weight of less than 30 gsm.

25 Optionally, the tissue paper material has a basis weight of less than 25 gsm.

Optionally, the tissue paper material has a basis weight greater than 10 gsm.

Optionally, the tissue paper material has a basis weight in the range from 14 gsm to
30 25 gsm.

In a second aspect, there is provided a single-ply tissue paper product comprising a single-ply tissue paper material according to the first aspect. This implies that the single-ply tissue paper product may consist of the single-ply tissue paper material.

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In a third aspect, there is provided a multi-ply tissue paper product in accordance with claim 7. Thus there is provided a multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 g/m², and the multi-ply tissue paper product having a GMT tensile strength of at least 100 N/m, wherein at least
5 one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres, said non-cellulose pulp fibres being present in an amount of at least 10% by dry weight of the non-wood tissue ply.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least
10 120 N/m, such as at least 150 N/m.

Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of at least 7 g/g.

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Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of at least 8 g/g.

20 Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of less than 20 g/g, such as less than 18 g/g.

Optionally, the multi-ply tissue paper product or the single ply tissue paper product has an
25 absorbency of 7 to 20 g/g.

Optionally, the multi-ply tissue paper product or the single ply tissue paper product has an absorbency of 8 to 15 g/g.

30 Optionally, a majority of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, all of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
5 an amount of at least 15% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

10 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 30% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the multi-ply tissue paper product.

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Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 70% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
20 an amount of no more than 60% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range from 15 % to 50% by dry weight of the multi-ply tissue paper product.

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Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range from 15 % to 40% by dry weight of the multi-ply tissue paper product.

30 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range from 25 % to 35% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises two to five plies.

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Optionally, each of the plies of the multi-ply tissue paper product comprises the same amount of non-wood cellulose pulp fibres.

Optionally, at least two plies in said multi-ply tissue paper product comprise different
5 amounts of non-wood cellulose pulp fibres.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 5% dry weight.

10 Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 10% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 20% dry weight.

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Optionally, the multi-ply tissue paper product comprises one or more plies with no non-wood cellulose pulp fibres.

Optionally, said at least one non-wood tissue ply is an outer ply of said multi-ply tissue
20 paper product.

Optionally, the multi-ply tissue paper product comprises at least two non-wood tissue plies, wherein the non-wood tissue plies form a first and a second outer ply of the multi-ply tissue paper product.

25

Optionally, for each of the alternatives relating to a multi-ply tissue paper product in the above, the non-wood ply may be such as defined in the above in any one of the options relating to the first aspect.

30 Optionally, the at least one non-wood tissue ply of the multi-ply tissue paper product comprises a single-ply tissue paper material in accordance with the first aspect as described in the above.

In a fourth aspect, there is provided a single-ply tissue paper material having a basis
35 weight less than 40 gsm and an absorbency of at least 3 g/g, comprising a non-wood

tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

Optionally, the tissue paper material has an absorbency of at least 4 g/g.

5 Optionally, the tissue paper material has an absorbency of at least 5 g/g.

Optionally, the tissue paper material is produced by CWP (Conventional Wet Pressed) technology.

Optionally, the tissue paper material is produced by structured tissue technology.

Optionally, the tissue paper material is produced by structured tissue technology and have
10 an absorbency of at least 6 g/g.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 7 g/g.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 8 g/g.

15 Optionally, the structured tissue technology is TAD technology.

Optionally, the tissue paper material has a GMT tensile strength of at least 60 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 70 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 80 N/m.

For example, the tissue paper material may have a GMT tensile strength of at least
20 100 N/m.

For example, the tissue paper material may have a GMT tensile strength of at least 150 N/m.

Optionally, the tissue paper material has a basis weight of less than 30 gsm.

Optionally, the tissue paper material has a basis weight of less than 25 gsm.

25 Optionally, the tissue paper material has a basis weight of more than 10 gsm.

Optionally, the tissue paper material has a basis weight of more than 15 gsm.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight from 15 to 20 gsm and an absorption of at least 5 g/g.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight from 20 to 30 gsm and an absorption of at least 4 g/g.

- 5 For example, the tissue paper material may be produced by CWP technology, and have a basis weight above from 30 gsm and an absorption of at least 3 g/g.

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 75 (g/m²).

- 10 For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 80 (g/m²).

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 90 (g/m²).

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight from 15 to 20 gsm and an absorption of at least 8 g/g.

- 15 For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight from 20 to 30 gsm and an absorption of at least 7 g/g.

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight above from 30 gsm and an absorption of at least 6 g/g.

- 20 For example, the tissue paper material may be produced by structured tissue technology, and the basis weight (gsm) x the absorption (g/g) may be at least 120 (g/m²).

For example, the tissue paper material may be produced by structured tissue technology, and the basis weight (gsm) x the absorption (g/g) may be at least 140 (g/m²).

For example, the tissue paper material may be produced by (g/m²) technology, and the basis weight (gsm) x the absorption (g/g) may be at least 180 (g/m²).

- 25 Optionally, the tissue paper material may have a thickness of above 0.08 mm.

Optionally, the tissue paper material may have a thickness below 0.5 mm.

In a fifth aspect, there is provided a single-ply tissue paper product comprising a single-ply tissue paper material according to the fourth aspect in the above.

In a sixth aspect, there is provided a multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having an absorption of at least 4 g/g, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

Optionally, the multi-ply tissue paper product has an absorbency of at least 5 g/g.

Optionally, the multi-ply tissue paper product has an absorbency of at least 6 g/g.

Optionally, at least one ply of the multi-ply tissue paper product is produced by CWP (Conventional Wet Pressed) technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology. For example, the structured tissue technology may be TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 7 g/g. For example, the ply may be produced by TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 8 g/g. For example, the ply may be produced by TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 9 g/g. For example, the ply may be produced by TAD technology.

Optionally all plies of the multi-ply tissue paper product are produced by structured tissue technology. For example, all of the plies may be produced by TAD technology.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 100 N/m.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 200 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least
5 300 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 400 N/m.

10 Optionally, a majority of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, all of the plies of the multi-ply tissue paper material are non-wood tissue plies.

15 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

20

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in
25 an amount of at least 30% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the multi-ply tissue paper product.

30 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 70% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 60% by dry weight of the multi-ply tissue paper product.

35

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 15 % to 50% by dry weight of the multi-ply tissue paper product.

- 5 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 15 % to 40% by dry weight the multi-ply tissue paper product.

- 10 Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 25 % to 35% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises two to five plies.

- 15 Optionally, each of the plies of the multi-ply tissue paper product comprises the same amount of non-wood cellulose pulp fibres.

Optionally, at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres.

20

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 5% dry weight.

- 25 Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 10% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 20% dry weight.

- 30 Optionally, the multi-ply tissue paper product comprises one or more plies with no non-wood cellulose pulp fibres.

Optionally, said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper product.

35

Optionally, the multi-ply tissue paper product comprises at least two non-wood tissue plies, wherein the non-wood tissue plies form a first and a second outer ply of the multi-ply tissue paper product.

- 5 Optionally, for each of the alternatives relating to a multi-ply tissue paper product in the above, the non-wood ply may be such as defined in the above in any one of the options relating to the fourth aspect.

- 10 Optionally, the at least one non-wood tissue ply of the multi-ply tissue paper product comprises a single-ply tissue paper material in accordance with the fourth aspect as described in the above.

The single-ply tissue paper product and the multi-ply tissue paper product as disclosed herein may for example be a tissue paper product for personal hygiene.

15

Optionally, the single-ply tissue paper product and the multi-ply tissue paper product disclosed herein may for example be toilet paper, hand wipes, paper napkins, facial tissue, handkerchiefs, or a kitchen towel or an industrial wipe.

- 20 The single-ply tissue paper product and the multi-ply tissue paper product may be embossed and/or calendared as is known in the art.

- 25 Optionally, the plies of the multi-ply product may be joined by ply bonding, such as for example embossing or knurling. For example, the multi-ply product may be joined by nesting.

Optionally, the plies of the multi-ply product may be joined by Goffra-Incolla technology.

- 30 Herein is disclosed a four-ply tissue product, such as a bathroom tissue product, such as toilet paper, having a basis weight of less than 80 g/m², such as 55 to 75 g/m², wherein each ply comprises wood cellulose fibres, such as hardwood and/or softwood cellulose fibres, and wheat straw cellulose fibres in an amount of 10 to 60 % by dry weight, such as 10 to 50 % by dry weight, 10 to 40 % by dry weight, 10 to 30 % by dry weight or 10 to 20 % by dry weight, the four-ply tissue product having a GMT tensile strength of at least

250 N/m, such as at least 300 N/m and/or an absorbency of at least 8 g/g, such as at least 9 g/g.

Each ply of said four-ply tissue product may have a basis weight of less than 30 g/m²,
5 such as 10 to 25 g/m². Each ply of said four-ply tissue product may comprise the same amount of wheat straw cellulose fibres.

