Fluff Pulp Performance Improved by Alternative Pine Species

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ABSTRACT
Absorbent products suppliers are constantly improving the main components of their product's matrix materials, but few of them are related to the fluff pulp itself, currently treated as commodity. In order to maximize the pulp potential, the objective of this work was to evaluate and compare different softwood species including *Pinus taeda* and *Pinus maximinoi* in terms of their properties and impact in absorbent pads. These species were chosen since *P. taeda* wood is the most used pine species in Brazil for softwood pulp production and *P. maximinoi* has potential for forest exploration due to its high fibrous yield. When compared to *P. taeda*, the pulp fibers from *P. maximinoi* showed better results regarding morphology through larger fiber length 8%, width 9% and wall thickness 25% resulting in a coarseness 23% higher, parameters considered important for wicking. *P.maximinoi* also presented lower cut tendency in the Hammermill, contributing to better process yields in the customer's facilities. However, due to higher coarseness, the number of fibers per milligram were reduced by 25%, which can contribute to higher empty volume between fibers, leading to greater liquid flow inside the pads. Other properties such as burst strength and shredding energy consumption usually correlated, showed significant reductions of 17% and 24% respectively. Altogether, this study proves the feasibility of exploring new wood species for fluff pulp, especially *P. maximinoi* as a raw material that through its properties may contribute to the final product's performances.

Keywords: fluff pulp, absorbent products, performance, softwood, *Pinus taeda, Pinus maximinoi.*

INTRODUCTION

Innovations related to absorbent products are performed mainly by the hygiene players due to the possibility of changes in the production line, low cost and aggressive competition among them, where over the last decades, customers have seen many changes in absorbent products like diapers, pantyliners and incontinence products. The majority of innovations in this market are related to odor control, thinner products, new designs according to end users, packaging and materials, superabsorbent polymers amount, channels, top sheet, back sheet and closure systems. In the same time, just a few new fluff pulp grades were developed, accepted and sold to the market. New grades are mainly focused on chemical additives to increase properties like shredding efficiency and odor control, but driven by additional cost in the fluff pulp, considered by hygiene producers to be one of the main expenses in this industry.

Currently Latin America kraft fluff pulp production stands out as the third largest global producer with an annual production of 475.000 tons having as differentiator the lowest production cost and better yield (m³/ha.y), the result of perfect weather conditions for these trees species growth [1,2].

Pine species such as *P. radiata*, *P. maritimus*, *P. elliotti,* and *P. taeda* correspond to 91% of the fluff market, being *P. taeda* the major species especially in Brazil. The mild climate in the southern region (Paraná and Santa Catarina states) provides better development and adaptation, leading to the shortest cutting cycle in the world, approximately 15 years versus 25 years for the United States and Chile [2,3].

Considering the high demand for softwood pulp by the paper and hygiene producers, combined with the low current availability in Brazilian territory, studies of tropical pine species have gained space and importance presenting a possibility to increase the planting area of *Pinus* genus trees, that could also impact positively the quality of final fluff pulp products made from different species, a topic that has not been much explored [2,4].

Among tropical species, *Pinus maximinoi* is a natural species that grows from Mexico to Nicaragua. It is classified as the second most common *Pinus* species that occurs in Central America and has been considered as an alternative raw material by the pulp industry in tropical and subtropical regions, mainly for presenting tree volume production and yields higher than other pine species commonly used in this field. Additionally, it presents good quality of final pulp [4,5]. This research was conducted as a continuation of the work from Milagres (2018), and has high relevance and impact into Klabin's products. Due to little exploration, research and innovation related to fluff pulps and potential relevant gains in final products related to woods species, this study was conducted to evaluate *Pinus maximinoi* as a raw material for fluff pulp manufacture, and its performance in absorbent pads correlating to the final use.

2. MATERIAL AND METHODS

Pulp samples were produced using wood chips of *P. maximinoi,* from 14-year-old plantations and as a comparative reference, wood chips of *P. taeda* species were used, at the same age. Pulping and bleaching operations followed the same parameters as described in Milagres (2018). The pulps were obtained using forced circulation cooking process. Pulp samples were submitted to oxygen-delignification in double-stage (O/O) and later bleached by the $D_0(EPO)D_1P$ sequence to a 87% ISO brightness target [2]. Pulp sheets (700 g/m^2) were formed in a dynamic sheet former (TechPap), pressed and dried in a drum dryer. Pulp shredding was performed with a Hammermill and then converted into pads. Pulp and pad properties were evaluated according to the procedures in Table I.

Table I – Methodology & Standards

Parameter	Standard/Procedure
Energy consumption	Proprietary Method
Burst strength (Mullen)	TAPPI/ANSI T 403 om-15
Sheet thickness	TAPPI 411 om-15
Absorption Capacity	SCAN 33:80
Absorption Rate	SCAN 33:80
Wicking	Adapted from SCAN 33:80
Morphology	ISO 16065-2
Good Fluff, Nits, Knots, Fines	Proprietary Method - Nit Counter
TEA index	Proprietary Method - Adapted from TAPPI/ANSI T 494 om-13/ASTM D828
Tensile strength	Proprietary Method - Adapted from TAPPI/ANSI T 494 om-13/ASTM D828

2.1 Energy Consumption in Shredding

The energy consumed by the equipment used to defibrate/shred the fluff pulp sheet (700 g/m² formed by a dynamic former model by "Techpap") was performed in a lab scale "Hammermill" using system electrical current consumption measurements.

2.2 Nit Counter – Yield

The Nit Counter from MTS Equipment is based on the particle size analysis and distribution of shredded content using different sieves (mesh) and distributing the content by percentage based on 3 fractions: good fluff/well defibrated fluff content (%) retained in 30" sieve, "Nits / Knots" (%) retained in 16" sieve, fines (%) sent to the exhaust system. The yield in percentage of shredded fluff can be calculated by the expressions:

$$\text{Fluff Total } (\%) = \text{Good Fluff} + \text{Nits \& Knots} + \text{Fines} \quad (1)$$

$$\text{Yield } (\%) = \text{Good Fluff} + \text{Nits \& Knots} \quad (2)$$

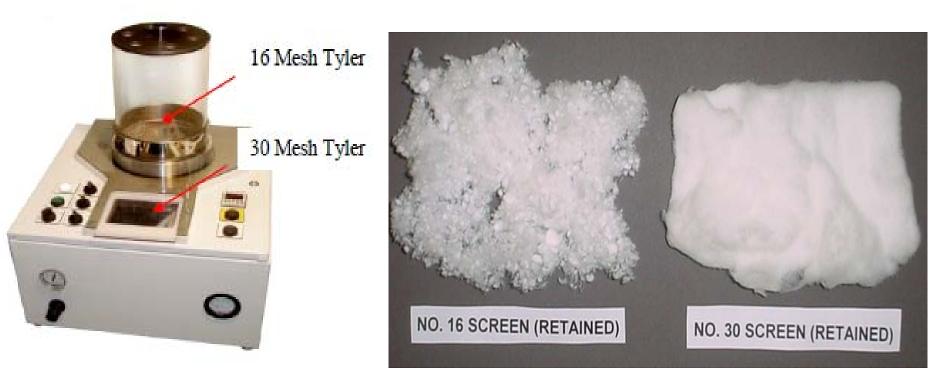

Figure 1) Nit Counter Equipment, Nits/Knots retained on 16" screen and Good Fluff on 30" screen
Source: Adapted from MTS, 2015.

Table II. Granulometric sieve data

Mesh Tyler	Open Area (mm)	Size retained material (mm)
16"	1.19	1.00
30"	0.59	1.12

Source: Sigma Aldrich, 2019

3. RESULTS

The performance results of *P. maximinoi* versus *P.taeda* fluff pulps regarding their morphology, mechanical strength, absorption, process yield, energy and its comparison are shown in the following sections.

3.1 Fiber Morphology & Pulp Properties

Compared to *P. taeda*, *P. maximinoi* pulp had 8% longer and 9% wider fibers as well as 24% thicker walls. These are the most important fiber properties affecting bulk/thickness of final products. Fiber width is correlated to fiber wall thickness and can affect panel collapsibility. This property can also predict stiffness because the thicker the wall the stiffer the fiber. Additionally, the wall thickness affects the resilience and liquid flow inside the pad, where walled fibers are less resilient, allowing the structure to maintain its shape and thickness when wet and under pressure.

Table III – Fiber Morphology & Pulp properties

Parameter	***Pinus maximinoi***	***Pinus taeda***
Tracheid length (mm)	2.88	2.65
Tracheid width (μm)	29.72	27.09
Wall thickness (μm)	10.92	8.34
Tracheid number (10^6/g)	2.1	2.8
Coarseness (mg/100m)	35	27
Sheet thickness (μm)	1350	1289
Sheet density (g/cm³)	0.53	0.55

Following the same formation, press and drying processes, sheets from *P. maximinoi* were thicker, hence less dense. These results could be also expected in the pad, showing higher voids between fibers, resulting in a better absorption capacity.

As consequence from fiber length, width and wall thickness, the coarseness from *P. maximinoi* pulps was 23% higher than *P. taeda.* This is a critical property, because usually coarse fibers are also stiff, delivering higher bulk products with better absorbency. Low coarseness and thinner fibers are required where opacity or coverage in a flatter product as air laid table top grades are important.

Fluff pulp of *P. maximinoi* had a lower number of tracheids per mass unit, which can affect the interfibrillar bonds between the fibers and result in less strength to the pad. On the other hand, it can increase capillarity to water absorption, which is interesting for fluff pulp grades.

3.2 Good Fluff, Nits/Knots and Fines Content – Yield

Fiber length and its distribution are also critical properties for fluff pulp yield for the customer. Absorbent products manufacturing comprises air or vacuum to form a fluff pulp pad on an air-permeable screen or wire. This open screen can increase waste due to cut fibers classified as "fines" that are pulled through, and results in filtered waste being lost in the process. The longer the average fiber length, the lower the percentage normally that is pulled through the screen, therefore longer fibers are preferred. On the other hand, sometimes the shredding process can be insufficient to individualize the fibers and it is classified as fiber bundles or "Nits and Knots" content being considered an inefficiency of process. Well defibrillated content is classified as "Good Fluff".

