Investigating the papermaking potential from recycling kraft paper sacks within standard high volume paper mills

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The recyclability of five kraft paper sack variants, which are representative of greater than 80% of the paper sacks placed on the market in Europe, was investigated using the Cepi recyclability laboratory test method. Subsequently, the benefits from including sack kraft paper fibres within a typical recycled fibre furnish which is used by high volume standard recycling paper mills were investigated.

The results indicate that four of the five kraft paper sacks are suitable for 'standard mill' recycling. Yield scores ranged from 63 to 96 for recyclable sacks with the highest yield score being judged 'Best in Class' and unlikely to pose any repulpability issues in a standard mill. Most of the pulps obtained from the kraft sacks resulted in an absence of deleterious visual or sheet adhesion impacts. One of the sacks tested was noted to pose 'major repulpability issues' due to the presence of a heavy gauge plastic film inner bag. It should be noted that this paper sack is designed to be separated from the plastic tube with the milk powder contents before it is brought into the food preparation area as part of its intended use. As such, the results presented here are a worst-case scenario. Once used, only the paper sack would be collected for standard mill recycling. A kraft paper sack which was used to pack cement attained a recyclability score of 83 and would again be considered suitable for recycling by standard mills. Any cement which remained within the shaken sack did not impact fibre dispersion nor sheet quality parameters. The Cepi method identified that reducing or eliminating the plastic content of the kraft paper sack would increase the recyclability score. These strategies align with those being proposed within Eurosac and CEPI-Eurokraft's recently published Design for Recyclability Guidelines.

Substitution of a recycled fibre furnish, which served as a control, with sack kraft fibre, resulted in a linear increase in length-weighted fibre length. Inclusion of sack kraft fibre at 5% increased length-weighted fibre length by 8.2% which increased tear, burst and tensile indices by 15.5, 2.0 and 2.2% respectively. Inclusion of sack kraft fibre at 20% increased length-weighted fibre length by 19.8% which increased tear, burst and tensile indices by 44.4, 45.1 and 16.6%. Substitution of sack kraft fibre at 5 and 20% increased recycled fibre pulp drainage by 7.1 and 12.5% as evidenced by a decrease in Schopper Riegler values from 28 to 26 and 24.5 seconds respectively. Such a result, if substantiated at mill scale, could lead to a drier sheet entering the press and dryer sections which would lead to energy savings. Sack kraft paper contained lower quantities of dissolved and colloidal substances (DCS) <10μm (0.1 to 0.9%) and ash (0.53%) than a recycled furnish (DCS 3.1% and ash 1.82%) which implies beneficial high fibre yield.

Taken together, kraft paper sacks could meet standard recycling mills' quest for sources of fresh long fibre to improve pulp drainage, machine runnability and increase dry sheet mechanical properties. The results indicate that most kraft paper sacks placed on the market in Europe could be recycled within standard recycling mills. Many kraft paper sacks are used by industry and are meticulously cleaned to recover the contents and could serve as a valuable, clean, source-separated fibre stream for standard recycling mills.

1 Introduction

The 4evergreen (4EG) alliance reports that 82.3% of fibre-based packaging is recycled in Europe and aims to reach an ambitious 90% target by 2030. To attain this recycling rate, focus is being given to increase recycling rates for household, out of home and on-the-go fibre-based packaging.[1] Fibre-based packaging is increasingly replacing non-recyclable single use plastic and is characterised by its huge variability in packaging applications. These applications include those which require functional barrier coatings and/or layers to extend product shelf life or to prevent leakage. Kraft paper sacks are a widely used packaging format with applications across numerous industrial and consumer end-use sectors including dry food and ingredients, animal feed, pet food and building materials. Much like household, out of home and on-the-go packaging, kraft paper sacks sometimes combine other materials with the paper layers, for example free polymer films, such as polyethylene and also bio-based barriers, to add functionality. These additional materials increase functionality but the implications for recyclability of kraft paper sacks need to be investigated and confirmed.