The wheat straw cellulose fibres of said four-ply tissue product may have an average fibre length in the range of 750 to 1000 µm, such as 800 to 900 µm or 825 to 875 µm. Said
10 wheat straw cellulose fibres may contain at least 15 % hemicellulose and/or no more than 15 % lignin.

Herein is also disclosed a three-ply tissue product, such as a bathroom tissue product, such as toilet paper, having a basis weight of less than 70 g/m², such as 40 to 60 g/m²,
15 wherein each ply comprises wood cellulose fibres, such as hardwood and/or softwood cellulose fibres, and wheat straw cellulose fibres in an amount of 10 to 60 % by dry weight, such as 10 to 50 % by dry weight, 10 to 40 % by dry weight, 10 to 30 % by dry weight or 10 to 20 % by dry weight, the three-ply tissue product having a GMT tensile strength of at least 200 N/m, such as at least 250 N/m and/or an absorbency of at least 8
20 g/g, such as at least 9 g/g.

Each ply of said three-ply tissue product may have a basis weight of less than 30 g/m², such as 10 to 25 g/m². Each ply of said three-ply tissue product may comprise the same amount of wheat straw cellulose fibres.

25

The wheat straw cellulose fibres of said three-ply tissue product may have an average fibre length in the range of 750 to 1000 µm, such as 800 to 900 µm or 825 to 875 µm. Said wheat straw cellulose fibres may contain at least 15 % hemicellulose and/or no more than 15 % lignin.

30

Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

5

In the drawings:

Fig. 1 is a diagram illustrating softness and GMT tensile strength for a number of base sheet samples including various amounts of non-wood fibre;

10 Fig. 2 is a diagram illustrating softness versus GMT tensile strengths for the base sheet samples of Fig. 1 comprising 0% non-wood fibre and 30% non-wood fibre;

Fig. 3 is a diagram illustrating softness and GMT tensile strength for a number of multiply tissue samples including various amounts of non-wood fibre;

Fig. 4 is a diagram illustrating the absorption for the tissue samples of Fig. 3;

15 Fig. 5 is a diagram illustrating the thickness for the tissue samples of Fig. 3;

Fig. 6 is a diagram of absorbency values obtained for tissue paper materials obtained in Example 4;

Fig. 7a is a diagram of absorbency values obtained for tissue paper materials obtained in Example 5;

20 Fig. 7b is a diagram of absorbency values obtained for tissue paper products obtained in Example 5;

Fig. 8 is a diagram of absorbency values obtained for tissue paper products obtained in Example 6;

25 Fig. 9 is a diagram of absorbency values obtained for tissue paper products obtained in Example 7; and

Fig. 10 is a diagram of absorbency values obtained for the tissue paper products obtained in Example 8, including variants of the tissue paper products obtained in Example 5.

DETAILED DESCRIPTION

30 The description in the below relates to examples of tissue paper materials and tissue paper products as obtained using the non-wood cellulose pulp fibres as proposed herein.

EXAMPLE 1: Single-ply tissue paper materials (base sheets)

35 Five different tissue paper materials were prepared.

The five different tissue paper materials are base sheets and suitable for forming bathroom tissue.

The samples were prepared using CWP technology to provide a dry creped tissue.

5

Two different grades of tissue were targeted:

Grade 1 (G1): soft bathroom tissue

Grade 2 (G2): standard bathroom tissue

10 The original fibre recipe for the two grades, without any non-wood fibre content is:

Trial ref	Reference furnish
Grade G1	50% softwood (never-dried pulp) – 50% hardwood (Eucalyptus – dried pulp)
Grade G2	70% softwood (never-dried pulp) – 30% hardwood (never-dried pulp)

The trial aimed at introducing different levels of non-wood fibrous pulp instead of standard wood pulp to assess base paper properties and consequently finished product quality.

15

The tissue machine is a Crescent former with suction press roll configuration, with a 2 layers Headbox: 50% Top Layer, 50% Bottom Layer.

The G1 grade was run in a stratified mode (different recipes on the 2 layers of the base paper), the G2 grade was run in homogenous mode (same recipe on both layers of the base paper), with target specifications as in the below:

G1:

Headbox: 2 layers

25 Blade: 20° ceramic

Basis weight: 16.5 g/m²

Thickness (10p): 0.97 mm/10 plies

MD dry tensile/ ply: 140 N/m

CD dry tensile/ply: 50 N/m

30 MD stretch: 18%

G2:

Headbox: 1 layer

Blade: 10° ceramic

Basis weight: 16 g/m²

- 5 Thickness (10p): 1.15 mm/10 plies

MD dry tensile/ ply: 150 N/m

CD dry tensile/ply: 60 N/m

MD stretch: 16%

- 10 The amount of non-wood fibres introduced ranged from 0 to 50% of the total blend. The compositions of the various base sheets are indicated in the table in the below:

Grade	Grade	Grade 1		Grade 2			
Trial	Trial	G 1A	G1B	G 2A	G2B	G2D	G2E
Over-all furnish	hardwood (dried pulp)	50%	50%				
	softwood (never-dried pulp)	50%	30%	70%	50%	40%	30%
	hardwood (never-dried pulp)			30%	30%	30%	20%
	non-wood fibre (never-dried pulp)	0%	20%	0%	20%	30%	50%

- 15 The non-wood cellulose fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp had a lignin content of 12.8% and a hemicellulose content of 18.0%.

- 20 The conventional short fibre content was made out of Hardwood dried pulp being a Eucalyptus dried pulp, and Hardwood never-dried pulp being a hardwood never-dried sulfite pulp.

The conventional long fibre content was made out of Softwood. In this example, the

- 25 Softwood fibre pulp was also never-dried sulfite pulp. The breaking length, average fibre length, and ratio breaking length/average fibre length of the hardwood never-dried pulp, softwood never-dried pulp and hardwood dried pulp (eucalyptus) were as indicated in the table below:

	Non-wood	Hardwood (dried)	Softwood (never-dried)	Hardwood (never-dried)
Breaking length (m)	3775	1724	1755	882
Average fibre length (μm)	748	714	2165	929
Ratio breaking length/fibre length (- /micro)	5.05	2.41	0.81	0.95

The non-wood cellulose pulp fibres substituted mostly conventional long fibre both for its intrinsic strength properties and the tensile developed after refining. Despite this, additional strength generated needed a decrease on the long fibre refining line.

5

Grade	Grade	Grade 1		Grade 2			
Trial	Trial	G 1A	G1B	G 2A	G2B	G2D	G2E
Long fibre line	softwood (never-dried pulp)	100%	100%	100%	100%	80%	60%
	non-wood fibre					20%	40%
	Refining kwh/T	60	50	70	32	32	37
Short fibre line	hardwood (dried pulp)	100%	70%				
	hardwood (never-dried pulp)			100%	60%	60%	40%
	non-wood fibre		30%		40%	40%	60%
	Refining		none	none	15	18	48
Headbox	Configuration	Stratified	Stratified	Homogenous	Homogenous	Homogenous	Homogenous
	Yankee layer	100% SF	100% SF	30% SF + 70% LF	50% SF + 50% LF	50% SF + 50% LF	50% SF + 50% LF
	Hood layer	100% LF	40% SF + 60% LF	30% SF + 70% LF	50% SF + 50% LF	50% SF + 50% LF	50% SF + 50% LF

The content of non-wood fibres, conventional long fibres, and conventional short fibres in each of the tissue paper materials is indicated in the table in the below:

Grade	Trial reference	Non wood fibre content	Long fibre content %	Short fibre content %	Long fibre line refining kwh/T	Short fibre line refining kwh/T
Grade 1 (soft grade)	G1-A	0%	50%	50%	60	0
	G1-B	20%	30%	50%	50	0
Grade 2 (standard grade)	G2-A	0%	70%	30%	70	0
	G2-B	20%	50%	30%	32	15
	G2-D	30%	40%	30%	32	18
	G2-E	50%	30%	20%	37	48

Dry tensile strength in CD and MD directions and panel softness, were measured for the various samples, with the results as indicated in the table in the below and in Figs. 1 and 5 2.

	Basis weight g/m ²	MD dry tensile N/m - 1 ply	CD dry tensile N/m - 1 ply	GMT dry tensile N/m - 1 ply	MD stretch %	Panel
G1 - A	16.8	145	51	86	20.1	2.7
G1 - B	17.2	151	56	92	18.6	2.7
G2 - A	16.1	130	54	83	19.2	2.5
G2 - B	16.2	156	64	100	18.2	2.6
G2 - E	16.5	192	81	125	18.8	2.1

Fig. 1 is a combined bar chart and linear chart, where the bars represent the softness values and the line indicates the GMT tensile strength of the tissue paper materials G1-A, G1-B, G2-A, G2-B, and G2- E of Table 1.