The shredding efficiency and consequent yield in fluff pulp from *P. maximinoi* was increased by 1.2% compared to *P. Taeda*, calculated according to the formula (2) described earlier. This parameter is the consequence of a slight nits/ knots reduction (-0.3%), but mainly due to fines reduction around 1% in this case (Fig. 2). Although absolute values seems low, when relative analyses are performed, nits/knots were reduced by 12% and fines by 82% compared to *P. taeda*.

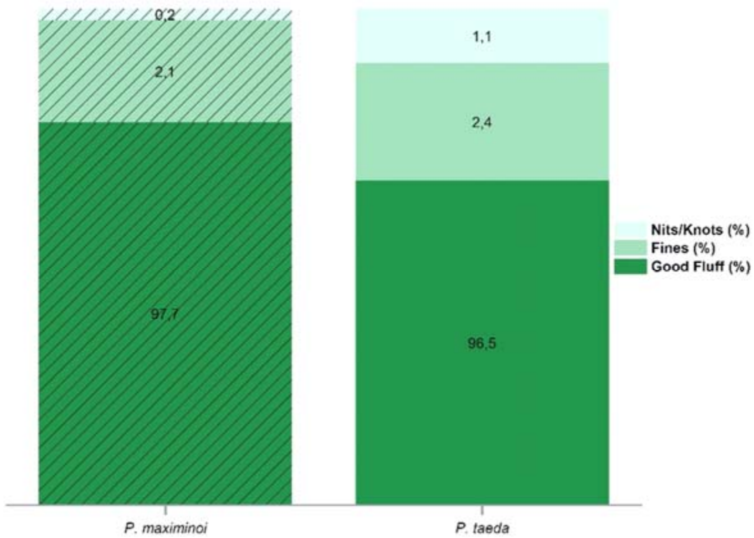

Figure 2) Fluff pulp yield after shredding classified by composition:good fluff, nits/knots, fines (%)

The yield measurement presented is considered one of the best laboratory procedures to correlate the potential impacts to the end user since it uses airflow, meshes for holding the shredded material and an exhaust system, which simulates the industrial process.

3.2 Energy Consumption in the Hammermill and Burst Strength/Mullen

Energy consumption for fluff pulp shredding is correlated to a common and quick method performed in the industry, the burst strength or Mullen (Fig. 3b). The most important parameter to increase efficiency in this case is fiber morphology, where higher coarseness, less collapsibility and less contact between fibers obtained from *P. maximinoi* allowed the energy consumption to be reduced by ca. 25% during sheet shredding compared to *P. Taeda* (Fig. 3a). This is a valuable opportunity to industries that are constantly looking for energy savings by using chemically treated fluff pulp grades. However, this fiber can affect pad strength properties (Fig. 4a, 4b).

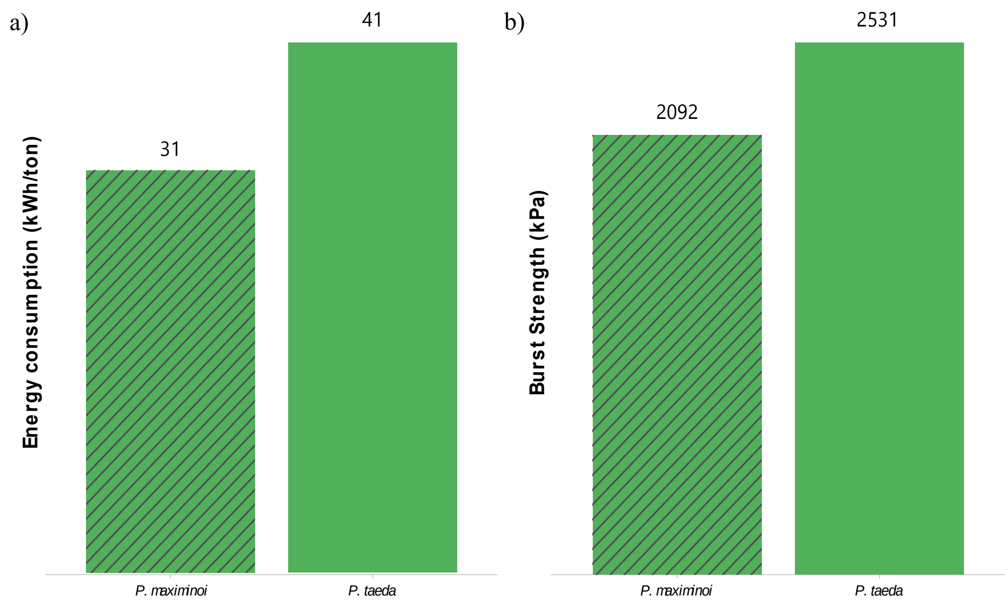

Figure 3: a) specific energy consumption for defibrillation/shredding processing in the Hammermill comparing fluff pulp obtained from *P. maximinoi* and *P. taeda;* b) burst strength in a fluff pulp sheet from *P. maximinoi* and *P. taeda*.

3.2 Strength properties – Pad

Pads formed by *P. taeda* presented TEA "Tensile Energy Absorption" and Tensile Strength Index higher than *P. maximinoi*, 25% and 7% respectively (Figs. 4a, 4b). Milagres 2018 in paper evaluation found the same tendency, reporting that *P. maximinoi* was more resistant in the refining process, a consequence of higher fiber coarseness, thickness and diameter.

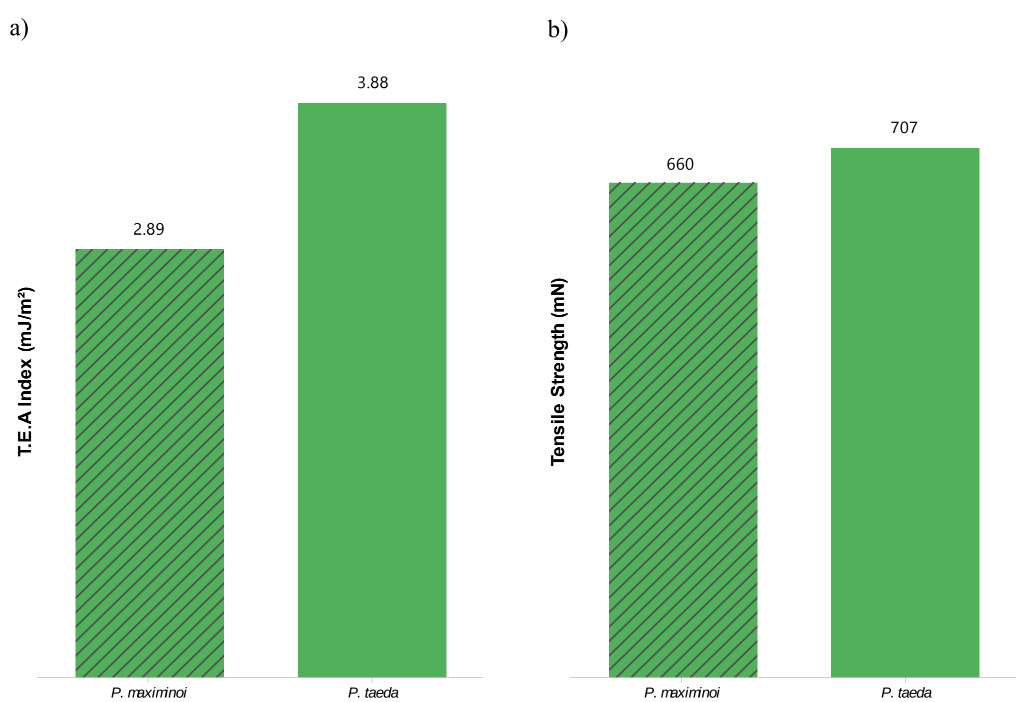

Figure 4: a) TEA index "Tensile Energy Absorption" in pads formed by fluff pulp from *P. maximinoi* and *P. taeda;* b) Tensile Strength in pads formed by fluff pulp from *P. maximinoi* and *P. taeda.*

3.3 Absorption Properties – PAD

Absorption according to SCAN33:80 shows a tendency in properties slightly better for *P. maximinoi,* although results are inside the method variation (Fig. 5). Capacity showed the most benefit mostly due the higher coarseness, better bulk, and less density (Table III). More pores and volumes between fibers generally increase liquids uptake.

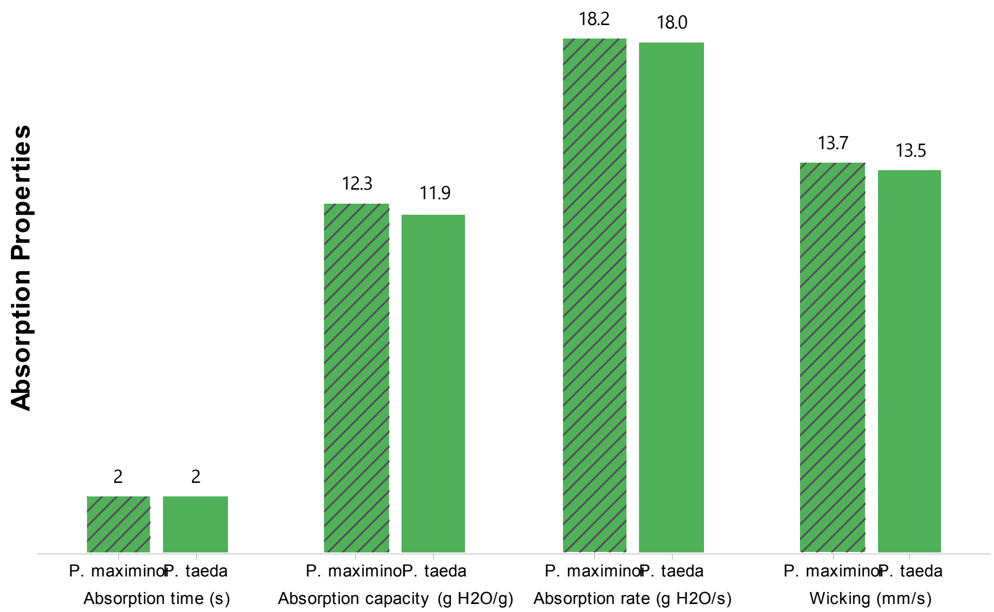

Figure 5) Absorption analysis according to standard SCAN 33:80 measuring absorption time, absorption capacity, absorption rate and wicking in pads formed by fluff pulp from *P. maximinoi* and *P. taeda.*

CONCLUSIONS

Energy consumption efficiency is well explored in the fluff pulp industry and a specie like *P. maximinoi* could provide some opportunities avoiding chemical additives, saving energy costs and following the global tendency for more natural products.