Hitherto, uncertainty existed as to the evidence required to demonstrate the recyclability of fibre-based packaging. Test methods are in operation in some countries, such as UNI 11743 in Italy,[2] but the results might not be accepted across all European countries. In response, Cepi developed a harmonised European laboratory test method to provide a common approach to evaluate the recyclability of fibre-based packaging materials within standard paper and board mills.[3] Cepi are also developing test methods to assess the recyclability of fibre-based packaging within flotation deinking mills and also mills able to reprocess special grades such as those described in group 5 of EN 643.[4]

Virgin fibres are widely used in the packaging industry and are the preferred choice for packaging in direct contact with food. Following usage, virgin fibres should return to the paper cycle as fresh cellulose to augment recycled fibre quality.[5] The addition of fresh cellulose, alongside fibre fractionation, chemical treatments and papermaking modifications are widely adopted strategies to increase the mechanical properties of recycled fibre-based products.[6,7] Recovering valuable fresh fibre from fibre-based primary packaging, as well as kraft paper sacks, makes economic and technical sense if proven to be recyclable and the benefits of including sack kraft fibres can be demonstrated.

The aim of this study was to evaluate the repulpability and recyclability of a range of commercially available kraft paper sacks using the Cepi laboratory test method. In addition, the recyclability of an emptied kraft paper sack which had previously been filled with cement was investigated to determine if there

Sample	Specification and Typical Application
1: Printed sack for 25kg flour	Cellulose fibre-based product. Printed valve sack made from 2 paper plies: 70gsm bleached kraft / 70gsm unbleached kraft representative of 25kg flour or animal feed sack (with internal paper valve)
2: Printed valve sack for 25kg cement / building material	Cellulose fibre-based product. Printed valve sack made from 3 plies: 70gsm bleached kraft / 9.5 gsm (10µm) HDPE free-film / 70gsm unbleached kraft representative of 25kg cement or other building materials with paper reinforced valve
3: Printed open mouth bag for animal feed	Cellulose fibre-based product. Printed open-mouth sack made from 3 plies: 70 gsm bleached kraft / 80 gsm unbleached kraft / 70 gsm unbleached kraft + 13.8 gsm (15µm) LDPE coating representative of seeds or animal feed sack
4: Printed open mouth bag with plastic tube for powdered milk	Cellulose fibre-based product. Printed open mouth sack made from 2 paper plies with separable LDPE tube: 90gsm unbleached kraft paper / 90gsm unbleached kraft / 55.2 gsm (60µm) LDPE tubular film representative of paper sack for powdered milk
5: Printed open mouth bag for 15kg pet food	Cellulose fibre-based product. Printed open mouth sack made from 3 plies: 80gsm bleached clay-coated kraft paper fully printed with non-slip glossy varnish / 70gsm unbleached kraft / 70 gsm unbleached kraft + 21.2 gsm (23µm) LDPE film representative of a pet food sack
6: Used printed valve sack for 25kg cement	Cellulose fibre-based product. Printed valve sack made from 3 plies: 70gsm bleached kraft / 9.5 gsm (10µm) HDPE free-film / 70gsm unbleached kraft representative of 25kg cement or other building materials with a paper reinforced valve. The sack had been thoroughly shaken-out before testing

Table 1. Description of samples for testing.

were impacts on fibre dispersion and paper sheet quality from any product residues that may be present. The benefits from including sack kraft paper fibres within a typical recycled fibre furnish which is used by high volume standard recycling mills were investigated through measurements of fibre length and coarseness, pulp drainage, DCS <10µm, ash and paper sheet mechanical properties. If proven recyclable and fibre benefits identified, then the recovery of clean kraft paper sacks, particularly from source-separated post-industrial sources, could assist 4EG reach their 90% recycling target by 2030.

2 Material and methods

2.1 Selection of kraft paper sacks

Unused kraft paper sacks were supplied by Mondi Flexible Packaging for testing. A used printed valve sack previously filled with 25kg of cement was also supplied to assess if any residual product impacted fibre dispersion, quantity of coarse or fine rejects or sheet quality parameters (*Table 1*). The selected sack configurations are representative of more than 80% of the paper sacks placed on the market in Europe.

2.2 Repulpability and recyclability of assessment of selected kraft paper sacks

Sacks were cut into pieces of 3cm x 3cm (+/- 0.5cm) in size. Care was taken to ensure that the sample contained the same proportion of materials as used in the finished sack construction. The repulpability and recyclability assessments were carried out as described in the Cepi laboratory test method. The test method emulates relevant process stages used by a standard paper mill to prepare fibre for papermaking and comprises the following phases:

- Ease at which fibres can be separated using standard process and equipment
- The potential to form sheets out of the recovered fibres without significant disruption
- The visual appearance when formed into sheets
- The levels of coarse and fine rejects
- The level of fragmentation of disrupting materials (adhesives, metals, plastic film)
- The level of colloidal solids below 10µm resulting from non-paper components in the tested sample.

