# Acacia – The Fibre of Choice

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## ABSTRACT

The role of short fibre pulp – Mixed Harwood, Eucalyptus, Aspen, Birch, etc for the manufacture of different grades of paper is very well recognized. At the same time, lots of efforts are in progress to maximize the advantages while preserving their own special property.

*Bleached Acacia Kraft Pulp (BAKP)* is comparatively new entry but gained quick recognition. *BAKP* was introduced to the world market by South East Asian suppliers in the late 1990's.

This paper discusses in detail the role and opportunities of use of short fibre pulps. A logical technical comparison has been made between *BAKP* and another short fibre grades.

*BAKP* being a short, thin-walled fibre shows several similarities with Eucalyptus pulp in terms of good bulk and stiffness. Refining energy and strength properties are very similar, but the shorter fibres and thinner cell walls give an outstanding opacity and formation compared to other commercial short fibre pulps. The collapsed and band-shaped nature gives a matchless smoothness, enabling less calendaring and exceptional printing properties.

*BAKP* is shown to give several advantages to fine paper manufactures, compared with a number of established short fibre pulps such as Brazilian and Chilean Eucalyptus, Canadian Aspen and Indonesian Mixed Hardwood. It is important to consider refining and calendaring conditions to achieve optimum performance.

For outer layers of multiply board, Acacia gives excellent coverage due to its high opacity and uniform fibre distribution. Its low roughness property gives improved printability.

For tissue products, Acacia gives unique property of superior softness both in terms of hand feel and bulk softness. The high fibre population gives an impression of much higher quality due to the higher opacity and good formation.

## INTRODUCTION

*Acacia or BAKP (Bleached Acacia Kraft Pulp)* is a relatively new fibre entering to the world pulp market. APRIL, Asia Pacific Resources and International Holdings Ltd., is one of the world's biggest manufacturers of pulp and paper as well as a leading developer of fibre plantations.

APRIL's operations are worldwide but main manufacturing plant is in Riau province, Indonesia. The group has also recently acquired a mill in Rizhao Shandong, China.

APRIL's products are MHW (Mixed Hardwood), BEKP (Bleached Eucalyptus Kraft) and BAKP (Bleached Acacia Kraft) market pulp, uncoated wood free paper and paperboard.

## SUITABILITY OF SHORT FIBRE PULP

This presentation will introduce the features of different short fibre pulps, with Eucalyptus as a benchmark. Mixed hardwood pulp from Indonesia is used for the comparison in some discussions since it is a well-known fibre in this part of the world.

The suitability of hardwood for UCWF is summarized in table 1. *Acacia* is superior in paper formation and opacity. The strength of *Acacia* is almost similar to Eucalyptus. When it comes to bulk and smoothness, MHW has the highest bulk, while *Acacia* gives the best combination of highest bulk at a specified smoothness.

Table 1, Suitability of hardwood for UCWF

| Properties | MHW | BEKP | BAKP |
|---|---|---|---|
| Formation | - | 0 | + |
| Opacity | - | 0 | + |
| Smoothness | - - | 0 | + |
| Strength | - | 0 | 0 |
| Bulk | ++ | 0 | ( - ) |
| Bulk/Smoothness | - | 0 | + |

For coated papers, table 2 shows the suitability for CWF. It is similar to UCWF. *Acacia* gives a more closed surface, which is an advantage for penetration of the coating color, especially for single coating. It should be noted that uncoated and coated paper are produced from both Mixed hardwood and Eucalyptus. Especially Asian paper makers in India, Korea and China have gained skills to produce excellent coated paper with these pulps.

Table 2, Suitability of hardwood for CWF

| Properties | MHW | BEKP | BAKP |
|---|---|---|---|
| Formation | - | 0 | + |
| Opacity | - | 0 | + |
| Smoothness | - - | 0 | + |
| Strength | - | 0 | 0 |
| Bulk | ++ | 0 | ( - ) |
| Bulk/Smoothness | - | 0 | + |
| Porosity | - | 0 | + |

As can be shown in table 3, the requirements for surface layers of paperboard are very similar to printing paper, where *Acacia* provides the best coverage by combination of the best formation and the highest opacity. The roughness of *Acacia* is lower than others, which gives improved printability both for coated and uncoated surfaces. The strength of Acacia is similar to BEKP and higher than MHW.