The yield related to better good fluff and less fines are also a relevant opportunity for fluff from *P. maximinoi,* where the customer could avoid an expensive pulp loss though the exhaust system.

Pulps with higher coarseness are known for benefits inside the products due to better liquid distribution, capacity and wicking, especially highlighted by superabsorbent polymer use growth in recent products and subsequent problems with channel blocking and liquid acquisition. *P. maximinoi* offers a great opportunity even though the absorption gains have only been slightly better than conventional *P. taeda*.

Results obtained from this study showed that *Pinus maximinoi* as raw material does offer an opportunity to add value and innovation in the fluff pulp segment.

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Gateway to
the Future

"FLUFF PULP PERFORMANCE IMPROVED BY ALTERNATIVE PINE SPECIES"

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TAPPI PEERS
Pulping • Engineering • Environmental • Recycling • Sustainability
October 27-30, 2019
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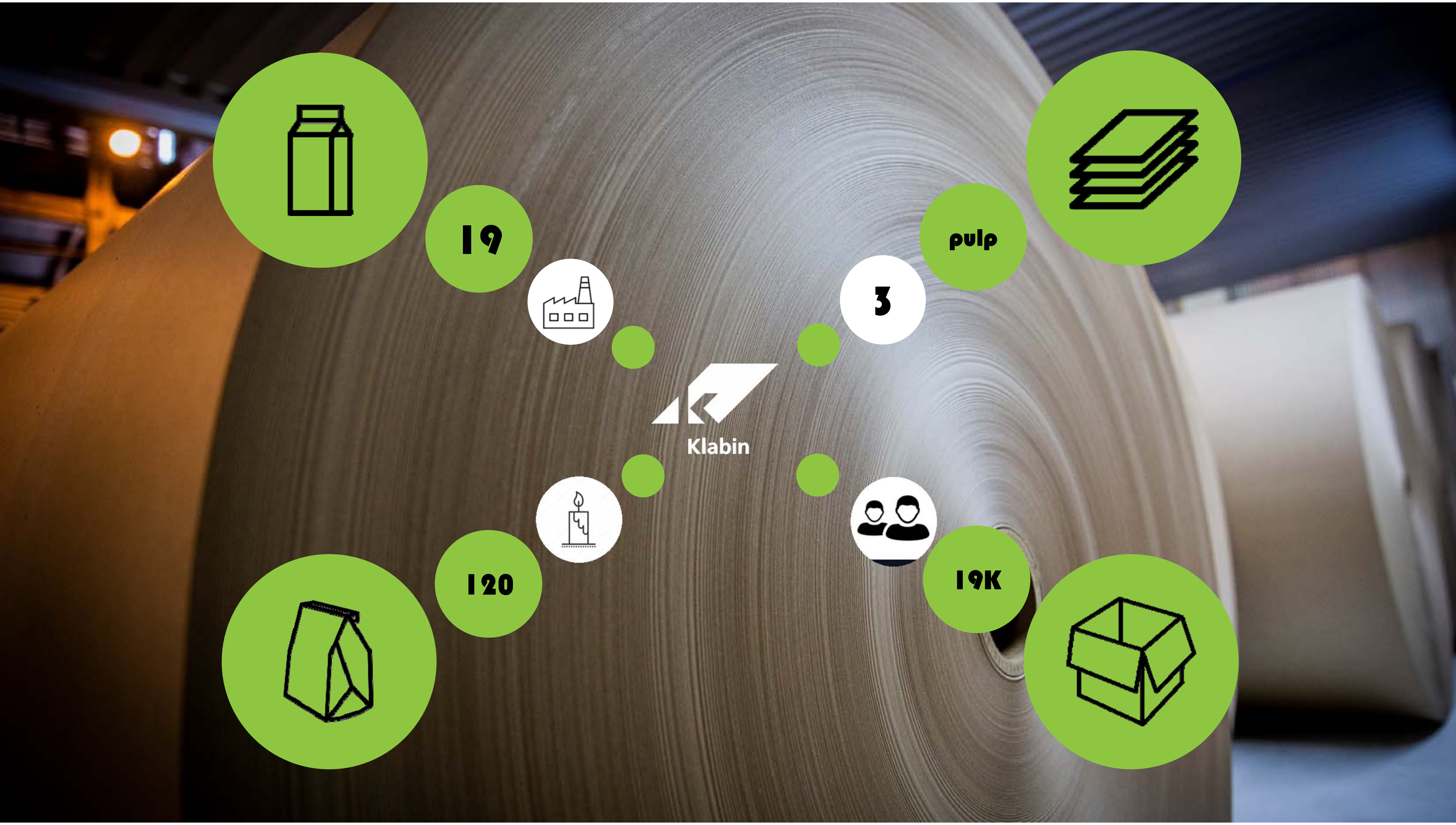
NEW PRODUCT'S DEVELOPMENT
PULP QUALITY & PERFORMANCE

WOOD QUALITY

PINE BREEDING

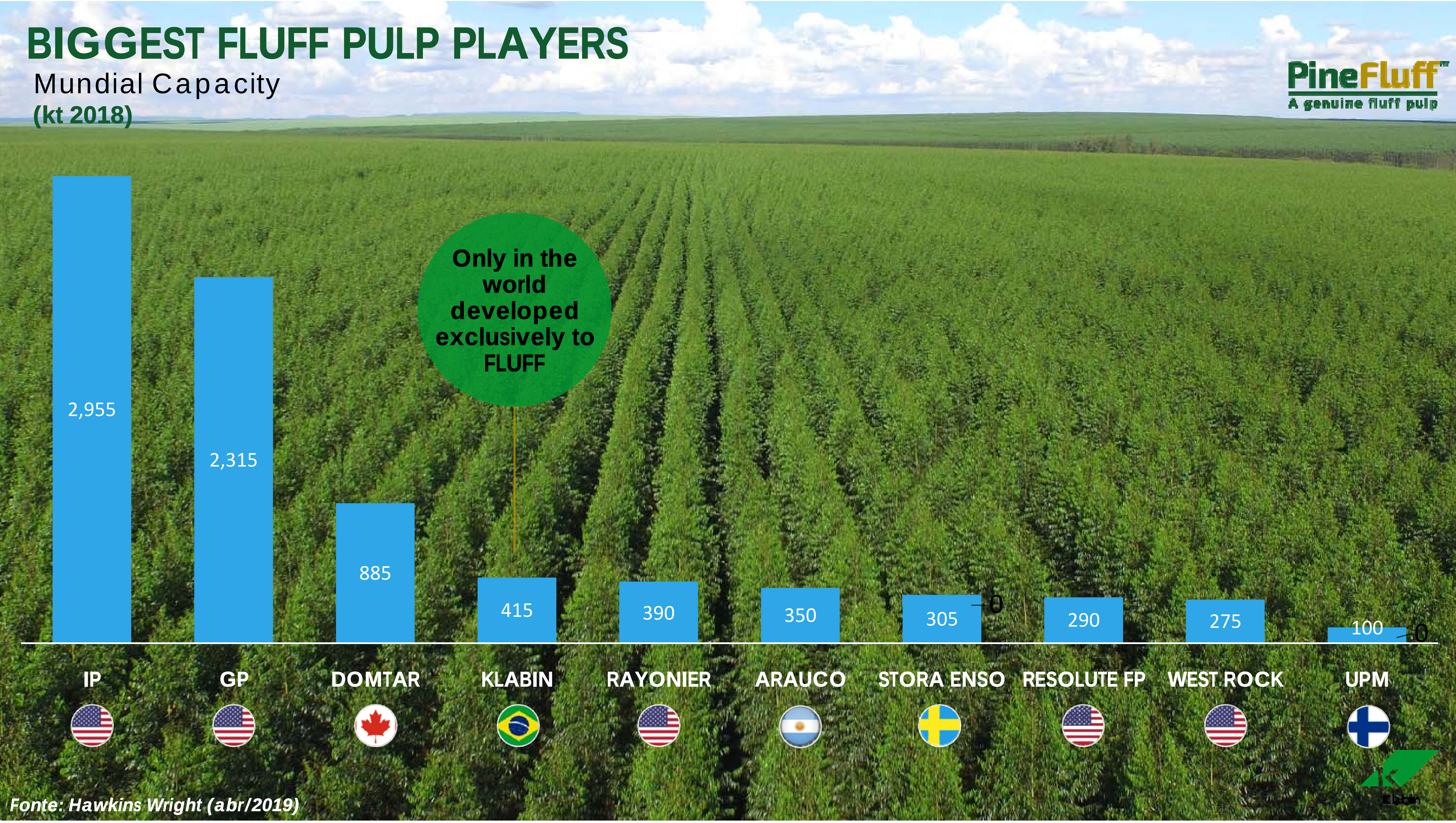
R&D+I
INDUSTRIAL
MANAGER


19
pulp
3
Klabin
120
19K

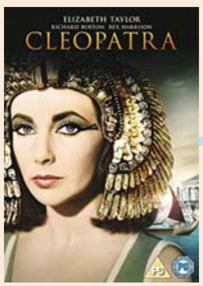

1.5
MILLION
TONS
SHORT FIBER (BEKP)
LONG FIBER (BSKP & FLUFF)

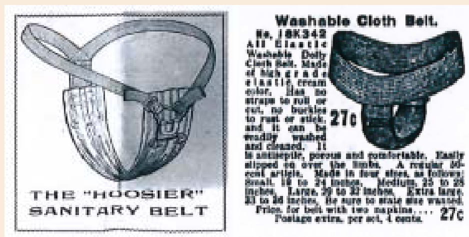
ONLY IN BRAZIL

LONG FIBER


BIGGEST FLUFF PULP PLAYERS
Mundial Capacity
(kt 2018)
PineFluff
A genuine fluff pulp
Only in the world developed exclusively to FLUFF
2,955
2,315
885
415
390
350
305
290
275
100
IP
GP
DOMTAR
KLABIN
RAYONIER
ARAUCO
STORA ENSO
RESOLUTE FP
WEST ROCK
UPM
Fonte: Hawkins Wright (abr/2019)