The samples of the different Grades denoted A, are all samples with no non-wood fibre content, whereas the samples of the different Grades denoted with other letters comprise increasing amounts of non-wood fibre content (in alphabetical order).

No general trend for the relationship between the GMT strength and the softness in view of the non-wood cellulose fibre content may be seen which is valid for all of the different Grades. For the grade G1 being the softer grade, the softness values with or without non-wood fibres are similar. For the grade G2 being the standard grade, the softness values deviate more, but the GMT strength is increasing with increasing non-wood content.

Surprisingly the GMT strength is seen to increase with increasing content of non-wood fibre in the two different grades. Turning to Fig. 2, the basesheet softness and strength are again visualized, this time for samples including 0% non-wood versus samples including 30% non-wood. The samples with 30% non-wood display advantageous softness and GMT tensile strength.

Further, another surprising result is that all of the Grades display a GMT strength and a softness which is within limits rendering them useful for tissue paper products.

10 EXAMPLE 2: Multi-ply products

Three different types of multi-ply products, MP1, MP2 and MP3 were prepared. For each type of multi-ply product, samples were made with different overall non-wood fibre content, using the base sheets of different grades and non-wood fibre content as described in the above.

The plies of the multi-ply products were assembled by means of Goffra-Incolla technology. All converting parameters were the same for the different non-wood content of each of the products MP1, MP2, MP3.

MP1:

4-ply product

	Embossing top ply	Basesheet Top ply	Basesheet Middle ply	Basesheet Middle ply 2	Basesheet Bottom ply
MP1 0%	Feather (RT 20D)	Grade 1 A	Grade 2 A	Grade 2 A	Grade 1 A
MP1 32%	Feather (RT 20D)	Grade 1 B	Grade 2 E	Grade 2 E	Grade 1 B

MP2:

4-ply product

	Embossing top ply	Basesheet Top ply	Basesheet Middle ply	Basesheet Middle ply 2	Basesheet Bottom ply
MP2 0%	Ornament (RT71D)	Grade 1 A	Grade 2 A	Grade 2 A	Grade 1 A
MP2 20%	Ornament (RT71D)	Grade 1 B	Grade 2 B	Grade 2 B	Grade 1 B
MP2 30%	Ornament (RT71D)	Grade 1 B	Grade 2 E	Grade 2 E	Grade 1 B

5 MP3:

3-ply product

	Embossing top ply	Basesheet Top ply	Basesheet Middle ply	Basesheet Middle ply 2	Basesheet Bottom ply
MP3 0%	Seven (RT305)	Grade 1 A	Grade 2 A	-	Grade 1 A
MP3 20%	Seven (RT305)	Grade 1 B	Grade 2 B	-	Grade 1 B
MP3 30%	Seven (RT305)	Grade 1 B	Grade 2 E	-	Grade 1 B

The resulting multi-ply tissues were tested for various parameters, and the results are
10 displayed in the below table.

	Number of	Non-wood dry weight (average)	Firmness	Basis weight	Thickness	GMT	Softness Panel	Absorption
	plies	%		(g/m²)	(1 sheet) mm	N/m		g/g
MP1 0%	4	0	61	63,8	0,58	267	1,7	9,0
MP1 32%	4	32	60	64,8	0,57	335	1,7	8,6

MP2 0%	4	0	59	63,0	0,53	255	1,7	9,3
MP2 20%	4	20	55	65,8	0,55	309	1,6	8,8
MP2 30%	4	30	54	65,9	0,55	329	1,5	9,0
MP3 0%	3	0	54	46,3	0,43	167	1,6	9,6
MP3 20%	3	20	47	48,2	0,44	200	1,6	9,0
MP3 30%	3	30	48	48,2	0,44	206	1,6	9,3

The results will be further discussed in the below with reference to Figs. 3 to 6.

- 10 Fig. 3 is a combined bar chart and linear chart, where the bars represent the softness values of the samples and the line indicates the GMT tensile strength.

In Fig. 3, as well as in the following Figs 4 to 6, for each type of multiply tissue paper material MP1, MP2, MP3, the samples are presented from left to right and with the
 15 sample having 0 percentage non-wood content to the left, and in increasing order of non-wood content towards the right in the figures.

As demonstrated by Fig. 3, the softness values for each type of multiply tissue paper material MP1, MP2, and MP3 is relatively constant or decreases only insignificantly with
 20 increasing amount of non-wood content. (A significant difference in the softness values (panel softness) would be about 0.2 points.) Thus, the results indicate that the softness is not significantly affected in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

25 Further, for each of the types MP1, MP2, and MP3, the GMT tensile strength increases with increasing amount of non-wood content. The increase in GMT tensile strength is significant, which was surprising. Thus, the results indicate that the GMT tensile strength is significantly increased in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

30

Thus, the results indicate that the balance between the softness and GMT strength in the samples comprising various amounts of non-wood, is better than for the samples with no non-wood content, i.e. increased GMT strength is achieved at about the same softness.

A satisfactory result for a tissue paper product comprising non-wood would be a balance being about the same as for a tissue paper product with no non-wood content. Based on the tests performed, it may therefore be assumed that the non-wood cellulose pulp fibres
5 used herein are useful for replacing wood fibres in numerous different multi-ply and single ply tissue paper products while achieving at least satisfactory results in terms of softness and strength.

Turning to absorption, Fig. 4 is a bar chart illustrating the absorption g/g of the different
10 samples of the three types of tissue paper material MP1, MP2, and MP3. As seen in the results, for each of the types MP1, MP2, and MP3, the highest value for absorption is obtained for the sample with no non-wood content. However, no general trend regarding the impact of increasing non-wood amount on the absorption values may be seen.

Further, the variations in the measured absorption values are mainly insignificant, as a
15 significant difference for absorption is about 0,5 g/g.

Thus, the results indicate that the absorption is not significantly affected in the samples comprising various amounts of non-wood, and instead the absorption is as good in the samples with various amounts of non-wood content as in the sample comprising no non-
20 wood.

Turning to thickness, Fig. 5 is a bar chart illustrating the thickness (mm) of the different samples of the three types of tissue paper material MP1, MP2, and MP3. The results indicate that the thickness is not significantly affected in the samples comprising various
25 amounts of non-wood as compared to the samples comprising no non-wood.

EXAMPLE 3: Bathroom tissue products

Hereinbelow are described two four-ply bathroom tissue products of relatively higher basis
30 weight and higher thickness (P1 and P2) as well as two three-ply bathroom tissue products of relatively lower basis weight and lower thickness (P3 and P4).

In the manufacture of the base tissues for the respective bathroom tissue products, the conventional long fibre content was made from softwood and the conventional short fibre

content was made from hardwood. The softwood pulp and hardwood pulp used in the manufacture of the base tissues were never-dried sulfite pulps.

The non-wood pulp used in the manufacture of the base tissues for P1 and P3 was a
5 never-dried cellulose fibre pulp derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The wheat straw cellulose fibres had an average length weighted fibre length in the range of 825–875 μm (Morfi fiber analyzer).

10 It is contemplated that similar base tissue and tissue product properties may be obtained irrespective of which forming technology (e.g., two-layer headbox or homogenous headbox) is used when manufacturing the base tissues.

Four-ply products P1 and P2

15

Two different top ply base tissues, T1 and T2, and two different bottom ply base tissues, B1 and B2, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Crescent former with a two-layer headbox. The top ply and bottom ply base tissues were manufactured in a stratified mode, the composition of the furnish for the
20 respective layers being as set out in the following table.

	T1 and B1	T2 and B2
Hood layer	Softwood pulp Non-wood pulp	Softwood pulp
Yankee layer	Hardwood pulp	Hardwood pulp

Two different middle ply base tissues, M1 and M2, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Twin Wire former with a
25 homogenous headbox.

The resulting base tissues are characterised in the following table.

	T1	T2	M1	M2	B1	B2
Composition (% dry weight)						
Softwood pulp	45	55	70	80	45	55
Hardwood pulp	45	45	20	20	45	45
Non-wood pulp	10	0	10	0	10	0
Basis weight (g/m ²)	≈ 16	≈ 16	≈ 15.5	≈ 15.5	≈ 19	≈ 19

Two different four-ply bathroom tissue products (toilet paper), P1 and P2, were manufactured by Goffra-Incolla technology assembly of four plies of base tissue as set out in the following table.

5

	P1	P2
Top ply	T1	T2
Middle plies	2 x M1	2 x M2
Bottom ply	B1	B2

Properties of the manufactured four-ply bathroom tissue products are reported in the following table. Results for P1 are means of 24 datapoints from 3 different production runs using base tissues from different production dates. Results for P2 are means of a larger

10 number of datapoints collected from a larger number of production runs.