The output values obtained for course rejects, fine rejects, visual impurities and adhesiveness were entered into an excel-based *Evaluation Protocol scorecard* and a 'Recyclability Score' calculated. This score is based on the sum of the 'Yield score' (derived from the sum of the % coarse reject and % fine rejects), visual impurity score and sheet adhesion scores which ranges from +100 to – (minus) 100 points, where the higher the number indicates increased recyclability. A Recyclability Score between 0 and 100 is required for a fibre-based pack to be considered 'Suitable for Standard Mill Recycling'. The testing was carried out by Centro Qualità Carta.[8]

2.3 Assessing the benefits of fibres from kraft sack paper on recycled fibre pulp and paper

Recycled liner (100gsm) was obtained from a UK paper mill and used as the reference recycled fibre pulp and paper. The reference sack kraft paper comprised 70gsm bleached kraft and 70gsm unbleached kraft which was harvested from a printed valve sack used to pack 25kg flour or animal feed. Both sets of paper samples were reduced to pieces measuring 3cm x 3cm (+/-0.5cm) in size. Trial mixes of recycled liner and sack kraft paper were prepared in the ratios shown in *Figure 1*. The fibre mixtures were repulped in a L&W Pulp Disintegrator under the conditions specified in the Cepi laboratory test method, i.e. 2.5% consistency, 40˚C for 10 minutes (30,000 stirrer revolutions) in tap water.

Average fibre length (length-weighted) and gravimetric fibre coarseness (both assessed using a Valmet Fiberline Analyzer), pulp drainage rate (Schopper Reigler), DCS <10µm (Cepi recyclability Laboratory Test Method V.2) and ash content (Tappi T413) were determined on each pulped mixture. Pulps were converted into 60gsm handsheets and tear (Tappi T414), burst (Tappi T403) and tensile (Tappi T494) indices measured.

3 Results

3.1 Repulpabilty and recyclability assessments

The repulpabilty and recyclability assessments of five sack variants together with a used sack are summarised in *Table 2*.

Notes:

1. Visual Impurities Level 1: poses no visual quality issues.
2. Visual Impurities Level 2: poses minor visual quality issues that can be acceptable in the mix.
3. Sheet Adhesion Level 1: poses no adhesion issues.