Table 3, Suitability of hardwood for Paperboard, top layer

| Properties | MHW | BEKP | BAKP |
|---|---|---|---|
| Formation | - | 0 | + |
| Opacity | - | 0 | + |
| Smoothness | - - | 0 | + |
| Strength | - | 0 | 0 |

Pulp properties suitable for tissue are quite different from those for other papers, where softness and bulk are the most important parameters. Table 4 indicates that. *Acacia* gives generally better softness than Eucalyptus.

Table 4, Suitability of hardwood for Tissue

| Properties | MHW | BEKP | BAKP |
|---|---|---|---|
| Softness | - | 0 | + |
| Formation | - | 0 | + |
| Opacity | - | 0 | + |
| Low fines content | - | 0 | + |
| Bulk | ++ | 0 | 0 |

On the other hand, MHW has better bulk than the rest. Formation and opacity are important because tissue is very light weight products, where the inherent individual fibre properties have higher importance. At last, fines content which is important for dusting and drying capacity is significantly lower in *Acacia* than Eucalyptus.

As *Acacia* is a new fibre for pulp and paper making, several independent pulp and paper institutes were commissioned by APRIL to make basic studies of the fibre morphology, refining response and paper making potential.

In this paper, basic concepts of fibre morphology are explained and the results of the study from *STFI, the Swedish Forest Research Institute*, are presented, which compare Acacia to two different grades of *Eucalyptus*, one from *Brazil* and the other from *Iberian Peninsula*.

In the second part, the results from a refining study about some different grades of pulp available in Asia are discussed from the point of papermakers view. This study was conducted by *MoRe Research, formerly MoDo Research*; an independent laboratory specialized in pulp and paper, located in Sweden.

## RESULTS

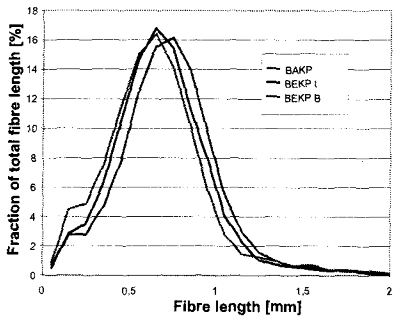
### Morphology study

The research at *STFI* was carried out with three different short fibre pulps, *Iberian* and *Brazilian Eucalyptus* and *Indonesian Acacia.*

Fibre dimensions are characterized by length, width, wall thickness and wall area. The methods used at *STFI* are traditional light microscopy, Confocal microscopy and *STFI* Fibremaster.

Fig. 1 shows the fiber length distribution. *Acacia* has similar narrow fibre length distribution like the two Eucalyptus grades although *Acacia*'s average fibre length is shorter, 0.66 mm compared to 0.69 mm for *Iberian* and 0.74 mm for *Brazilian* Eucalyptus.

Fig. 1, fibre length distribution(length weighted)

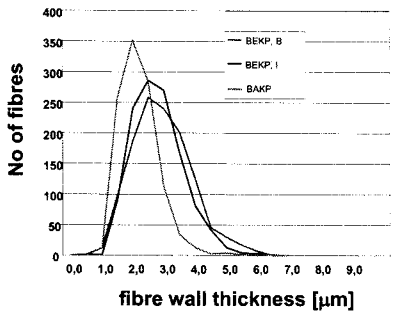



Average fibre length, mm

| | |
|---|---|
| BAKP | 0.661 |
| BEKP, I | 0.688 |
| BEKP, B | 0.740 |

Similar tendency can be seen from the cell wall thickness measurements, where Acacia shows significant lower cell wall thickness, 1.96μm compared to 2.55μm and 2.70μm respectively for *Brazilian* and *Iberian* Eucalyptus. Fig. 2 manifests that. It has even narrower distribution than the other two Eucalyptus grades. Note that the figures from microscopic evaluation are much smaller than figures from Kajaani Fibrelab. The optics of this equipment can not be accurately measured for very thin fibres.