ABSORBENT **PRODUCTS** EVOLUTION





Fonte: Edana, 2019

ABSORBENT **PRODUCTS** EVOLUTION

Source: Drylock Technologies, 2019

Source: Price Hanna, 2019

Source: Pampers, 2019

Source: Pampers, 2019

Source: Kymberly Clark , 2019

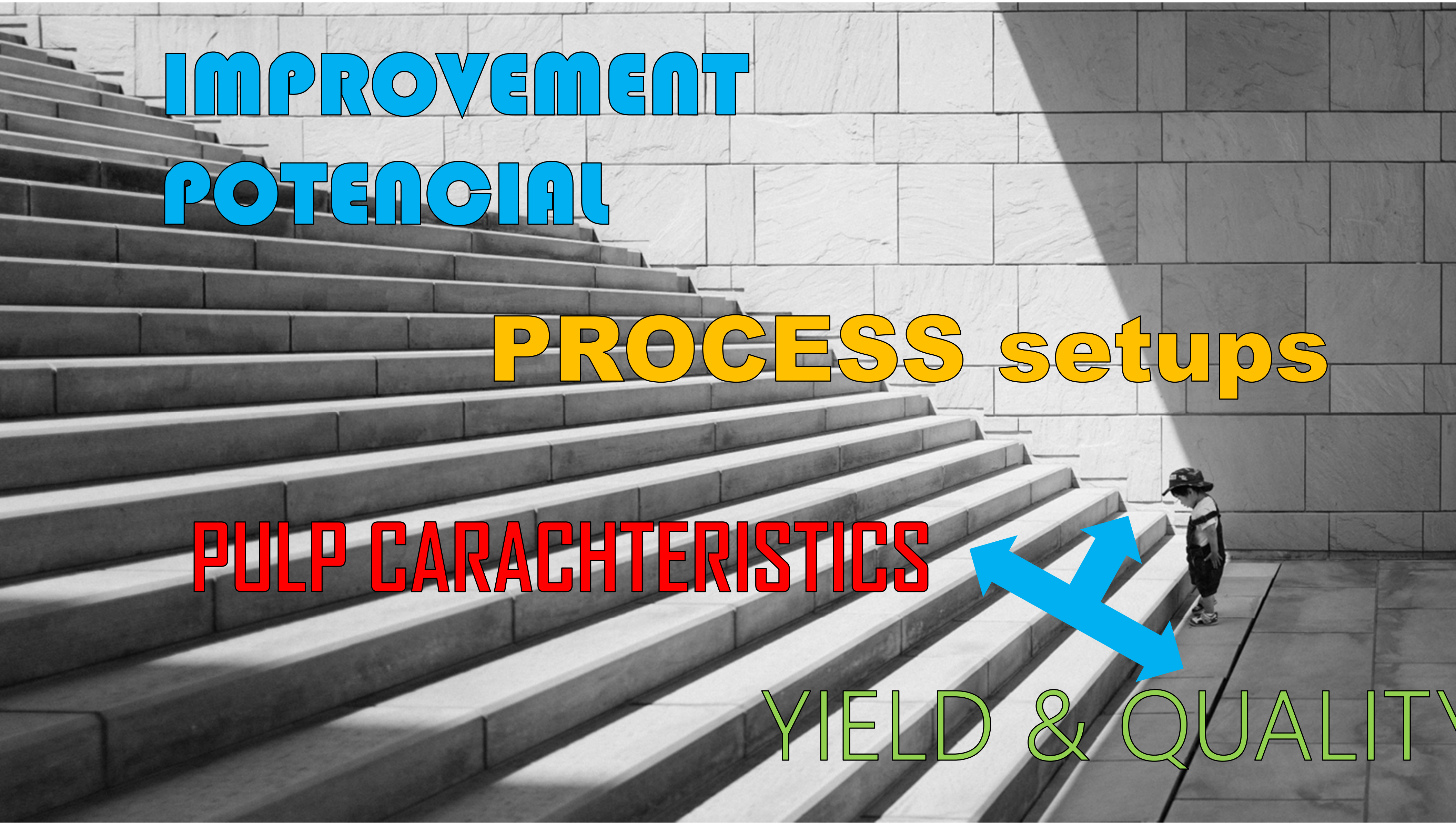
ALL ABSORBENT PRODUCTS SEGMENTS HAVE POSITIVE PERSPECTIVE

PineFluff
A genuine fluff pulp

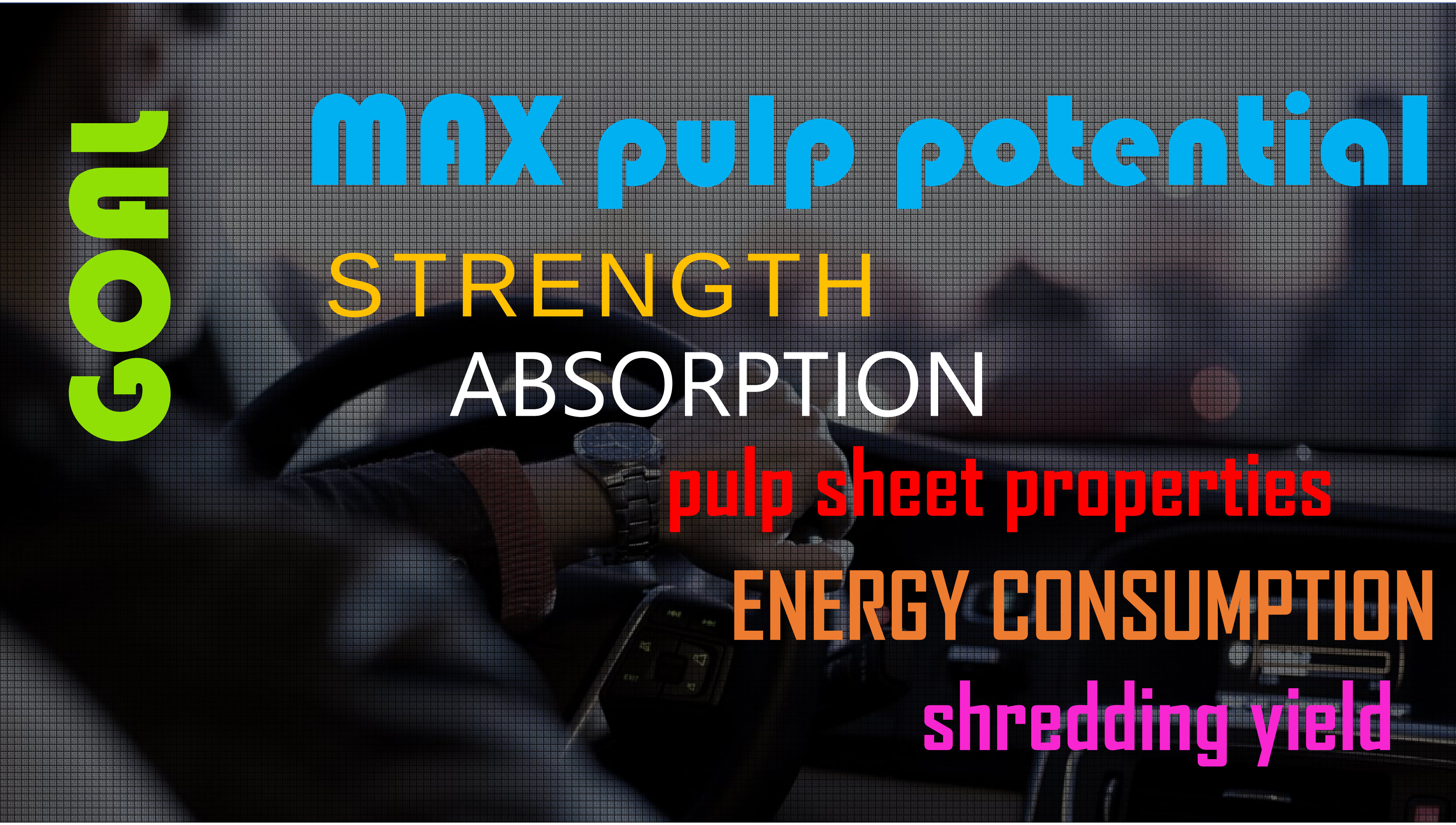
		2018 MM t de fluff	2023	
Infant Diapers		1,86	1,96	1,1% p/ year
Incontinence		1,83	2,65	7,7% p/ year
Feminine Higiene		1,33	1,53	2,8% p/year