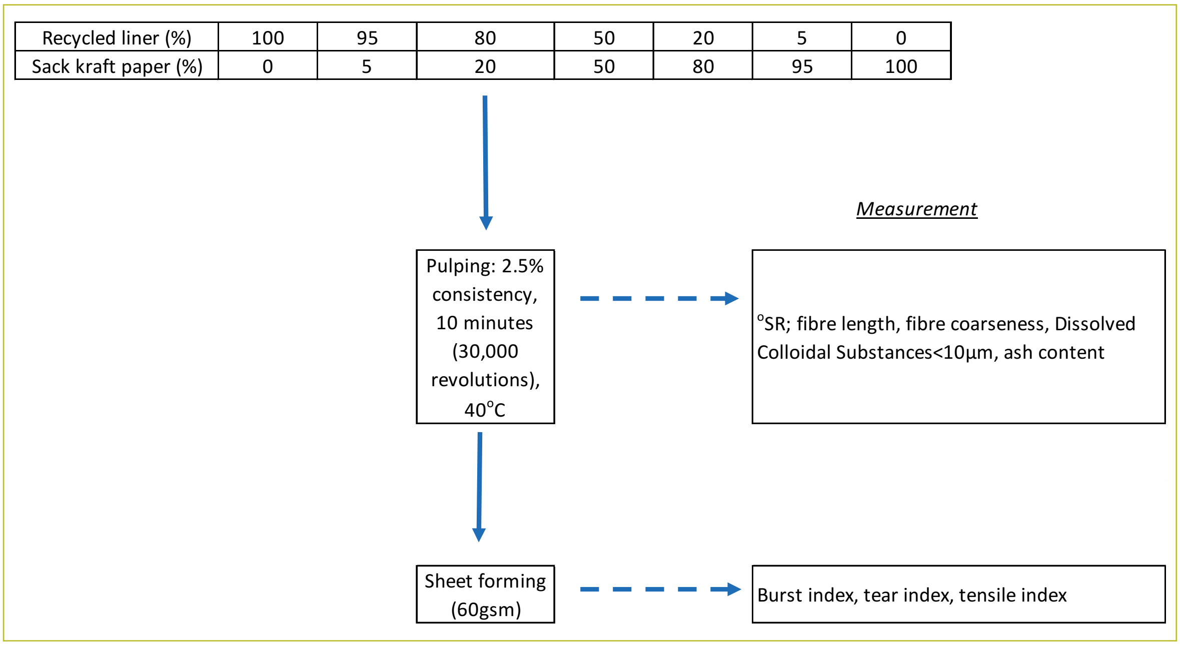

Figure 1. Schematic of test methodology.

Sample	Coarse Reject (%)	Fine Reject (%)	Visual Impurities	Sheet Adhesion	Recyclability Score	Notes
1	0.0	2.4	1	1	96	no repulpability issues expected
2	5.9	1.4	2	1	75	minor repulpability issues expected
3	6.5	0.8	1	1	80	minor repulpability issues expected
4	22.5	0.6	1	1	-27	major repulpability issues expected
5	10.2	0.9	1	1	63	some repulpability issues expected
6	5.0	1.7	1	1	83	minor repulpability issues expected

Table 2. Summary of recyclability scores and suitability for standard mill recycling.

3.1.1 Sample 1: Printed valve sack for 25kg flour

The sum of the percent dry weight of the coarse and fine screenings resulted in a yield score of **96** (*Table 2*). The Evaluation Protocol judges that a Yield score anywhere between 100-90 points is considered *Best in Class* and that the packaging is not expected to pose any repulpabilty issues in a standard mill. Handsheets made from the fibre accepts were observed to have no visual quality issues and no adhesion issues (both assigned Level 1). A score of '0 points' was assigned to the recyclability score for each sheet quality parameter. The sum of the scores for yield, visual impurities and sheet adhesion amounts to **96** and as such this paper sack can be judged '*Suitable for Standard Mill recycling'*.

DCS <10µm was **0.1%** of the original sack weight indicating high fibre yield. If a mill accepted 1,000kg of paper sacks for recycling and subtracting fine rejects (2.4%) and DCS losses (0.1%), then 975kg of the paper sacks could be converted into recycled paper.

3.1.2 Sample 2: Printed valve sack for 25kg cement/building material

The recovery of coarse rejects (5.9%) and fine rejects (1.4%) of the original sack weight resulted in a fibre yield score of 80 (*Table 2*). The recyclability score indicates that this sack has '*minor repulpability issues that could have limited impact on the recyclability in standard mills*'. Sheet adhesion was noted to be absent (scoring 0 points). Impurities were noted in the handsheet which reduced the recyclability score by 5 points, bringing the final score to 75.

DCS was measured at 0.2% of the original sack weight indicating high fibre yield.

The data identifies several areas of sack construction which could be improved to increase the recyclability score. These include reduction/elimination of HDPE content to improve the yield score. It would be useful to identify the impurities observed in the handsheet; for instance, these may relate to inks used to print the sack and changing the ink composition might reduce sheet impacts.

3.1.3 Sample 3: Printed open mouth bag for animal feed

The recovery of coarse rejects (6.5%) and fine rejects (0.8%) of the original sack weight resulted in a fibre yield score of 80 (*Table 2*). The recyclability score indicates that this sack has '*minor repulpability issues that could have limited impact on the recyclability in standard mills*'. Visual impurities and sheet adhesion were noted to be absent (both scoring 0 points) bringing the final recyclability score to 80. DCS was measured at 0.1% of the original sack weight, indicating high fibre yield.