Fig. 2, Fibre wall thickness distribution




Fibre width and perimeter are quite similar, as shown in table 5. Basically *Acacia*'s thin cell wall at the same fibre perimeter and length gives significantly lower coarseness.

Table 5, Fibre morphology of Acacia and Eucalyptus

| Fibre | Fibre length | Fibre width | Fibre perimeter | Fibre wall thickness |
|---|---|---|---|---|
| | mm | μm | μm | μm |
| Acacia | 0.661 | 14.8 | 41.3 | 1.96 |
| Eucalyptus, I | 0.688 | 15.5 | 39.4 | 2.55 |
| Eucalyptus, B | 0.740 | 15.4 | 38.9 | 2.70 |

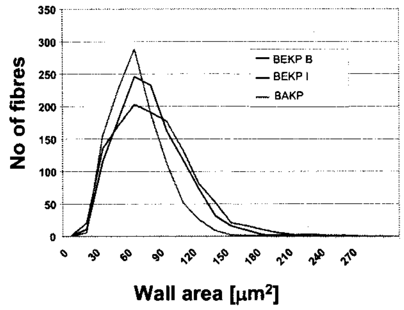
The conclusion is confirmed by fig. 3, which shows fibre wall area distribution. As can be seen in this figure, *Acacia*'s average wall area per fibre is lower and the distribution is significantly narrower than the rest. In practice, this means that *Acacia* fibres have very uniform fibre size, all fibres more or less identical.

Comparing various short fibre pulps coarseness and fibre population give certain specific paper properties.

Low roughness and high population favour tensile strength and initial web strength at the same fibre length. With respect to good contact between fibres, low coarseness gives large surface area per weight. Opacity and light scattering is mainly related to fibre wall thickness, while paper formation is similarly improved by increased number of fibres per weight. Surface smoothness is enhanced by thin and collapsed fibres.

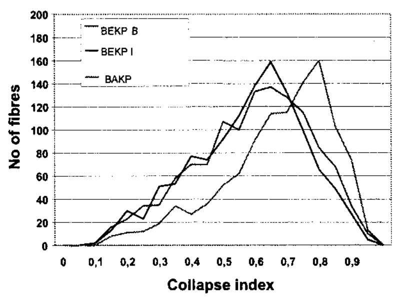
On the other hand high coarseness gives high bulk, which is closely related to high porosity and good drainage. Tear strength depends on fibre length and also can be positively affected by bulk.

Fig. 3, Fibre wall area distribution



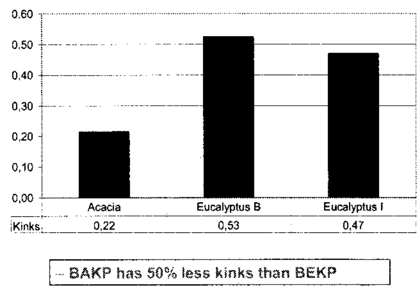

Fibre shape is characterized by collapse index, curl index and kinks. Fig. 4 shows fibre collapse index distribution. Collapse index is defined as 1 minus lumen area divided by an area of a circle with same perimeter as the lumen. *Acacia* fibre is already collapsed to a great extent even in unrefined state compared to Eucalyptus due to the thinner cell walls. The effect of sheet consolidation from once-dried pulp is not included.

Fig. 4, Fibre collapse index distribution




*Acacia* appears to be a very straight fibre. Fig. 5 indicates that. The kinks per fibre are less than half of that of Eucalyptus. The segment length and consequently the effective bonding length of *Acacia* are slightly higher than the others even if the average fibre length is shorter.