Fonte: **Price Hanna**

Klabin


IMPROVEMENT
POTENCIAL
PROCESS setups
PULP CARACHTERISTICS
YIELD & QUALITY


LANDSCAPE
21% of brazilian planted areas
300.000.000 U$$ IMPORT IN 2012
CORRUGATED PAPER, LPB, SACKRAFT, FLUFF PULP
SHORTEST CUTTING AGE
15 X 25 (EUA, CHILE)
TROPICAL SPECIES
P. maximinoi spp. due higher productivity


GOAL
MAX pulp potential
STRENGTH
ABSORPTION
pulp sheet properties
ENERGY CONSUMPTION
shredding yield

PINE maximinoi

+20% MAI

DBH 26.24 cm

Commercial volume (m³/ha)
620.79

+ Extractives content

Less chemicals consumption

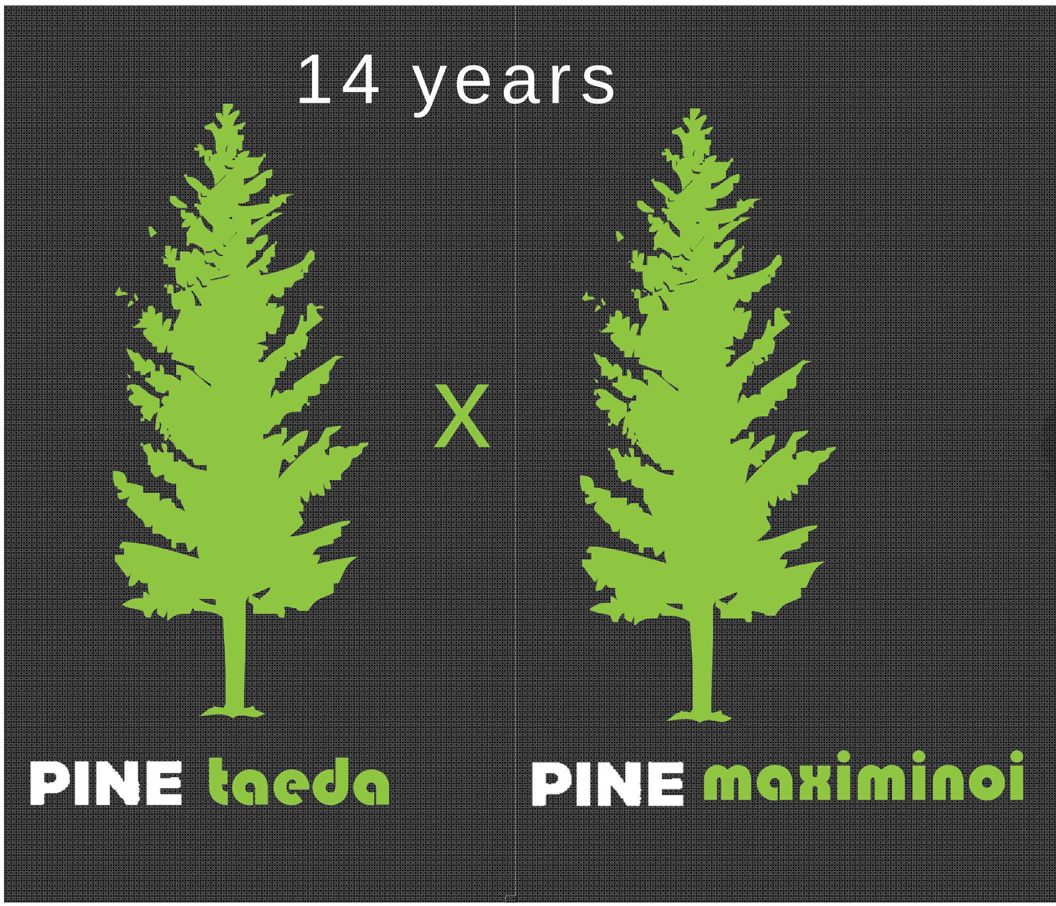
PINE taeda

DBH 22.22 cm

Commercial volume (m³/ha)
515.72

+ Xylan content

METHOD



Fiber Properties (wood) (ISO)

Morphology

Pulp sheet properties (ISO)

Energy consumption - Burst Strenght - Thickness

Absorption Properties (Scan 33:80)

Capacity - Rate - Wicking

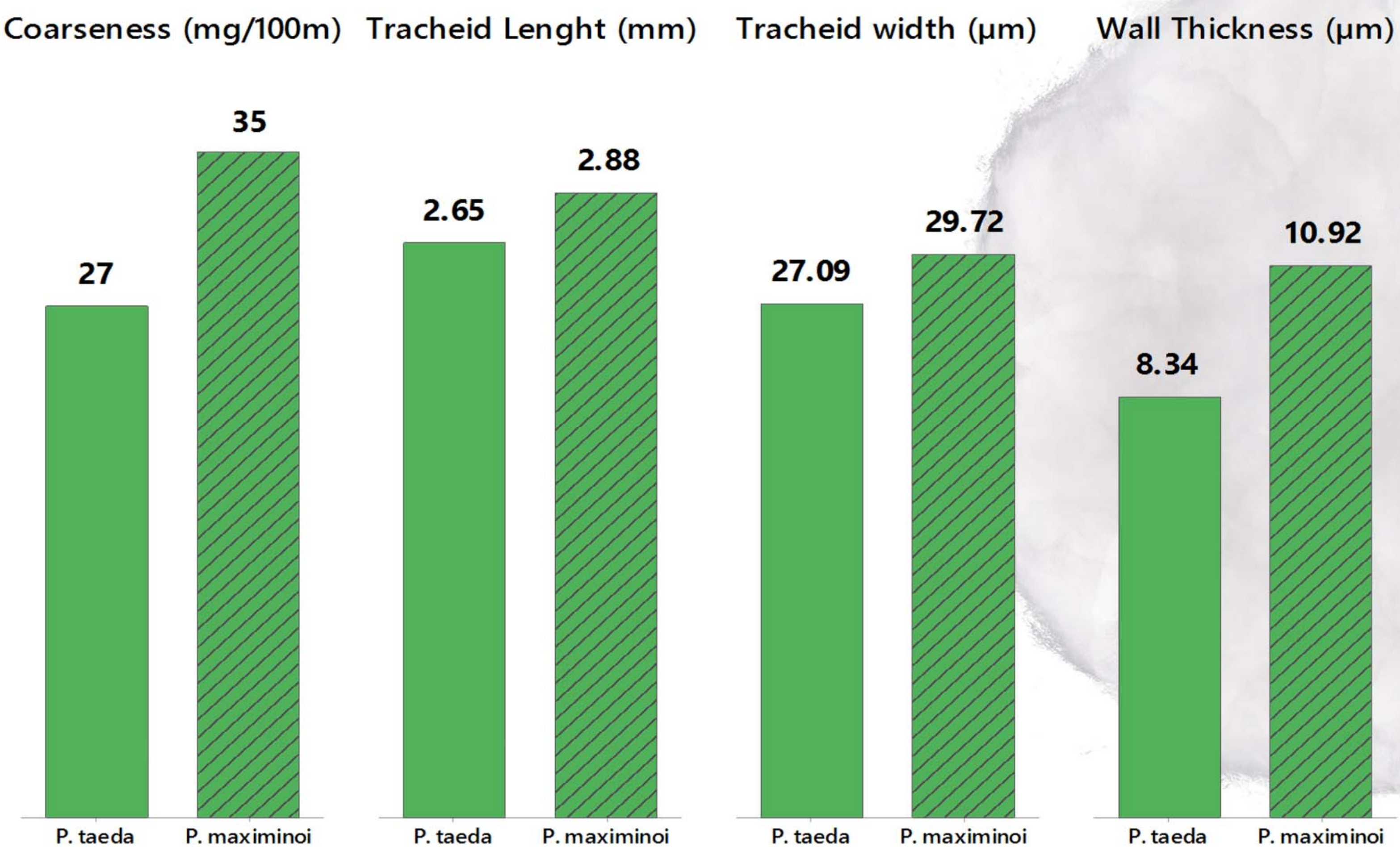
Fluff Pulp Yield (Nit Counter)

Good Fluff - Nits/Knots - Fines

Pad Strength (adapted ISO)