3.1.4 Sample 4: Printed open mouth bag with plastic tube for powdered milk

The recovery of coarse rejects (22.5%) and fine rejects (0.6%) of the original sack weight resulted in a fibre yield score of -27 (*Table 2*). The recyclability score indicates that this sack has

Trial	Furnish Content		Lc(l)	Optical Coarseness	Tear Index	Burst Index	Tensile Index	°SR	Ash
	Recycled Liner	Sack Kraft							
	%	%	mm	mg/m	mN	kPa	N	sec	%
1	100	0	0.892	0.153	370.33	99.25	27.85	28	1.82
2	95	5	0.965	0.153	427.73	101.25	28.46	26	1.88
3	80	20	1.069	0.157	534.93	144.00	32.47	24.5	1.72
4	50	50	1.358	0.179	698.82	200.75	39.56	20.5	1.30
5	20	80	1.561	0.177	905.43	264.25	47.52	19.5	1.14
6	5	95	1.738	0.206	1001.65	290.00	51.74	18	0.88
7	0	100	1.783	0.200	1001.90	328.75	57.65	17	0.53

Table 3. Summary of impacts from stepwise substitution of recycled liner with sack kraft fibres on physical properties of handsheets – average data.

Trial	Furnish Content		Lc(l)	Optical Coarseness	Tear Index	Burst Index	Tensile Index	°SR	Ash
	Recycled Liner	Sack Kraft							
	%	%	%	%	%	%	%	%	%
1	100	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	95	5	8.2	0.0	15.5	2.0	2.2	-7.1	3.3
3	80	20	19.8	2.6	44.4	45.1	16.6	-12.5	-5.5
4	50	50	52.2	17.0	88.7	102.3	42.1	-26.8	-28.6
5	20	80	75.0	15.7	144.5	166.2	70.6	-30.4	-37.4
6	5	95	94.8	34.6	170.5	192.2	85.8	-35.7	-51.6
7	0	100	99.9	30.7	170.5	231.2	107.0	-39.3	-70.9

Table 4. Summary of impacts from stepwise substitution of recycled liner with sack kraft fibres on physical properties of handsheets – percentage changes.

'***major repulpability issues*** *which could stop the process at a standard mill and therefore not suitable for this mill*'. It is recommended that this product is recycled at a specialist mill. Visual impurities and sheet adhesion were noted to be absent (both scoring 0 points) bringing the final recyclability score to -27.

It should be noted that this paper sack is designed to be separated from the plastic tube with the milk powder contents before it is brought into the food processing clean room. As such, the results presented here are a worst-case scenario. Only the paper sack would be collected for standard mill recycling. It should also be noted that reducing the LDPE gauge from 60 to 50µm would result in a positive recyclability score (49-0) with 'significant repulpability issues' but still suitable for standard mill recycling.

DCS was measured at 0.1% of the original sack weight, indicating high fibre yield.

3.1.5 Sample 5: Printed open mouth bag for 15kg pet food

The recovery of coarse rejects (10.2%) and fine rejects (0.9%) of the original sack weight resulted in a fibre yield score of 63 (*Table 2*). The recyclability score indicates that this sack has '*some repulpability issues that affect the process in standard mill and should therefore not be abundant*'. Visual impurities and sheet adhesion were noted to be absent (both scoring 0 points) bringing the final Recyclability Score to 63. DCS was measured at 0.9% of the original sack weight, indicating high fibre yield.

3.1.6 Sample 6: Used printed valve sack for 25kg cement

The recovery of coarse rejects (5.0%) and fine rejects (1.7%) of the original sack weight resulted in a fibre yield score of 83 (*Table 2*). The recyclability score indicates that this sack has '*minor repulpability issues that could have limited impact on the recyclability in standard mills*'. Sheet adhesion was noted to be absent (scoring 0 points). No impurities were noted in the handsheet bringing the final score to 83. DCS was measured at 0.3% of the original sack weight, indicating high fibre yield.

The data indicate that product residues from filled cement sacks that have been thoroughly shaken empty do not impact on fibre dispersion, fibre yield (as quantified by the recovery of coarse and fine rejects) or sheet quality parameters. The used sack scored marginally better than the unused version in terms of fibre yield and absence of impurities which affect sheet impacts, but this probably reflects the margin of error in the sampling and test methods.

It is stressed that these results pertain to a paper sack for cement that has been properly emptied at the end of use before the recycling test procedure. Of course, results might be different if more contamination was present.

3.2 Papermaking potential of sack kraft fibre

The results from increasing the quantity of sack kraft fibre within a recycled fibre furnish are shown in *Table 3*; the percentage changes are summarised in *Table 4*.

3.2.1 Length-weighted fibre length (Lc(l))

The length-weighted fibre length values recorded for the recycled liner and sack kraft fibre were 0.892 and 1.783mm respectively. Stepwise substitution of a recycled fibre furnish control with sack kraft fibre resulted in a linear increase (R^2 = 0.9683) in length-weighted fibre length over the 5 to 100% substitution range investigated.