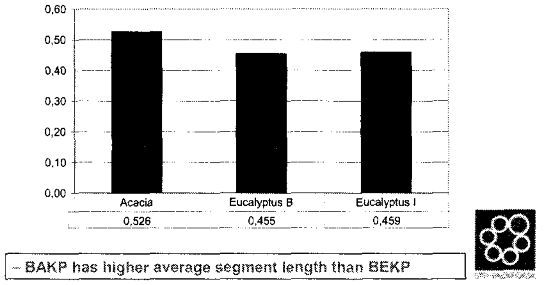
Fig. 5, Kinks per fibre



Kinks are often induced by equipment or process conditions in the pulp mill or stock preparation of the paper mill.

The shape factor decreases with fibre length. The low number of kinks contributes to a high shape factor, normally as measured in Fibremaster between 92 to 94%, compared to Eucalyptus of 89 to 91,5%. The impact of lower shape factor is a significant loss of tensile index, about 5 – 8 Nm/g for every percent. Fig. 6 shows segment length.

Fig. 6, Segment length




## REFINING STUDY

The refining study was conducted by *MoRe Research*, an independent laboratory based in Northern Sweden.

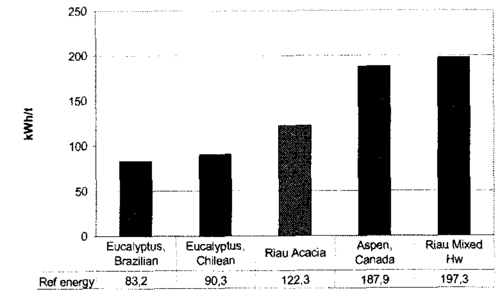
The evaluated short fibre pulps are, beside *Acacia*, two kinds of South *American Eucalyptus*, *Canadian Aspen* and *Indonesian Mixed hardwood.* An Escher-Wyss conical pilot refiner was used with furnish of 3.5% consistency with water of a specified ionic strength. 63 g/m$^2$ hand sheets were made in a conventional sheet former with deionised water. Refining energy input per ton is for that reason, considerably higher than that for industrial refining.

Comparisons of paper properties relevant for uncoated printing properties have been made at a constant tensile strength, as freeness or refining energy input does not have same importance as the paper specifications to the papermaker. It is of highest importance to select refining strategy that considers not only the furnish but also the paper specification, not just refining all different pulp in the same way by routine. Type of paper machine will also have a big impact due to different layout in press section and open draws for instance. For that reason, tensile index of 45 Nm/g is chosen as reference level, similar to standard tensile strength of uncoated woodfree papers.

As can be seen in fig. 7, refining energy input to achieve reference level is slightly higher for *Acacia* than for Eucalyptus, but considerably lower than for Aspen and Mixed hardwood. Note that the energy level is higher than that for industrial refining, but the internal relation should be correct.

Fig. 8 shows that the tear strength of *Acacia* is lower than that of Eucalyptus and considerably lower than that of Indonesian Mixed hardwood due to the short fibres.

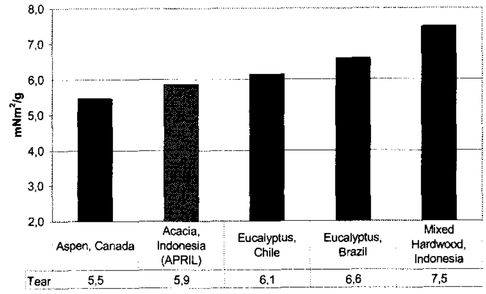
Fig. 7, Refining energy at 45 tensile index




***MoRe Research***

The tear strength is most important for runnability on the paper machine. However it is not directly related with product quality. Because most uncoated printing paper and many big fine paper machines in Asia are today running at speeds over 1500 m/min, at world class efficiencies.

Fig. 8, Tear index at 45 tensile index




***MoRe Research***

Today, one of the important issues for paper makers is shifting from traditional strength related properties to optical and printing properties. No fibres or paper making strategies can really combine high strength properties with excellent printing properties. There will be always a trade-off.