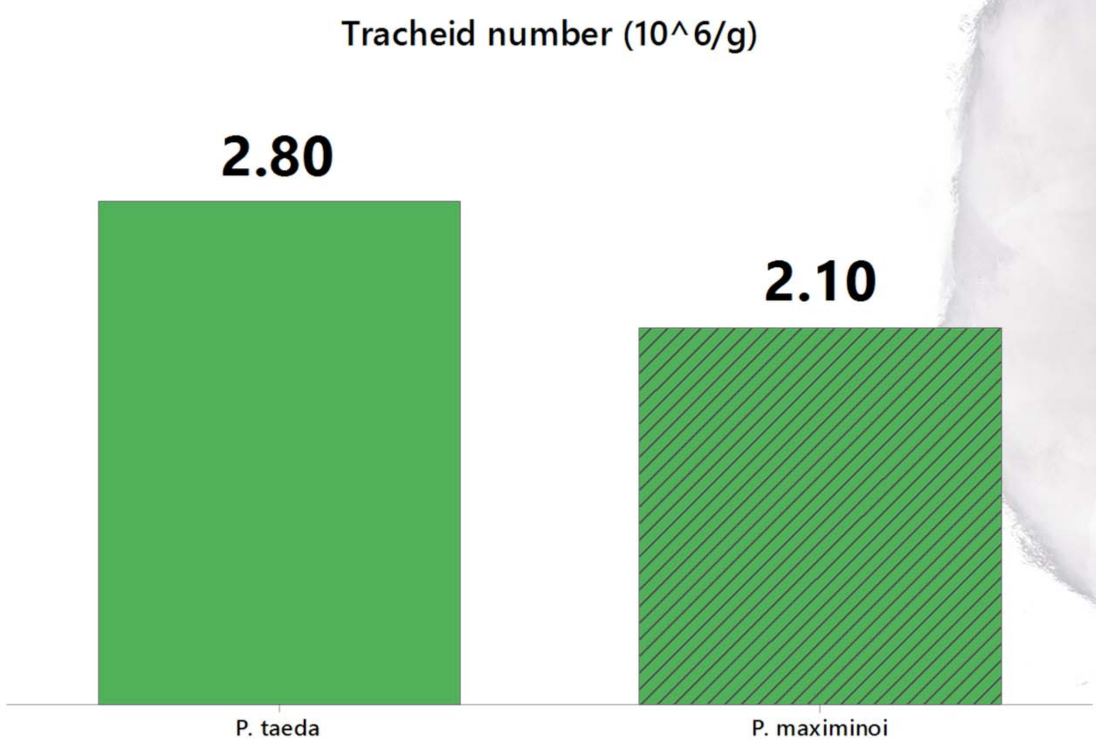
TEA - Tensile

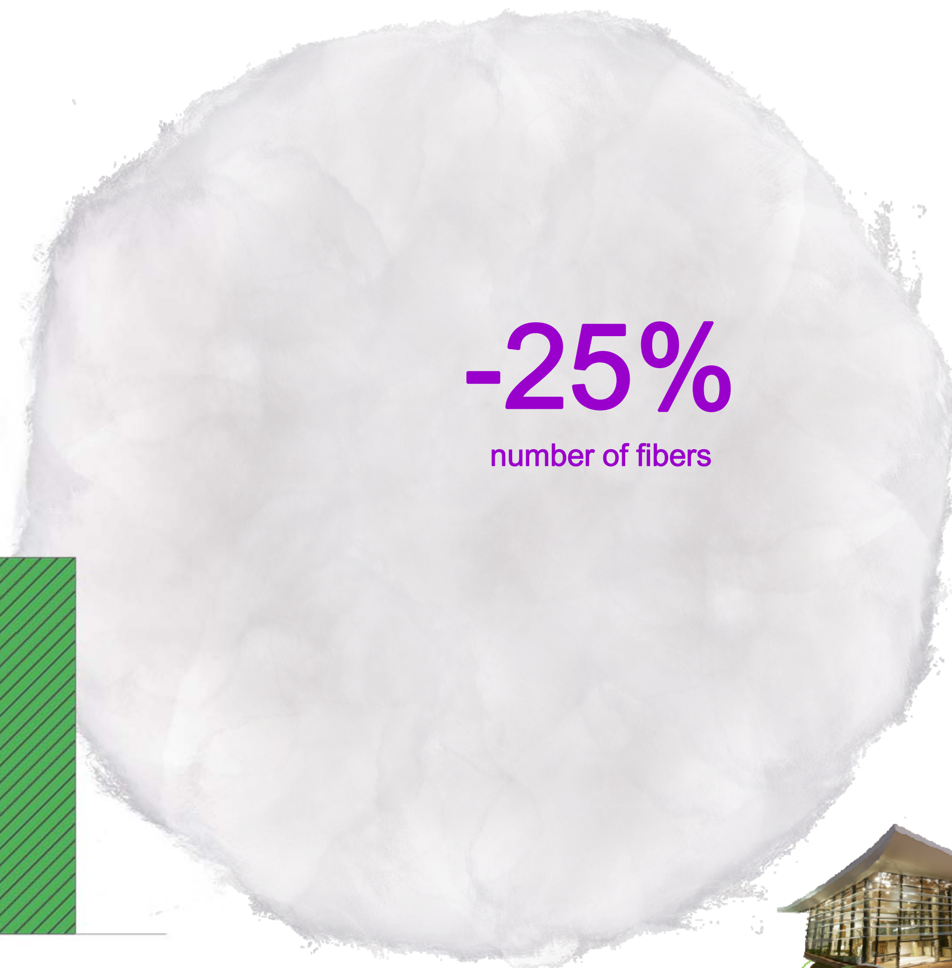
MORPHOLOGY



+23%
COARSENESS

MORPHOLOGY


Tracheid number (10^6/g)
2.80
2.10
P. taeda
P. maximinoi


-25%
number of fibers

NIT COUNTER

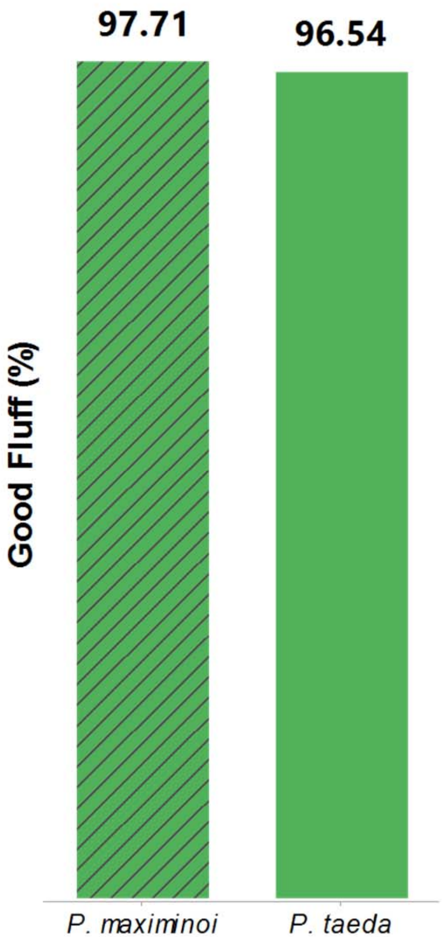
FLUFF CONTENT (%) = Good Fluff + Nits / Knots + Fines