	P1	P2
Basis weight (g/m ²)	65.4	65.7
Thickness per sheet (mm)	0.59	0.56
GMT strength (N/m)	352	335
Ball burst (N)	6.3	6.7
Softness panel	82	82

Three-ply products P3 and P4

15 Two different top/bottom ply base tissues, T3 and T4, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Crescent former with a two-layer headbox. The top/bottom ply base tissues were manufactured in a stratified mode, the composition of the furnish for the respective layers being as set out in the following table.

	T3	T4
Hood layer	Softwood pulp Non-wood pulp	Softwood pulp
Yankee layer	Hardwood pulp	Hardwood pulp

Two different middle ply base tissues, M3 and M4, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Twin Wire former with a
5 homogenous headbox.

The resulting base tissues are characterised in the following table.

	T3	T4	M3	M4
Composition (% dry weight)				
Softwood pulp	45	55	70	80
Hardwood pulp	45	45	20	20
Non-wood pulp	10	0	10	0
Basis weight (g/m ²)	≈ 16	≈ 16	≈ 19	≈ 19

- 10 Two different three-ply bathroom tissue products (toilet paper), P3 and P4, were manufactured by Goffra-Incolla technology assembly of three plies of base tissue as set out in the following table.

	P3	P4
Top ply	T3	T4
Middle ply	M3	M4
Bottom ply	T3	T4

- 15 Properties of the manufactured three-ply bathroom tissue products are reported in the following table. Results for P3 are means of 31 datapoints from 5 different production runs using base tissues from different production dates. Results for P4 are means of a larger number of datapoints collected from a larger number of production runs.

	P3	P4
Basis weight (g/m ²)	50.3	50.4
Thickness per sheet (mm)	0.50	0.48
GMT strength (N/m)	290	264
Ball burst (N)	4.4	4.7
Softness panel	80	80
Absorption (g/g)	9.2	9.4

Thus, in summary, the results indicate that introduction of various amounts of the non-wood cellulose fibres into different tissue paper materials results in acceptable or insignificant changes in parameters relevant for the function of the tissue paper material, such as the GMT strength, the softness, the absorption and/or the thickness, as compared to the same tissue paper material without non-wood fibre content.

The advantageous results are believed to be at least partially due to the use of the non-wood fibres, and in particular the various features which may be contributing to the advantageous properties of tissue paper materials and products including the non-wood fibres as set out in the above.

For example, as in the samples in the above, the non-wood cellulose pulp fibre may have a breaking length/average fibre length ratio greater than 4. Also, the non-wood pulp fibres may be never-dried. Further, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts such as one out of wheat straw, oat straw, barley straw, and/or rye grass, for example wheat.

20

However, other combinations of features as described in the above for the non-wood cellulose fibres may be made by a person skilled in the art to provide the tissue materials and tissue products as proposed herein.

Hence, the results, although relating to specific examples of tissue paper materials and tissue paper products are believed to indicate that the non-wood fibres as such may be used to provide advantageous results in for a wider range of tissue paper materials and tissue paper products.

EXAMPLE 4: (TAD Tissue paper material)

One-ply tissue paper materials intended for use as kitchen towels were produced using TAD technology with different dry content of non-wood fibre.

5

Two versions of the tissue paper materials were made, one comprising 0% dry weight non-wood fibres, and one comprising 30% by dry weight non-wood fibres.

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp of this type generally has a lignin content of less than 15 % and a hemicellulose content of more than 15 %.

The breaking length, average fibre length, and ratio breaking length/average fibre length of the non-wood cellulose fibre pulp are indicated in the table below:

	Non-wood fibre
Breaking length [m]	5338
Average fibre length[μm]	854
BL/av fibre length	6.25

15

The conventional short fibre content was made out of dried hardwood cellulose fibre pulp. The dried hardwood cellulose fibre pulp was dried Eucalyptus fibre pulp, BEK (Bleached Eucalyptus Kraft).

The conventional long fibre content was made out of dried softwood cellulose fibre pulp. In this example, the dried softwood cellulose fibre pulp was NBSK (Northern Bleached Softwood Kraft).

The breaking length/average fibre length ratio of BEK in general has been found to be about 2.4, and the breaking length/average fibre length ratio of NBSK has been found to be about 1.2, as indicated in the table in the Summary section in the above.

20

The machine was a stratified machine with 3 layers headbox, fed with 2 fibre lines:

- The long fibre line is feeding the Hood and Yankee layers of the headbox
- the short fibre line is feeding the middle layer of the headbox

The overall furnish of the reference and the trial were the following

- 5
- Reference: 42% BEK – 58% NBSK
 - Trial: 12% BEK– 58% NBSK – 30% straw

The different fibres were split and treated as follow:

Trial	Trial	reference	trial
Overall furnish	NBSK	58%	58%
	BEK	42%	12%
	Non-wood	0	30%
Long fibre line	NBSK	83%	83%
	Non-wood	17%	17%
	Refining	160 kwh/T	160 kwh/T
Short fibre line	BEK	100%	0%
	Non-Wood	0%	100%
	Refining	30 kwh/T	none
Headbox	Configuration	stratified	stratified
	Yankee layer	41.5% NBSK + 8.5% BEK	41.5% NBSK + 8.5% BEK
	Middle layer	100% BEK	100% Non-wood
	Hood layer	41.5% NBSK + 8.5% BEK	41.5% NBSK + 8.5% BEK

10

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the different qualities.

The average base sheet properties are as follows

15

	Basis weight (g/m ²)	Thickness (1 sheet) mm	Dry tensile MD (N/m)	Dry tensile CD (N/m)	Stretch MD (%)	GMT (N/m)	Wet tensile MD (N/m)	Wet tensile CD (N/m)	ABSORPTION (g/g)
Reference	22.1	0.43	257	189	15.0	220	87.1	68.4	13.7
Trial 30% Non-wood	22.4	0.45	276	205	13.9	237	87.5	63.4	14.5

Despite no refining on the short fibre line, the tissue paper material containing non-wood fibres tends to be stronger than the reference paper material without non-wood.

- 5 As seen from the values in the table in the above, and as illustrated by the diagrams in Fig. 1, the trial with non-wood is significantly more absorbent than the reference tissue paper material without non-wood.

Thus, the tissue paper material including 30% non-wood fibres was even more absorbent
10 than the tissue paper material including 0% non-wood fibre.

EXAMPLE 5: TAD tissue paper material and 2-ply TAD tissue paper product

- Two-ply tissue paper products intended for use as kitchen towels were produced using
15 TAD technology. The two-ply tissue paper products were produced from tissue paper materials (base sheets) produced using TAD technology and with different dry content of non-wood fibre.

The non-wood fibre pulp was derived from wheat straw, being treated according to the
20 Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp of this type generally has a lignin content of less than 15 % and a hemicellulose content of more than 15 %.

The breaking length, average fibre length, and ratio breaking length/average fibre length of the non-wood cellulose fibre pulp are indicated in the table below:

25

	Non-wood fibre
Breaking length [m]	5493
Average fibre length[μ m]	861
BL/av fibre length	6.38

The softwood cellulose fibre pulp and the hardwood cellulose pulp were similar to those used in Example 1 in the above.

Tissue paper material 1 (TP1) was made using 0% dry content of non-wood fibres.

Tissue paper material 2 (TP2) was made using 20% dry content of non-wood fibres.

Tissue paper material 3 (TP3) was made using 30% dry content of non-wood fibres.

The proportions between the conventional short fibre i.e. the Eucalyptus fibre pulp BEK (Bleached Eucalyptus Kraft), the conventional long fibre content, i.e. the Softwood fibre pulp NBSK (Northern bleached softwood kraft), and the non-wood fibres are indicated in the table in the below.

Conditions		TP1 (0%)	TP2 (20%)	TP3 (30%)
Overall furnish	BEK	25%	5%	
	NBSK	75%	75%	70%
	Non-wood		20%	30%
Refining kwh/T	Long fibres	160	150	150
Refining kwh/T	Short fibres	32	Off	Off

The machine was a stratified machine. Long fibre line was feeding Hood and Yankee layers of the headbox; the short fibre line feeding the middle layer.

10

For TP1, Long fibre line was 100% NBSK, and Short fibre line was eucalyptus BEK .

For TP2 and TP3, non-wood fibre substituted or all of the eucalyptus (BEK). The non-wood fibre was not refined.

15

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the 3 qualities TP1, TP2 and TP3.

Chemical flows were equally split between both fibre lines.

20

Basis weight, thickness, dry tensile strength and absorption were measured for the resulting tissue paper materials. The results are indicated in the table in the below.

	Non-wood content	Basis weight (g/m ²)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT	Absorption (g/g)
TP1	0%	21.2	0.4	334	245	286	14.0
TP2	20%	21.3	0.4	265	232	248	13.9
TP3	30%	21.4	0.4	279	234	255	14.7

Fig. 2a is a diagram illustrating the absorption of the tissue paper material comprising 0 % non-wood cellulose pulp fibres as compared to the absorption of the tissue paper material comprising 30% non-wood cellulose pulp fibre.