The optical properties of *Acacia* are excellent due to the high population and thin cell walls of the fibre, which differ the most from other fibres.

Fig. 9 exhibits that opacity of a hand sheet from *Acacia* without filler is almost 2.5 units higher than from Chilean Eucalyptus and 6 units higher than from Aspen and Mixed hardwood. Using *Acacia* has, in many cases, more impact than the filler level.

Similarly formation is very much improved comparing papers made from fibres with high population. There is a difference against Eucalyptus in terms of formation but not as noticeable as the difference of opacity in our experience.

Fig. 10 shows the bulk as measured by a hand sheet is average level for *Acacia*, definitely less than Mixed hardwood and Brazilian Eucalyptus but higher than Chilean Eucalyptus and Aspen.

Fig. 9, Opacity at 45 tensile index

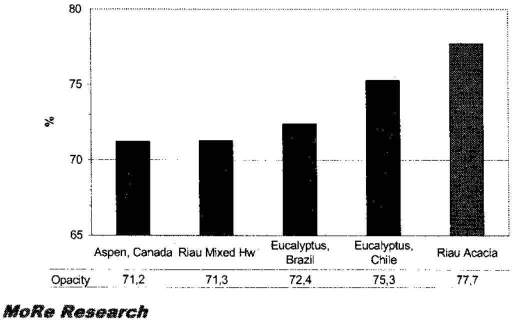
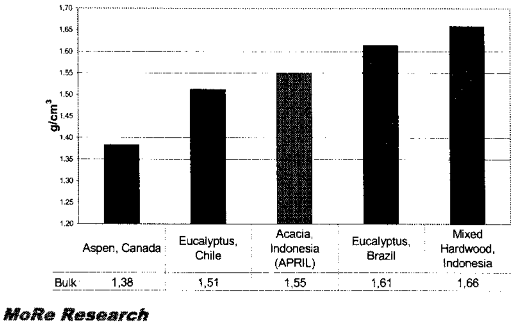


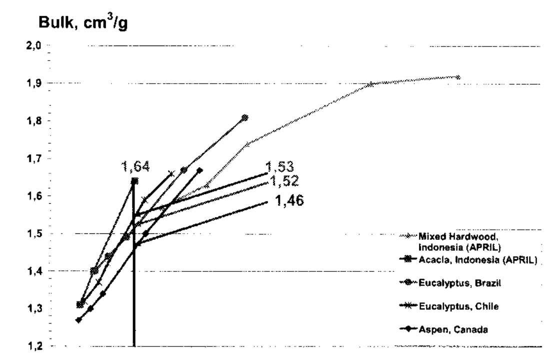

Fig. 10, Bulk at 45 tensile index




The bulk for paper is, on the other hand, not entirely related to this property as no consideration is taken to the roughness of the paper to be produced. For book paper and low grades of uncoated printing paper, where there are no requirements on roughness, this is relevant. But most printing paper today has a very precise roughness or smoothness specification to give the desired print result.

Experience from our own paper machine has shown that paper made from *Acacia* has a more "true thickness" as the paper surface is noticeably more even from the beginning than paper produced from Mixed hardwood. This affects the traditional thickness measurement, which only measures the "peak" thickness and not the averages. After calandering the difference becomes smaller while measured thickness remains the same.

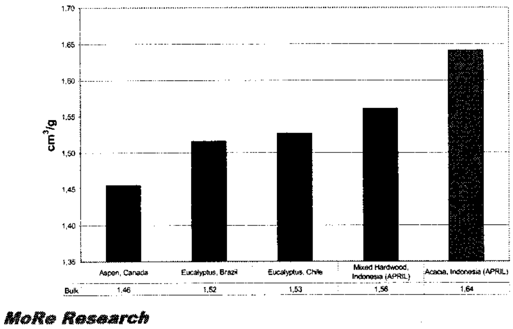
Fig. 11, Bulk comparison




As already mentioned, most paper grades have a specification on roughness, so comparing at the same roughness will give the actual bulk.