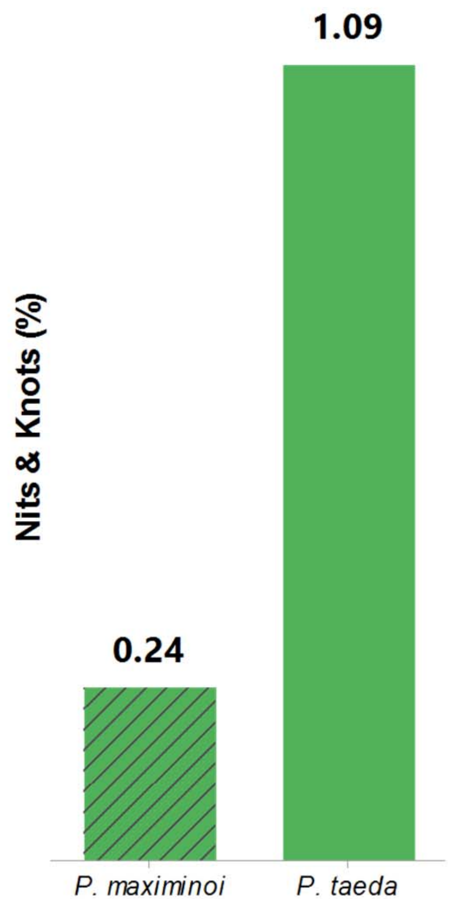
YIELD (%) = Good Fluff + Nits / Knots

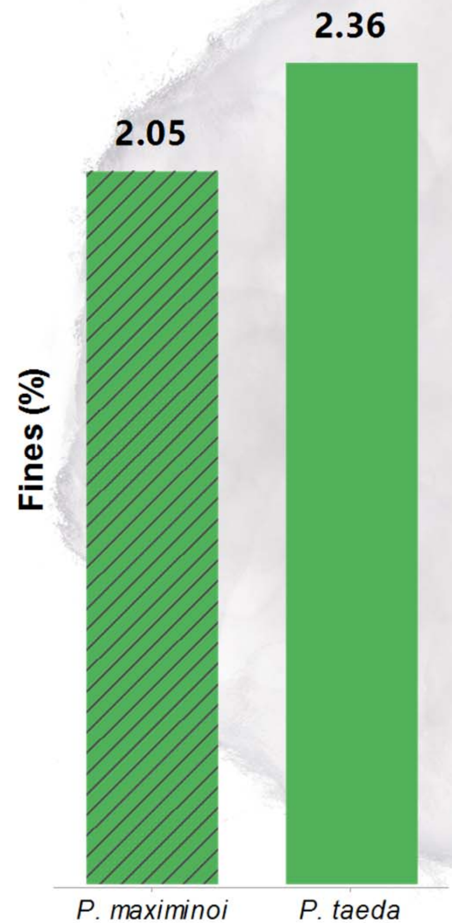
Source: Intern

Source: MTS Equipments

FLUFF YIELD & SHREDDING QUALITY





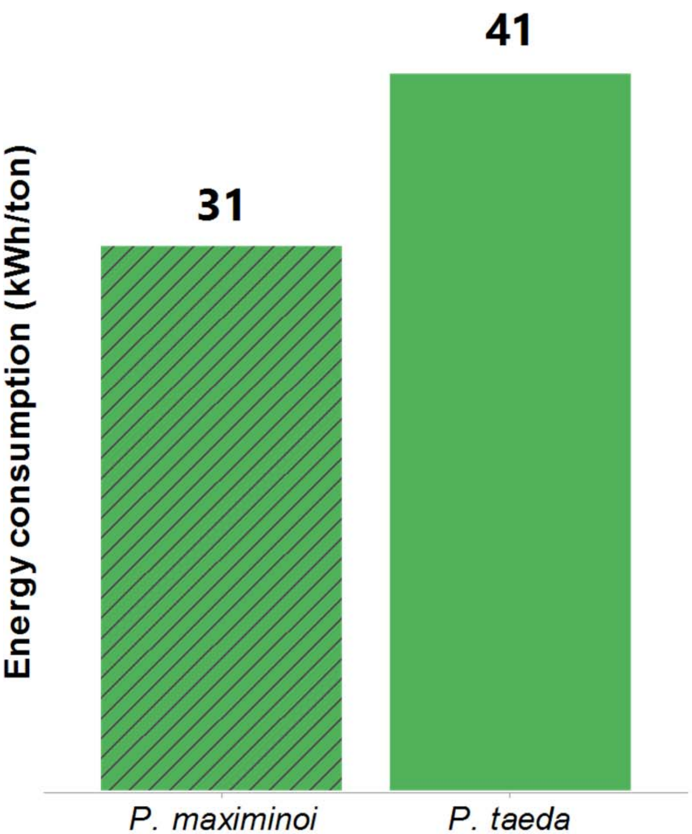


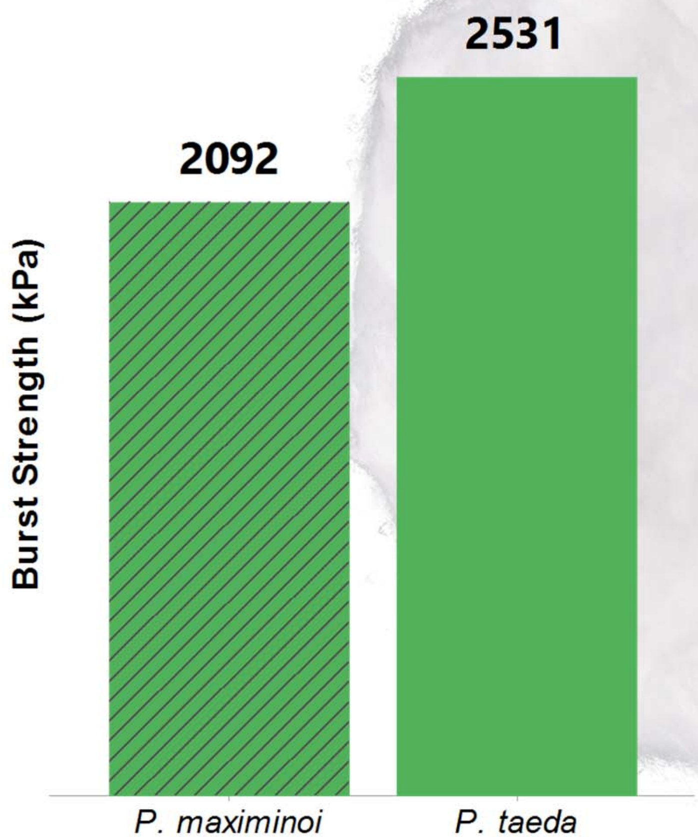
+1.2%
GOOD FLUFF

-13%
FINES

-78%
NITS&KNOTS

SHEET PROPERTIES & CUSTOMER PROCESS

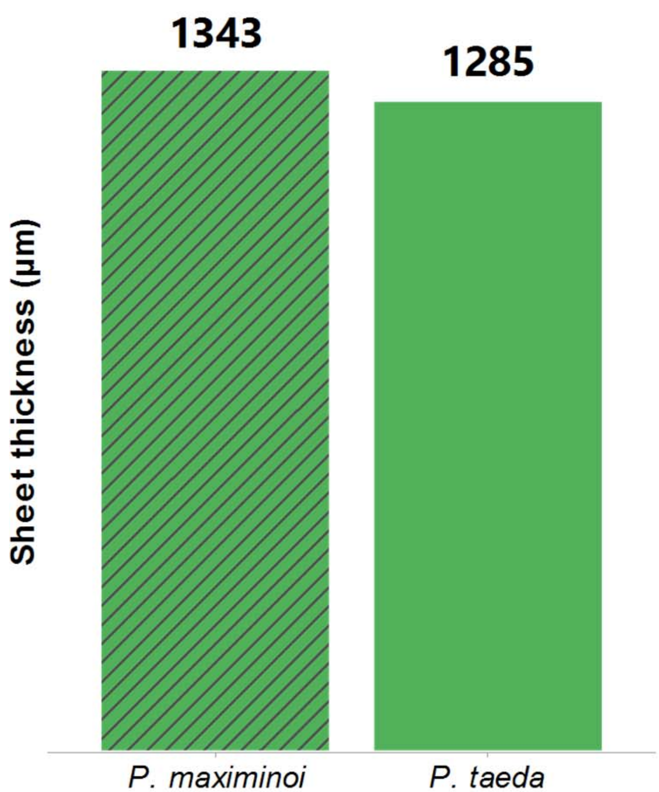


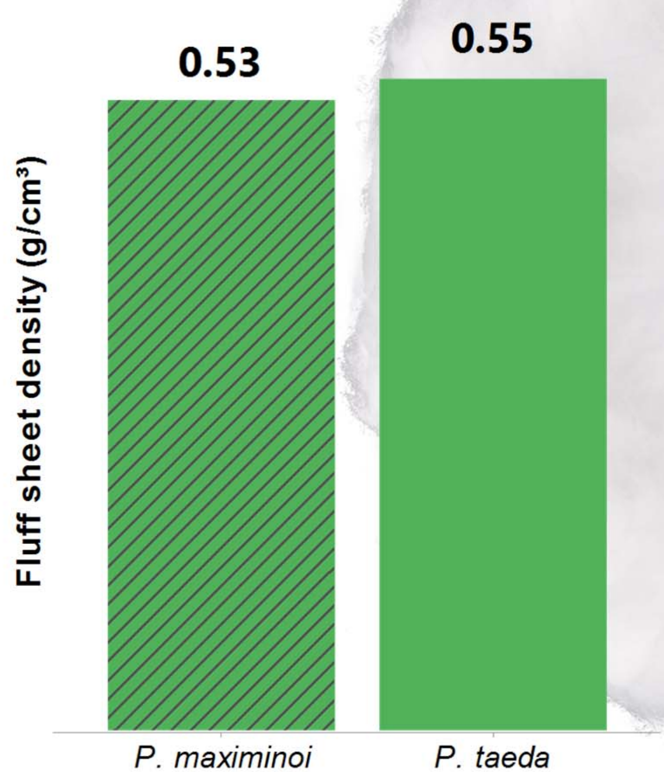


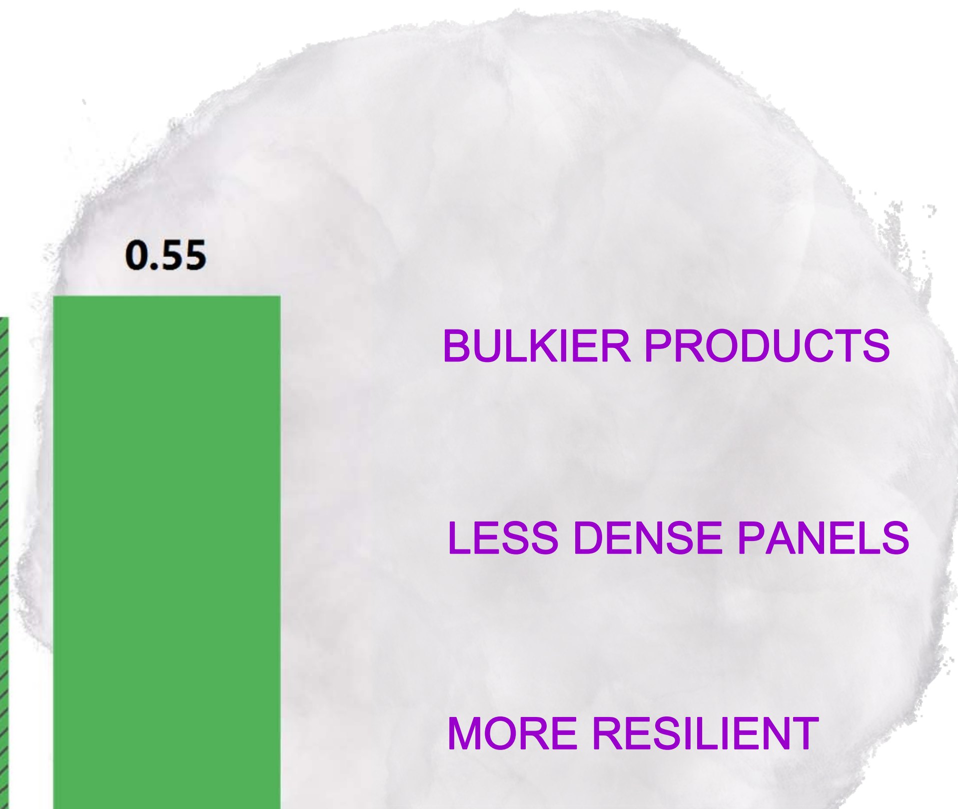
-25%
ENERGY CONSUMPTION

-18%
BURST / MULLEN

SHEET PROPERTIES & CUSTOMER PROCESS





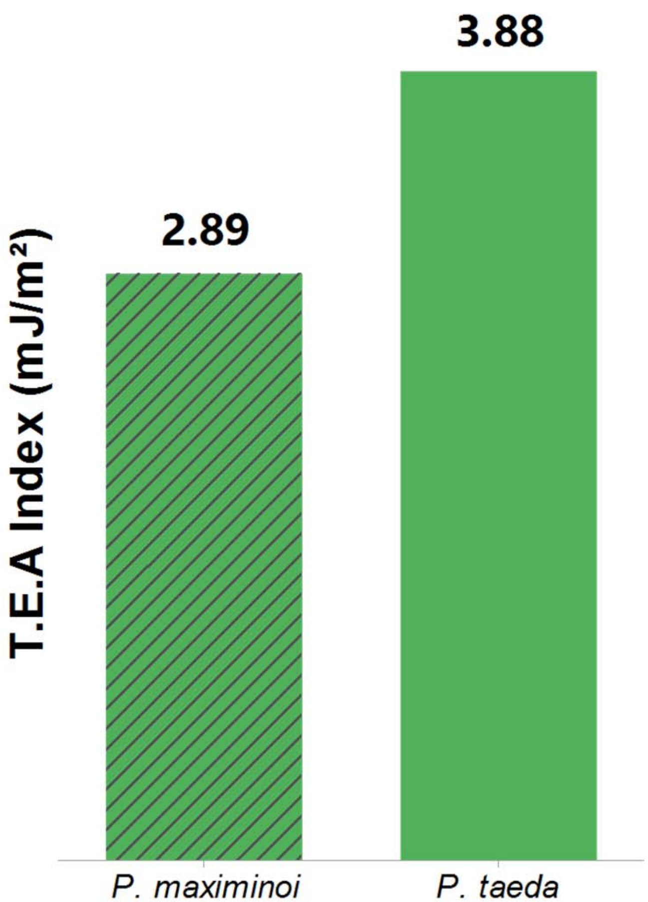


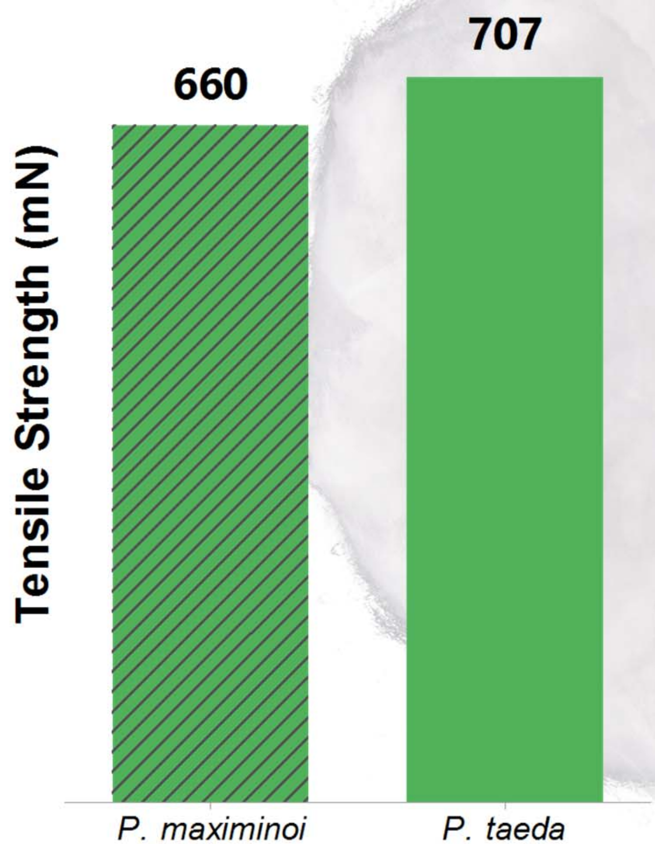