5

As seen in Fig. 2a and indicated in the table, the tissue paper material comprising 30% non-wood fibre displayed better absorption than the tissue paper material comprising 0% non-wood fibre. The tissue paper material comprising 20% non-wood cellulose pulp fibre displayed similar absorption as the tissue paper material comprising 0% non-wood

10 cellulose pulp fibre.

The tensile strength of the tissue materials comprising non-wood cellulose pulp fibre is slightly less than the tensile strength of the tissue material with no non-wood cellulose pulp fibre. However, the deviation in tensile strength is not very significant and the tensile

15 strength is still within acceptable limits.

Two-ply products were formed using the reference tissue paper material TP1 comprising 0% non-wood fibre and the tissue paper material TP3 comprising 30% non-wood fibre as described in the above.

20

2-ply product 1 (2P-1): 2 plies of the TP1, meaning that the 2-ply product comprises 0% non-wood fibres.

2-ply product 2 (2P-2): 2 plies of TP3, meaning that the 2-ply product comprises 30% dry weight non-wood fibres.

25

The 2-ply tissue paper products were produced by assembling the tissue paper materials (base sheets) using nested 2-ply technology.

Basis weight, thickness, tensile strength, softness panel and absorption was measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m ²)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
2P-1	0%	41.5	0.72	647	457	544	5.6	13.5
2P-2	30%	41.1	0.74	581	431	500	5.5	14.4

5

Fig. 2b illustrates the absorption of the two-ply tissue paper products. As seen in Fig. 2b and in the table above, the two-ply tissue paper product comprising 30% by dry weight non-wood fibres (2P-2) displayed a higher absorption at a comparable basis weight and thickness than the two-ply tissue paper product comprising no non-wood fibres.

10

The dry tensile strength results of the two-ply tissue paper product comprising 30% by dry weight of non-wood fibres (2P-2) were satisfactory to the intended use of the two-ply tissue paper product as a kitchen towel. Further, the softness of the two-ply tissue paper product comprising 30% by dry weight non-wood fibres (2P-2) displayed a similar softness

15 to the two-ply tissue paper product comprising no non-wood fibres.

In all, the results indicate that the two-ply tissue paper products comprising non-wood fibres will display at least a similar absorption as the multi-ply tissue paper product comprising no non-wood fibre. Also, dry tensile strength and softness of the two-ply tissue

20 products are satisfactory. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Example 6: CWP Tissue paper product

Three-ply tissue paper products intended for use as kitchen towels were produced using

25 CWP technology. The three-ply tissue paper products were produced from tissue paper

materials (base sheets) produced using CWP technology and with different dry content of non-wood fibre.

The pilot machine used was a Crescent former with suction presser roll configuration, with
5 a 2 layers Headbox: 50% Top Layer, 50% Bottom Layer.

The machine was run in homogenous mode (same recipe on both layers of the base paper), but 2 fibre lines were used and treated differently.

10 The amount of non-wood fibre introduced ranged from 0 to 50% of the total blend for producing the tissue paper materials (base sheets).

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was
15 never-dried pulp. The non-wood fibre pulp had a lignin content of 12.8 and a hemicellulose content of 18.0.

The conventional short fibre content was made out of Hardwood. The Hardwood fibre pulp was never-dried pulp.

20

The conventional long fibre content was made out of Softwood. In this example, the Softwood fibre pulp was also never-dried pulp. The breaking length and morphology of the hardwood and softwood fibre pulp were as indicated in the table below:

	Non-wood (never-dried)	Softwood (never-dried)	Hardwood (never-dried)
Breaking length (m)	3775	1755	882
Average fibre length (microm)	748	2165	929
Fibre width (microm)	20	29	21
Fibre coarseness (mg/m)	0.13	0.20	0.13
Ration breaking length/fibre length (- /micro)	5.05	0.81	0.95

25

The composition of the different tissue paper materials (base sheets) and the refining level used is indicated in the below

Trial reference	Non-wood content	Long fibre content	Short fibre content	Long fibre line refining	Short fibre line refining
		%	%	kwh/T	kwh/T
G3-A	0%	85%	15%	150	0
G3-B	20%	65%	15%	120	10
G3-C	50%	45%	5%	80	10

5

The different fibres were split in the different layers of the stock preparation as follows:

Trial	Trial	G3-A	G3-B	G3-C
Overall furnish	softwood (never dried pulp)	85%	65%	45%
	hardwood (never dried pulp)	15%	15%	5%
	Straw	0%	20%	50%
Long fibre line	softwood (never dried pulp)	100%	100%	100%
	Straw	0%	0%	0%
	Refining kwh/T	150	120	80
Short fibre line	hardwood (never dried pulp)	100%	43%	9%
	Straw		57%	91%
	Refining	No	10	10
Headbox	Configuration	Homogenous	Homogenous	Homogenous
	Yankee layer	85% LF + 15% SF	65% LF + 35% SF	45% LF + 55% SF
	Hood layer	85% LF + 15% SF	65% LF + 35% SF	45% LF + 55% SF

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the different qualities.

10

Average base sheet properties

Trial reference			BW	Caliper	MD	Stretch MD	CD	MD wet	CD Wet	Dry/Wet
			g/m ²	mm/10-ply	N/m	%	N/m	N/m	N/m	%
	Non-wood content	Target	18	1.2	290	17	145	90	30	25
		Min	17.5	0.9	280	15	130	65	25	21
		Max	18.5	1.4	350	19	170	100	35	
G3-A	0%	Average	17.9	0.97	299	18.3	136	77	27	26
		std	0.3	0.11	14	1.4	8	2	3	2
G3-B	20%	Average	18.5	0.95	327	17.9	141	85	28	26
		std	0.5	0.08	38	3.0	15	10	4	4
G3-C	50%	Average	18.7	1.00	293	16.7	139	67	23	23
		std	0.6	0.03	17	1.7	10	11	1	3

Trial reference	Non-wood content	Long fibre content	Short fibre content	Long fibre line refining	Short fibre line refining	GMT	Absorption g/g
		%	%	kwh/T	kwh/T		
G3-A	0%	85%	15%	150	0	201	6.7
G3-B	20%	65%	15%	120	10	215	6.5
G3-C	50%	45%	5%	80	10	202	6.3

5

Despite the lower long fibre content and the lower refining level, the tissue paper materials with non-wood cellulose pulp fibre had similar or higher tensile strength than the tissue paper material without non-wood cellulose pulp fibre.

- 10 As for absorption, the tissue paper materials with non-wood cellulose pulp fibre did not differ significantly from the tissue paper materials without non-wood cellulose pulp fibre.

Multi-ply products were formed out of the tissue paper materials (basesheets with)the different non-wood fibre contents. The multi-ply products where three-ply products formed by nesting.

- 15 Multi-ply product 1: G3A+ G3A+ G3A – i.e. 3 plies with 0% non-wood fibre, and fibre content by dry weight of the entire multi-ply product 1 is 0%.

Multi-ply product 2: G3B+G3B+ G3B – i.e. 3 plies with 20% non-wood fibre, and fibre content by dry weight of the entire multi-ply product 2 is 20%.

Multi-ply product 3: G3B+G3C+G3b – i.e. 2 plies with 20% non-wood fibre and 1 ply with 50% non-wood fibre, giving a fibre content by dry weight of the entire multi-ply product 3 being 30%.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m ²)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
MP1	0%	55.2	0.71	623	234	382	4.4	9.2
MP2	20%	55.6	0.69	799	309	497	4.2	9.6
MP3	30%	56.5	0.73	695	252	418	4.3	9.6

Fig. 3 is a diagram over the absorption values of the three different multi-ply products MP1, MP2, and MP3. As seen from the table and in Fig. 3, the absorption of the multi-ply tissue paper products comprising 20% or 30% by dry weight of the non-wood fibres were even better than the absorption of the multi-ply tissue paper product comprising no non-wood further. Also, as indicated in the table in the above, the multi-ply tissue paper products comprising non-wood fibres displayed values for dry tensile strength and softness which were comparable to that of the multi-ply tissue paper product comprising no non-wood fibre.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Example 7: HYBRID tissue paper product

Two-ply tissue paper products intended for use as kitchen towels were formed comprising one ply being produced with structured tissue technology and one ply being produced with CWP (Conventional Wet Pressed) technology.

- 5 A reference two-ply tissue paper product (HYB1) comprising 0% non-wood fibres was formed from one tissue paper material ply produced by TAD technology being TP1 as described in Example 2 in the above, and one tissue paper material ply produced by CWP technology being G3-A as described in Example 3 in the above.