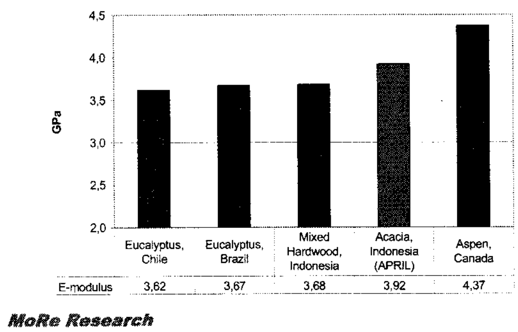
Fig. 12 shows measured roughness as Bendtsen at 120 ml/min. *Acacia* will give by far the highest bulk, which is confirmed by our own paper mill as well as by other prominent fine paper producers in the world. This indicates that there are other factors influencing as the type of the calendaring on the paper machine – if no possibility to unload calender the effect will be less. Leading paper machine suppliers in the world are now offering soft nip calendars that go down to a linear load of 5 kN/m compared to around minimum 25 to 30 in the past. For multi nip steel calendars, it might not be possible to adjust calandering at all.

Fig. 12, Bulk at 120 roughness Bendsen




For many paper makers, stiffness is a very important property, most related to the thickness impacting in 3rd potential. At the same thickness the elastic modulus is, as a material constant, proportional to stiffness. Fig.3 manifests that *Acacia* being a very straight fibre with fewer kinks than the evaluated Eucalyptus pulp, has higher E-modulus, but still lower than Aspen. From APRIL paper machines, paper produced from *Acacia* has normally a 5 to 8 % higher bending stiffness than that from Mixed hardwood at the same thickness.

Fig. 13, E-modulus at 45 tensile index




## DISCUSSION

The results from the studies can be summarized that *Acacia* pulp offers following advantages to paper makers, provided process conditions are adjusted in an optimum way.

The merits of *Acacia* for uncoated printing paper are an excellent formation and opacity, important especially for thin and low basis weight products. Provided calandering can be adjusted, a favorable combination of high bulk and a low roughness can be obtained. A good E-modulus will improve stiffness in addition.

The disadvantage is that *Acacia* should not be used for products that require high bulk and accept rough surface. Similarly bulk potential can not be utilized for old machines equipped with multi-steel nip calendars.

Refining conditions have to be considered for all new pulp used. *Acacia* and Eucalyptus are in this respect quite similar and principal suppliers of refiners recommend using finer fillings and higher consistency before refiners, than for higher coarseness hardwood and softwoods. As mentioned before, calender loadings should be reduced to preserve bulk.

Similar evaluation has been made of unrefined samples of same pulp with requirements for tissue in mind, where the major advantage seems to be a very good softness, both in terms of "*handfeel*" softness and bulk softness or flexural rigidity. Major tissue companies in the world have showed a huge interest in the fibre, which probably will be next key usage area for *BAKP*. For very thin sheets of 14 – 21 g/m$^2$ as facial towels and tissue, the good formation and high opacity give the perception of better softness and high quality product. Low fines content is appreciated due to less dusting tendency and less required drying capacity at the Yankee cylinder. *Acacia* shows good absorbency due to high fibre population and high unrefined bulk.

## CONCLUSIONS

The high fibre population of *Acacia* promotes excellent formation and outstanding opacity compared to all of the rest commercial short fibre pulps. The thin cell walls of *Acacia* fibres provide unique smoothness of the paper surface. At a given surface roughness, *Acacia* offers superior bulk. A straight fibre without kinks gives higher stiffness at the same thickness due to better E-modulus. The high population combined with thin and collapsed fibres gives an exceptional softness for tissue.

Quoting a famous consultant in the Pulp and Paper industry, "The competitiveness of pulps can be estimated by the number of fibres per gram. This correlates with most of the important requirements set for fine paper. Large number of fibres improves the smoothness and opacity of pulp and improves the printability properties of paper."

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