BULKIER PRODUCTS

LESS DENSE PANELS

MORE RESILIENT

PAD STRENGTH

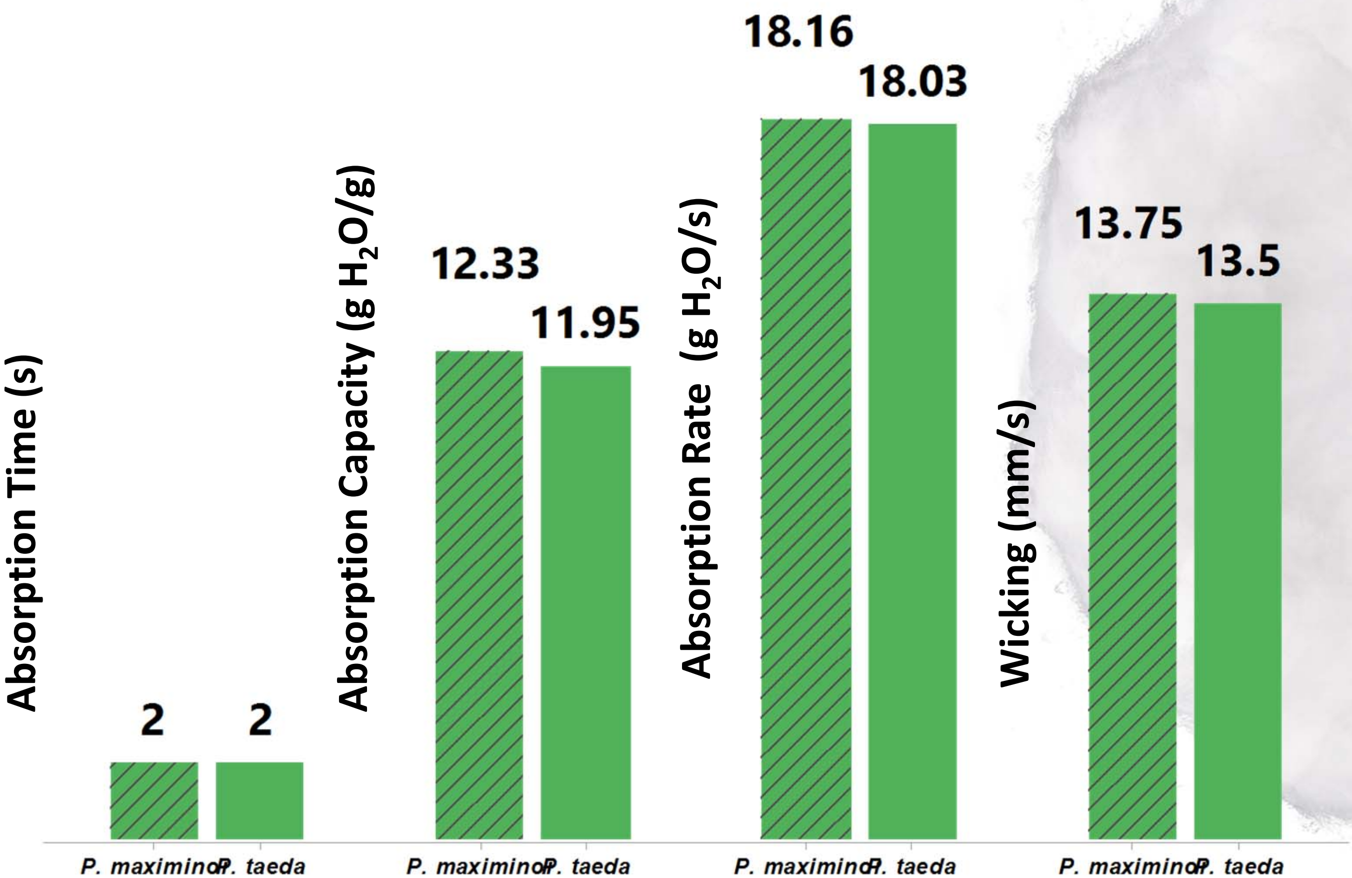


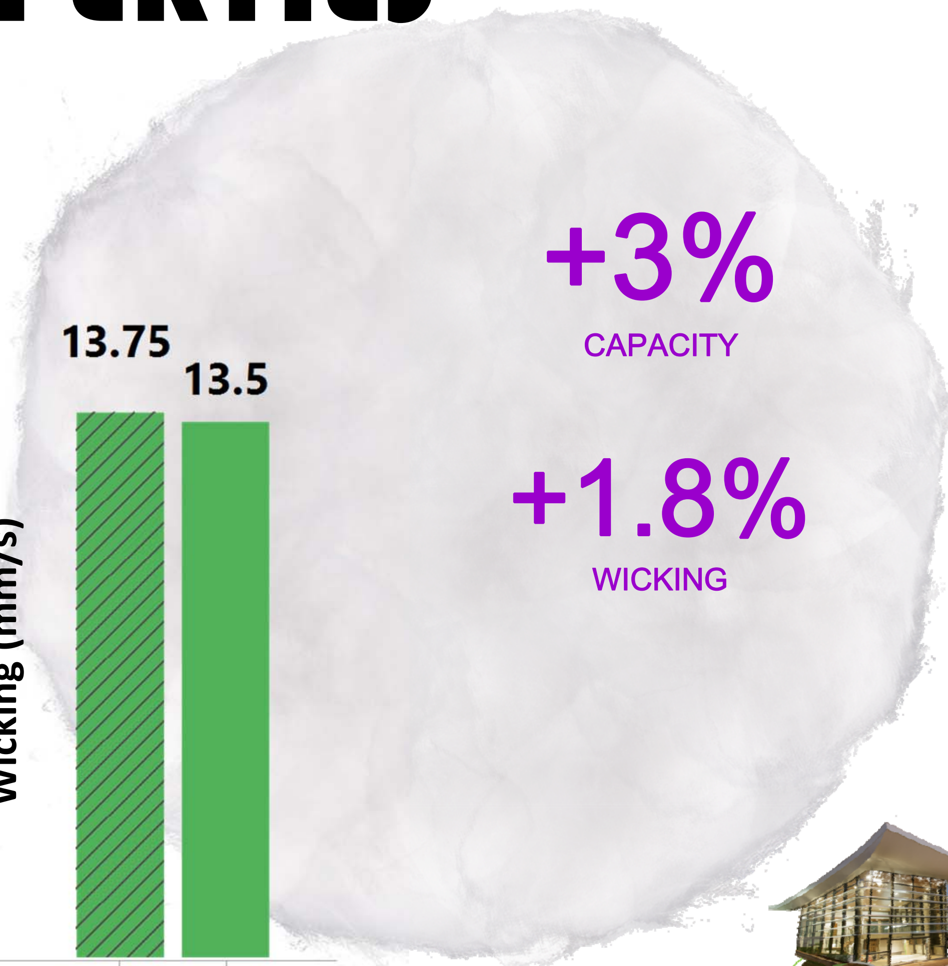


-25%
TEA

-7%
TENSILE

ABSORPTION PROPERTIES





+3%

CAPACITY

+1.8%

WICKING

P. maximinoi

20% MAI and MAIcel

Provide better liquids distribution

Increases shredding performance and yield in the customer process

Demand less energy to defibration (alternative to chemicals)
Decrease pad strength

POSITIVE COST x BENEFIT

NEXT STEPS

INDUSTRIAL TRIAL AT PUMA MILL

P. taeda X P. maximinoi

12 years

THANK YOU !!!

Forestry and Industrial R&D+I

CONTACT

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