- 10 A two-ply tissue paper product (HYB2) comprising 25% non-wood fibres was formed from one tissue paper material ply produced by TAD technology and comprising 30% by dry weight non-wood fibre being TP3 as described in example 2 in the above, and one tissue paper material ply produced by CWP technology comprising 20% by dry weight non-wood fibre, being G3-B as described in example 3 in the above.

The two-ply tissue paper products were assembled by nesting.

- 15 Basis weight, thickness, tensile strength, softness panel and absorption were measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
HYB1	0%	40.4	0.73	503	270	368	4.6	13.3
HYB2	25%	39.0	0.75	456	309	375	4.4	13.9

- 20 Fig. 4 is a diagram over the absorption values of the two two-ply tissue paper products HYB 1 and HYB2. As seen from the table above and in Fig. 4, the absorption of the multi-ply tissue paper product comprising 25% by dry weight of the non-wood fibres was even better than the absorption of the multi-ply tissue paper product comprising no non-wood. Also, as indicated in the table in the above, the multi-ply tissue paper product comprising non-wood fibres displayed values for dry tensile strength and softness which were comparable to that of the multi-ply tissue paper product comprising no non-wood fibre.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

5 EXAMPLE 8: varying thickness

Two-ply tissue paper products comprising two plies made by TAD technology and similar to 2P-1 and 2P-2, as obtained in the above Example 2, were used as a starting point.

To vary the thickness of the two-ply products, the assembly of the two plies in each product was varied by varying the nip used when nesting the two plies together. Thus,
10 one two-ply product with original thickness, one two-ply product with increased thickness, and one two-ply product with decreased thickness was formed for each of the qualities 2P-1 and 2P-2, as indicated in the above.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the two two-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m ²)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	Softness panel	Absorption (g/g)
2P-1 Decreased thickness	0	42.5	0.71	707	507	5.0	13.3
2P-1 original	0	41.9	0.75	613	467	5.2	13.2
2P-1 Increased thickness	0	43.3	0.79	608	430	5.2	13.0
2P-2 Decreased thickness	30	40.5	0.73	513	488	4.6	14.3
2P-2 original	30	40.4	0.76	518	478	4.7	14.7
2P-2 Increased thickness	30	40.2	0.82	462	421	4.5	14.7

The absorption over thickness achieved for the two qualities 2P-1 and 2P-2 are illustrated in Fig. 5.

As may be seen in Fig. 5 and as indicated in the table above, the absorption of the two-ply
5 paper tissue product 2P-2 comprising non-wood fibres is higher than the absorption the
two-ply paper tissue product 2P-1 comprising no non-wood fibres for all of the various
thicknesses.

Further, the results indicate that the absorption results are stable to thickness variations.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood
5 fibres may be obtained while still achieving a satisfactory tissue paper product.

Although the results in the above were achieved for specific examples of tissue paper materials and tissue paper products, the finding that the non-wood cellulose pulp fibres and the non-wood plies as described herein are indeed suitable for forming tissue paper materials and tissue paper products may be applied to a wide range of such materials and
10 products.

EXAMPLE 9: Non-wood pulp

Non-wood pulp was manufactured in the form of a never-dried cellulose fibre pulp derived
15 from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. By analysis of samples taken during manufacture, the non-wood pulp was characterised as set out in the following table.

	Length weighted fiber length (µm)	Fiber width (µm)	Breaking length (m)	Breaking length / fiber length ratio
Minimum	785	19	5870	7.2
Average	862	20	6788	8.1
Maximum	965	22	7790	9.5
Number of data points	22	21	24	11

20

DEFINITIONS

Tissue paper material: The term “tissue paper material” as used herein refers to the one-ply base tissue as obtained from a tissue machine.

25

Layer: The tissue paper material may comprise one or more layers, i.e. it may be a single-layered or a multi-layered web. The term “layer” refers to a stratum within the web having

a defined fibre composition. The one or more layers is/are formed by depositing one or more streams of pulp furnishes onto a wire with a pressurized single-or multi-layered headbox.

- 5 Ply: The term "ply" as used herein refers to the one or more plies of tissue paper material in the final tissue paper product as are obtained after processes, i.e. converting, one or more base tissue webs. Each individual ply consists of a tissue paper material comprising one or more layers, e.g. one, two, or three layers.
- 10 Hardwood: As hardwood we understand herein fibrous pulp derived from the woody substance of deciduous trees (angiosperms). For example, hardwood includes eucalyptus. Typically, hardwood fibres are relatively short fibres. For example, the hardwood fibres may have an average fibre length less than 1700 μm . The hardwood fibres may for example have a diameter of 15 to 40 μm and a wall thickness of 3 to 5 μm .
- 15 Softwood: as softwood we understand fibrous pulp derived from the woody substance of coniferous trees (Gymnosperms). Typically, softwood fibres are relatively long fibres. For example, the softwood fibres may have an average fibre length above 1700 μm , such as above 1950 micron, for example the soft wood fibres may have an average fibre length in
- 20 a range from 1700 to 2500. μm . The softwood fibres may for example have a diameter of from 30 to 80 μm , and a wall thickness of from 2 to 8 μm .
- Conventional short fibres: As conventional short fibres we understand herein hardwood fibres as described in the above. Generally, the conventional short fibres may have an
- 25 average fibre length less than 1700 μm .

Conventional long fibres: As conventional long fibres we understand herein softwood fibres as described in the above. Generally, the conventional long fibres may have an average fibre length greater than 1700 μm .

30

CWP & structured tissue technology:

As described in the above, paper tissue webs can be produced in several ways. Conventional paper machines have been used for many years for that purpose, to produce such conventional webs at a relatively low cost.

An example of a conventional paper tissue web process is the dry crepe process which involves creping on a drying cylinder, the so-called yankee cylinder, by means of a crepe doctor. Wet creping can be used as well, if there are lower demands on the tissue quality. The creped, finally dry raw tissue paper, the so-called base tissue, is then available for
5 further processing into the paper product for a tissue paper product.

Recently, more advanced methods have been developed, such as e.g. Through Air Drying (TAD), Advanced Tissue Molding System (ATMOS) and similar methods for producing structured tissue webs. A common feature for these latter methods is that they result in a more structured web with a lower density than a web produced on a
10 conventional paper machine.

As used herein the term CWP technology (Conventional Wet Pressed technology) refers to conventional paper web processes, in which the tissue is formed on a forming fabric and dewatered by pressing with one or more pressure roll nips. The process may involve
15 transfer of the sheet to a Yankee dryer and removing the sheet from the Yankee surface by a doctor blade in a creping process. CWP technology as used herein includes for example dry crepe technology, wet crepe technology, and flat NTT (New Tissue Technology).

20 As used herein, the term structured tissue technology relates to the newer technologies for producing a structured tissue web. Such methods will not employ the high pressure used to dewater the web in the CWP process. Therefore, structured tissue technology is sometimes referred to as non-compressing de-watering technology. The structured tissue technology may for example be TAD (Thru-Air-Dried), UCTAD (Uncreped-
25 Through-Air-Dried) or ATMOS (Advanced-Tissue- Molding-System), textured NTT, QRT, PrimeLineTEX technology and eTAD technology.

The structured tissue technology methods are known from prior art, for example TAD is known from US5853547; and ATMOS from US 7744726, US7550061 and
30 US7527709; and UCTAD from EP 1 156925 and WO 02/40774.

TAD technology has been developed since the 1960's and is well known to a person skilled in the art. It generally involves developing functional properties of the tissue by moulding the fibre mat on a structured fabric. This results in the fibre mat forming a

structured tissue which may acquire high bulk and absorption due to air passing through the web while drying the web when still on the structured fabric.

ATMOS technology is a production method developed by Voith and which is also well known to a person skilled in the art.

Another example is textured NTT (New Tissue Technology). Textured NTT was designed to overcome some of the limitations of ATMOS by pressing at even higher pressures before transferring to the Yankee. A shoe press is used in the first pressing section between the former felt and a belt with cells designed to provide absorptive capacity and increase strength. The NTT technology may reduce the Yankee Hood drying load as compared to ATMOS.

Yet other examples are Prime Line Tex technology as rendered available by Andritz for production of textured tissue, and eTAD technology as rendered available by Valmet.

METHODS

Lignin content:

The measurement of residual lignin content in the pulp fibres has been carried out according to the draft standard ISO/DIS 21436: Pulps-Determination of lignin content – Method of acid hydrolysis 1), which includes:

- i) the gravimetric measurement of the residue after acid hydrolysis (AIL : Acid Insoluble Lignin or Klason Lignin), also described in the Tappi T222 om-02 method 2 ; and
- ii) the measurement of soluble lignin (ASL : Acid Soluble Lignin), also described in the technical note Tappi UM2503 .

3.1) Sample preparation: The samples were disintegrated with a grinder/mixer. Their dry matter contents were determined before analysis, by drying in an oven of an aliquot of 2-3 g at 105°C, according to the ISO 638 standard 4 .