3.2.2 Optical coarseness

Optical coarseness (average mass per unit length of fibre) values recorded for the recycled liner and sack kraft fibre were 0.153 and 0.2mg/m respectively. Optical coarseness remained unchanged following addition of 5% sack kraft fibre and increased to 2.6% following substitution of a recycled fibre furnish control with 20% sack kraft fibres. Percent increase in optical coarseness plateaued following substitution of sack kraft fibre at 95%.

3.2.3 Tear Index

Average tear index values recorded for handsheets prepared from recycled liner and sack kraft fibre were 370.33 and 1001.90mN respectively. Stepwise substitution of a recycled fibre furnish control with sack kraft fibres increased tear index linearly (R^2 = 0.9582) which plateaued when sack kraft fibre reached 95% of the fibre furnish. A 5 and 20% substitution resulted in a 15.5 and 44.4% increase in tear index respectively. Tear index increased linearly with increasing length-weighted fibre length (R^2 = 0.9921).

3.2.4 Burst index

Average burst index values recorded for handsheets prepared from recycled liner and sack kraft fibre were 99.25 and 328.75kPa respectively. Stepwise substitution of a recycled fibre furnish control with sack kraft fibres increased burst index linearly (R^2= 0.9715). A 5% substitution resulted in a 2.0% increase in burst index which increased to 45.1% following 20% substitution of sack kraft fibres. Burst index increased linearly with increasing length-weighted fibre length (R^2 = 0.9873).

3.2.5 Tensile Index

Average tensile index values recorded for handsheets prepared from recycled liner and sack kraft fibre were 27.85 and 57.65N respectively. Stepwise substitution of a recycled fibre furnish control with sack kraft fibres increased tensile index linearly (R^2 =0.9700). A 5 and 20% substitution resulted in an increase in tensile index of 2.2 and 16.6% respectively. Tensile index increased linearly with increasing length-weighted fibre length (R^2 = 0.9811).

3.2.6 Schopper Riegler (°SR)

Recycled liner and sack kraft fibre pulp drainage rates, as determined by the Schopper Reigler test, were recorded to be 28 and 17 seconds respectively. Substitution with sack kraft fibre at 5 and 20% increased recycled fibre pulp drainage by 7.1 and 12.5% as evidenced by a decrease in °SR from 28 to 26 and 24.5 seconds respectively.

3.2.7 Ash

Percentage ash values recorded for the recycled liner and sack kraft fibre were 1.82 and 0.53% respectively. Stepwise substitution of a recycled fibre furnish control with sack kraft fibre largely resulted in a decrease in percent ash.

4 Conclusions

The Cepi laboratory test method provides up to date methodology and guidance to investigate and score the recyclability of fibre-based packaging, such as kraft paper sacks, within standard mills. The results are intended to be used to support the design of packaging to achieve the best possible ‘circularity performance’. The current study examines the recyclability of kraft paper sacks which are representative of greater than 80% of the paper sacks placed on the market in Europe.

Four of the five specifications of kraft paper sacks have been shown to be suitable for recycling by standard recycling paper mills using Cepi methods. One paper-based sack obtained a yield score of 96 which is judged Best in Class (Printed valve sack for 25kg flour). Two sack constructions obtained yield scores of 80, which would likely offer only ‘minor repulpability issues.’ A third variant (Printed open mouth bag for 15kg pet food) was noted to be suitable for standard recycling paper mills but would have some repulpability issues and should not be abundant within the feedstock.

In all but one case (Printed valve sack for 25kg cement/building material), none of the pulps obtained from the kraft sacks resulted in visual or sheet adhesion issues.

One sack variant (Printed open mouth bag with plastic tube for powdered milk) would likely have major repulpability issues and would not be suitable standard mill recycling. It should be noted that this represents the worst-case scenario. The paper sack is intended to be separated from the plastic tube and its milk contents as part of the intended use. Once used, only the paper sack would be collected for recycling. It may also be noted that reducing LDPE thickness from 60 to 50µm would also result in a positive recyclability score (49-0) with ‘significant repulpability issues’ but still suitable for Standard Mill recycling.

A kraft paper sack which was used to pack cement scored 83 and would be considered to be suitable for recycling by standard recycling paper mills. Product residues from filled cement sacks that have been thoroughly shaken empty do not appear to affect fibre dispersion nor sheet quality parameters.