- 3.2) Measurement of acid insoluble lignin (AIL or Klason lignin) after acid hydrolysis An aliquot of ~1 g was hydrolysed with a solution of sulfuric acid, firstly at ambient temperature (2 h) and then under reflux during 4 h (Procedure B of the future standard). After cooling, the suspension was filtered and washed and the solid residue
- 5 was collected, dried and weighted. The acid insoluble lignin content in the sample was determined by difference between the dry hydrolysis residue weight and the ash weight, reported to the dry mass content of the initial sample. Note 1 : Detection limit (DL) ~0.1% ; Quantification limit (QL) ~0.5%.
- 10 3.3) Measurement of acid soluble lignin. The absorbance at 205 nm of the hydrolysate (i.e. the filtrate collected during the filtration of the suspension, cf 3.2), were measured. The acid soluble lignin content (ASL) was determined according to the predefined extinction coefficient of the lignin (i.e. 110 L/g.cm). Note 2 : : Detection limit (DL) ~0.1% ; Quantification Limit (QL) ~0.5% Remark: This quantification method is sensitive to the
- 15 contaminants being present into the sample. Each compound other than hemicelluloses and cellulose and the acid insoluble minerals are susceptible to interfere with the measurement of the hydrolysis residue and with the acid soluble lignin.

Hemicellulose

- 20 The determination of the contents of the main polysaccharides in the pulp (arabinane, galactane, glucane, xylene, and mannane) has been made by using high performance anion exchange chromatography with a pulsed amperometric detector, HPAE/PAD-Dionex® analysis of free monosaccharides (arabinose, galactose, glucose, xylose and mannose) after sulphuric acid hydrolysis of the sample pulp. The cellulose and
- 25 the hemicellulose content in the pulp sample is determined according to standard method ISO / DIS21437 – Pulps: Determination of carbohydrate (under publication) after calibration. The samples studied are chemical pulp which has not required extraction of acetone beforehand. In contrast, the samples have been dried. However, considering the pulp state (wet lap sheets), samples were grinded before analysis. Dry content of the
- 30 grinded samples was measured according to NF EN ISO 638:2008.

Basically the method is quantifying the amounts of sugars (monosaccharides) after hydrolysis of cellulose and hemicellulose using the ISO / DIS 21437 – Pulps: Determination of carbohydrate. Then, calculation is made backwards to estimate level of hemicelluloses

35 (knowing proportion of sugars in hemicellulose and cellulose)

Basis weight

Basis weight is determined in accordance with ISO 12625-6: 2016.

The basis weight is determined in g/m².

5 Thickness per sheet:

Thickness is determined in accordance with ISO 12625-3:2014.

GMT strength:

GMT strength (Geometric Mean Tensile strength) refers to the square root of the product of the machine direction dry tensile strength and the cross-direction dry tensile strength of
10 a tissue web/product.

The GMT strength is determined in accordance with ISO 12625-4:2016.

A load cell of 100N was used.

Absorption:

Absorption is herein the water absorption capacity of the tissue paper. Water absorption
15 capacity is the amount of water the sample is able to absorb, reported in g/g (i.e. g water / g material in sample).

Absorption was measured according to ISO12625-8:2010.

The water is deionized water, conductivity ≤ 0.25 mS/m at 25°C, in accordance with ISO14487.

20 Softness panel:

Panel softness is determined by evaluation made by panel members. The panelists rank products in terms of softness. The Softness Panel values are therefore comparative values enabling a comparison between the samples tested, rather than an absolute parameter.

25 The softer the product/tissue base sheet is rated the higher the value will be.

Softness values of tissue paper products (finished goods) and tissue base sheets are not directly comparable as there are different scales/reference products.

Each sample is composed of one product, i.e. a multi-ply tissue paper product.

The dimensions of the samples are therefore the dimensions of the finished products.

Samples are placed in MD before the panelists.

Samples are conditioned for minimum 2 hours in a controlled area at 23°C and 50%
5 relative humidity.

The different samples are comfort rated by five or ten panelists, and an average comfort rating for each product is determined over the panelists.

Hence, softness panel values are comparative values within a test and indicate the perceived softness of a product.

- 10 For the purpose of this application, softness panel values given in one and the same table are comparable and indicate the perceived relative softness of the products tested. The higher the value of the rating, the more comfortable is the product.

Average fibre length measurement:

- 15 Fibre length measurement was made using the standard for fibre analyser: ISO 16065-2:2014: Pulps – Determination of fibre length by automated optical analysis – Part 1: Unpolarized light method.

Length-weighted mean length was used and the average of the length – weighted fibre-
20 length distribution.

Breaking length measurement

- The breaking length is the calculated upper limit of length of a uniform paper strip that would support its own weight if it were suspended at one end. Breaking length (m) = $102 \times$
25 T/R , where T = Tensile strength, N/m, and R = basis weight, g/m².

The breaking length is a pulp characteristic obtained by tensile strength and basis weight measurements as measured on lab handsheets produced in accordance with EN ISO 5269-2. (Tensile strength: ISO 12625-4:2016; basis weight: ISO 12625-6: 2016)

Ratio of breaking length measurement/average fibre length measurement

The ratio of breaking length/average fibre length is herein using the values of the fibre length measurement and the breaking length measurements as achieved according to the methods in the above, the average fibre length measurement being reported in μm , and

5 the breaking length being reported in m.

It may be noted that the breaking length, as well as the average fibre length, are pulp characteristics. Accordingly, the measurements of these properties are to be performed on the pulp as received from the pulping process, before reaching the papermaking
10 process, such as before entering the stock preparation in a paper machine. Thus, the measurements are done prior to any mechanical and/or chemical and/or enzymatic treatment for strength adjustment which may occur during the paper making process.

Ball-burst

15 Ball-burst is determined according to ISO 12625-9:2015.

Fiber width

Fiber width is herein determined using a Morfi fiber analyzer.

20

ITEMIZED LIST OF EMBODIMENTS

- 25 1. A single-ply tissue paper material having a basis weight less than 40 gsm and an absorbency of at least 3 g/g, comprising a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 30 2. A single-ply tissue paper material according to item 1, wherein the tissue paper material has an absorbency of at least 4 g/g.
3. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has an absorbency of at least 5 g/g.

4. A single-ply tissue paper material according to any one of the previous items being produced by CWP (Conventional Wet Pressed) technology.
- 5 5. A single-ply tissue paper material according to any one of the items 1 to 3, being produced by structured tissue technology and having an absorbency of at least 6 g/g.
- 10 6. A single-ply tissue paper material according to any one of the items 1 to 3, being produced by structured tissue technology and having an absorbency of at least 7 g/g.
- 15 7. A single-ply tissue paper material according to any one of the items 1 to 3, being produced by structured tissue technology and having an absorbency of at least 8 g/g.
8. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has a GMT tensile strength of at least 60 N/m.
- 20 9. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has a GMT tensile strength of at least 70 N/m.
10. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has a GMT tensile strength of at least 80 N/m.
- 25 11. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of less than 30 gsm.
12. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of less than 25 gsm.
- 30 13. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of more than 10 gsm.
- 35 14. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of more than 15 gsm.

15. A single-ply tissue paper product comprising a single-ply tissue paper material according to any one of the items 1 to 14.
- 5 16. A multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having an absorption of at least 4 g/g, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 10 17. A multi-ply tissue paper product according to item 16, wherein the multi-ply tissue paper product has an absorbency of at least 5 g/g.
- 15 18. A multi-ply tissue paper product according to item 16 or 17, wherein multi-ply tissue paper product has an absorbency of at least 6 g/g.
- 20 19. A multi-ply tissue paper product according to any one of the items 16 to 18, wherein at least one ply of the multi-ply tissue paper product is produced by CWP (Conventional Wet Pressed) technology.
- 25 20. A multi-ply tissue paper product according to any one of the previous items, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 7 g/g.
- 30 21. A multi-ply tissue paper product according to any one of the previous items, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 8 g/g.
- 35 22. A multi-ply tissue paper product according to any one of the previous items, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 9 g/g.

23. A multi-ply tissue paper product according to any one of the previous items but item 19, wherein all plies of the multi-ply tissue paper product are produced by structured tissue technology.
- 5 24. A multi-ply tissue paper product according to any one of the items 16 to 23, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 100 N/m.
- 10 25. A multi-ply tissue paper product according to any one of the items 16 to 24, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.
- 15 26. A multi-ply tissue paper product according to any one of the items 16 to 25, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.
- 20 27. A multi-ply tissue paper product according to any one of the items 16 to 26, wherein at least 50 % of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 25 28. A multi-ply tissue paper product according to any one of the items 16 to 27, wherein all of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 30 29. A multi-ply tissue paper product according to any one of the items 16 to 28, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.
- 35 30. A multi-ply tissue paper product according to any one of the items 16 to 29, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

- 5 31. A multi-ply tissue paper product according to any one of the items 16 to 30, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.
32. A multi-ply tissue paper product according to any one of the items 16 to 31, wherein said multi-ply tissue paper material or product comprises two to five plies.
- 10 33. A multi-ply tissue paper product according to any one of the items 16 to 32, wherein each ply of the multi-ply product comprises the same amount of non-wood cellulose pulp fibres.
- 15 34. A multi-ply tissue paper product according to any one of the items 16 to 33, wherein at least two plies comprise different amounts of non-wood cellulose pulp fibres.
- 20 35. A multi-ply tissue paper product according to any one of the items 16 to 34, wherein said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper material.
- 25 36. A multi-ply tissue paper product according to item 35, wherein the multi-ply tissue paper material comprises at least two non-wood tissue plies, the non-wood tissue plies forming a first and a second outer ply of the multi-ply tissue paper product.
- 30 37. A multi-ply tissue paper product according to any one of the items 16 to 36, wherein said non-wood tissue ply is formed by a single-ply tissue paper material in accordance with any one of items 1 to 14.
38. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres contain at least 15% hemicellulose.

39. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres contain no more than 15 % lignin.
- 5 40. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1700 μm .
- 10 41. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1200 μm .
- 15 42. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1000 μm or less than 900 μm .
- 20 43. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose fibres have a breaking length of more than 3000 m or more than 5500 m.
- 25 44. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 3.7.
- 30 45. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.
- 35 46. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding items, wherein

the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5, such as more than 5, more than 5.5 or more than 6.5.

- 5 47. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are derived from a member of the Poaceae family, such as from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sugar cane bagasse and/or sorghum.
- 10 48. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family, such as from hemp and/or hop.
- 15 49. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are agricultural waste or byproduct, such as derived from agricultural waste or byproduct of the Poaceae family and/or
- 20 Cannabaceae family such as exemplified in the above, including agricultural waste or byproduct from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop and/or wherein the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct such as banana harvest residue (belongs to the family Musaceae), pineapple residue
- 25 (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.
- 30 50. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass, succulents, alfalfa (belongs to the family Fabaceae), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).

51. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 15%.
52. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 20%.
53. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight.
54. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight.
55. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.
56. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to item 55, wherein said non-wood tissue ply comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the non-wood tissue ply.
57. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to item 55 or 56, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 95/5.

58. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the items 55 to 57, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 90/10.
- 5
59. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the items 55 to 58, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 80/20.
- 10
60. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the previous items, wherein said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply or plies.
- 15
61. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the previous items, wherein said non-wood tissue ply or plies comprises two or more layers, and at least one layer comprises non-wood cellulose pulp fibres.
- 20
62. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, said non-wood tissue ply or plies being produced by conventional wet press technology (CWP).
- 25
63. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, said non-wood tissue ply or plies being produced by structured tissue technology, for example TAD (Through Air Drying), ATMOS, textured NTT, UCTAD, eTAD, QRT or PrimeLineTEX.
- 30
64. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein a portion or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibre.
- 35

- 5 65. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, comprising softwood cellulose pulp fibres and wherein a portion or all softwood cellulose fibres are never-dried softwood cellulose pulp fibre.
- 10 66. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, comprising hardwood cellulose pulp fibres and wherein a portion or all hardwood cellulose fibres are never-dried hardwood cellulose pulp fibre.
- 15 67. Single-ply tissue paper product or multi-ply tissue paper product according to any one of the items 15 to 66, the tissue paper product being for personal hygiene, such as toilet paper, hand wipes, paper napkins, facial wipes, handkerchiefs or the tissue paper product being a kitchen towel or industrial wipe.

CLAIMS

1. A single-ply tissue paper material having a basis weight less than 40 gsm and a GMT tensile strength of at least 60 N/m, comprising a non-wood tissue ply, said
5 non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
2. A single-ply tissue paper material according claim 1, wherein the tissue paper
10 material has a GMT tensile strength of at least 70 N/m.
3. A single-ply tissue paper material according claim 1 or 2, wherein the tissue paper material has a GMT tensile strength of at least 80 N/m.
- 15 4. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 30 gsm.
5. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 25 gsm.
- 20 6. A single-ply tissue paper product consisting of a single-ply tissue paper material according to any one of the claims 1 to 5.
7. A multi-ply tissue paper product comprising two or more plies, wherein an
25 average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having a GMT tensile strength of at least 100 N/m, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 30 8. A multi-ply tissue paper product according to claim 7, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

9. A multi-ply tissue paper product according to claim 7 or 8, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.
- 5 10. A multi-ply tissue paper product according to any one of the claims 7 to 9, wherein at least 50 % of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 10 11. A multi-ply tissue paper product according to any one of the claims 7 to 10, wherein all of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.
- 15 12. A multi-ply tissue paper product according to any one of the claims 7 to 11, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.
- 20 13. A multi-ply tissue paper product according to any one of the claims 7 to 12, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.
- 25 14. A multi-ply tissue paper product according to any one of the claims 7 to 13, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.
- 30 15. A multi-ply tissue paper product according to any one of the claims 7 to 14, wherein said multi-ply tissue paper material or product comprises two to five plies.
- 35 16. A multi-ply tissue paper product according to any one of the claims 7 to 15, wherein each ply of the multi-ply product comprises the same amount of non-wood cellulose pulp fibres.

17. A multi-ply tissue paper product according to any one of the claims 7 to 15, wherein at least two plies comprise different amounts of non-wood cellulose pulp fibres.
- 5 18. A multi-ply tissue paper product according to any one of the claims 7 to 17, wherein said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper material.
- 10 19. A multi-ply tissue paper product according to claim 18, wherein the multi-ply tissue paper material comprises at least two non-wood tissue plies, the non-wood tissue plies forming a first and a second outer ply of the multi-ply tissue paper product.
- 15 20. A multi-ply tissue paper product according to any one of the claims 7 to 19, wherein said non-wood tissue ply is formed by a single-ply tissue paper material in accordance with any one of claims 1 to 5.
- 20 21. A single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 6 to 20, wherein the tissue paper product has an absorbency of at least 7 g/g.
- 25 22. A single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 6 to 21, wherein the tissue paper product has an absorbency of at least 8 g/g.
- 30 23. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres contain at least 15% hemicellulose.
- 35 24. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres contain no more than 15 % lignin.
25. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein

the non-wood cellulose pulp fibres have an average fibre length of less than 1700 μm .

- 5 26. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1200 μm .
- 10 27. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1000 μm or less than 900 μm .
- 15 28. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length of more than 3000 m or more than 5500 m.
- 20 29. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 3.7.
- 25 30. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.
- 30 31. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5, such as more than 5, more than 5.5 or more than 6.5.
- 35 32. A single-ply tissue paper material, a single-ply tissue paper product or a multiply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the *Pocacea*

family, such as from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sugar cane bagasse and/or sorghum.

- 5 33. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family, such as from hemp and/or hop.
- 10 34. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are agricultural waste or byproduct, such as derived from agricultural waste or byproduct of the Poaceae family and/or Cannabaceae family such as exemplified in the above, including agricultural waste or byproduct from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop and/or wherein the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.
- 15 35. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae) , switchgrass , succulents, alfalfa (belongs to the family Fabaceae.), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).
- 20 36. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 15%.
- 30 37. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein
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said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 20% by dry weight.

- 5 38. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight.
- 10 39. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight.
- 15 40. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.
- 20 41. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 40, wherein said non-wood tissue ply comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the non-wood tissue ply.
- 25 42. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 40 or 41, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 95/5.
- 30 43. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 40 to 42, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 90/10.
- 35 44. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 40 to 43, wherein

the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 80/20.

- 5 45. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply or plies.
- 10 46. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises two or more layers, and at least one layer comprises non-wood fibres.
- 15 47. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by conventional wet press technology (CWP).
- 20 48. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by structured tissue technology, for example TAD (Through Air Drying), ATMOS, NTT(textured), UCTAD, QRT, eTAD or PrimeLineTEX.
- 25 49. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein a portion of or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibre.
- 30 50. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, comprising softwood cellulose pulp fibres and wherein a portion of or all softwood cellulose fibres are never-dried softwood cellulose pulp fibre.
- 35 51. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims,

comprising hardwood cellulose pulp fibres and wherein a portion of or all hardwood cellulose fibres are never-dried hardwood cellulose pulp fibre.

- 5 52. Single-ply tissue paper product or multi-ply tissue paper product according to any one of the claims 6 to 51, the tissue paper product being for personal hygiene, such as toilet paper, hand wipes, paper napkins, facial wipes, handkerchiefs or the tissue paper product being a kitchen towel or industrial wipe.