The results obtained from the Cepi recyclability laboratory test method identify that reducing or eliminating free polymer film content increases the kraft paper sack recyclability score. This could be achieved through gauge reduction or through the use of recyclable barrier coatings. These strategies align with those being proposed within Eurosac and CEPI-Eurokraft’s *Design for Recyclability Guidelines*.[9]

Standard recycling mills need a constant supply of high yield fresh long fibres to maintain key paper sheet mechanical properties such as tear, burst and tensile. This study indicates that substitution of recycled fibre with sack kraft fibres resulted in linear increases in length weighted fibre length of a recycled fibre furnish, leading to increases in tear, burst and tensile indices:

- 5% substitution increased length-weighted fibre length by 8.2% which increased tear, burst and tensile indices by 15.5, 2.0 and 2.2% respectively.
- 20% substitution increased length weighted fibre length by 19.8% and tear, burst and tensile indices to 44.4, 45.1 and 16.6% respectively.

It could be speculated that a 1% inclusion of sack kraft fibres would increase tear, burst and tensile indices by ~ 3.1, 0.4 and 0.4% respectively. Whilst not measured in this study, the inclusion of long fresh fibre could increase wet web tensile strength which would reduce web breaks and improve machine runnability.

Optical coarseness increased from 2.6% to 17.0% following substitution of a recycled fibre furnish control with 20% and 50% sack kraft fibres respectively. Incorporating sack kraft fibres, which have thicker fibre walls/unit length increases the resilience of recycled fibre furnishes to resist successive recycling and refining cycles without the loss of fibre length and bonding potential.

Sack kraft paper contained lower quantities of DCS <10µm ranging from 0.1 to 0.9% and ash (0.53%) than a recycled furnish (DCS 3.1% and ash 1.82%) which implies beneficial high fibre yield and increased pulp drainage rate. Inclusion of sack kraft fibre at 5 and 20% increased recycled fibre pulp drainage by 7.1 and 12.5% as evidenced by a decrease in °SR from 28 to 26 and 24.5 seconds respectively. Such a result, if substantiated at mill scale, could lead to a drier sheet entering the press and dryer sections which would lead to energy savings.

Alongside fibre fractionation and chemical treatments, the controlled addition of clean fresh fibres which are obtained from household, out of home and on-the-go fibre-based packaging as well as sack kraft paper could become a strategy of increasing importance to standard recycling mills to improve pulp drainage and increase dry sheet mechanical properties.

The results indicate that most kraft paper sacks placed on the European market could be recycled within standard recycling mills. Many kraft paper sacks are used by industry and are meticulously cleaned to recover the contents as part of their intended use and could serve as a valuable, clean, source-separated fibre stream for standard recycling mills.

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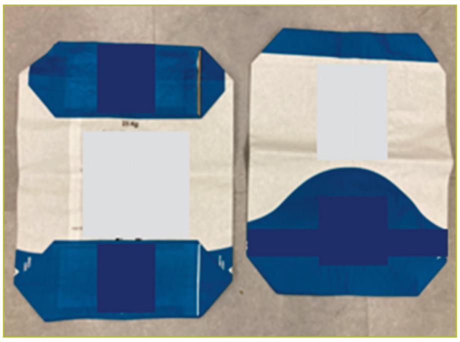
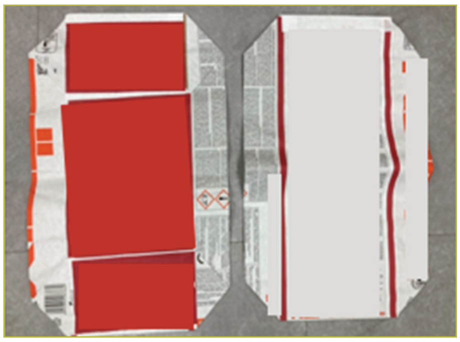


3.1.1 Sample 1: Printed valve sack for 25kg flour



3.1.2 Sample 2: Printed valve sack for 25kg cement

3.1.3 Sample 3: Printed open mouth bag for animal feed

3.1.4 Sample 4: Printed open mouth bag with plastic tube for powdered milk

3.1.5 Sample 5: Printed open mouth bag for 15kg pet food

3.1.6 Sample 6: Used printed valve sack for 25kg cement