Development of Sustainable Menstruation Pants using Speciality Viscose Fibres

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Abstract

Kelheim Fibres GmbH is one of the leading suppliers for fibres used in menstruation hygiene products. However, conventional menstruation products like sanitary pads, which are made from petrochemical fibres and raw materials, lead to a huge amount of non-biodegradable and non-recyclable waste. Therefore, it is necessary to engage in the development of more sustainable solutions. Here the development of a reusable menstruation pants mainly based on renewable cellulosic raw materials is described and the market potential of such a product is determined. In order to get to know the existing market for period pants a competitor product analysis of ten brands from the core markets Europe and North America was carried out. Simultaneously different cellulosic fabric materials were tested in order to design and assemble a prototype. The acquisition time and the rewet value of the products and material samples were tested. The best market product showed an outstanding performance but has drawbacks concerning the physical properties of the pants. The material tests showed that the performance is dependent on both, the material composition as well as the material structure. The most promising results showed CELLIANT® Viscose and Danufil® Fibres in the Topsheet, Galaxy® in the ADL layer, Bramante, a hollow viscose fibre, in the Absorbent Core and a water repellent woven fabric, a biodegradable PLA film or a sustainable coating as a Backsheet. Further work is planned to optimize the composition and the knitting structure of the individual layers.

Keywords: *Period Pants, Sustainability, Menstruation, Reusable products, Textiles, renewable fibres, cellulosic fibre, Circular economy*

Abbreviations:

- ADL: Acquisition distribution layer
- EU: European Union
- SUPD: Single Use Plastic Directive
- PLA: Polylactic acid

Conventional menstruation products like sanitary pads, are well established in the feminine hygiene sector. However, they have serious negative effects on the environment as they generate huge amounts of waste and cause marine pollution. With the Single Use Plastic Directive the European Union aims to substitute single use plastics and drive more attention towards this topic (European Parliament, 2019). As a result, menstruation products using synthetic materials have to be labelled accordingly. Due to the rising environmental consciousness, new, more sustainable products are on the rise. In the feminine hygiene sector, reusable products like menstruation pants have been developed and placed on the market. However most period pants use different raw materials, including synthetic fibres, in order to achieve an adequate performance. At the end of their product lifetime, these products contribute to the growing amount of textile waste, as they are hard to recycle and non-biodegradable. In this article the development of fully sustainable and biodegradable menstruation pants using predominantly cellulose based raw mate-

rials is displayed. In addition to that, the market prospects of such a product are showcased.

To determine the performance of menstruation pants and material combinations, an adaption of the acquisition time and rewet test method was used. The acquisition time is the time a defined liquid volume takes to be absorbed by the test specimen. The rewet value measures the amount of liquid that is given back by the test specimen to a filter paper in 10 seconds under the pressure of 1 kg. Both values should be as low as possible. The competitor product test was carried out with liquid volumes of 10, 15 and 20 ml. For the material test, a standardized sample size of 15 x 8 cm and a standard liquid volume of 10 ml were used. Further measurements of the thickness, the air permeability and the weight of all tested products and materials have been done as well.

Menstruation is a topic that affects half of the human population on earth at a certain time of their lives, which equals 3,865 billion people (United Nations, 2019). On average, the length of a menstruation cycle is 28 days and the amount of blood lost varies between 20 and 60 ml, with amounts over 80 ml classified as heavy menstruation (Mengel, 2020). As the subject of menstruation is still stigmatized and considered as a taboo topic, adequate communication is hard to achieve. As a result, informed choice of the product selection is not possible for a huge number of women and single use menstruation products are frequently disposed incorrectly leading to environmental and marine pollution. In 2017, 49 billion sanitary menstruation products that equal 590,000 tons were used alone in the 28 member states of the European Union (Van den Bossche , 2020). In addition to that single use sanitary pads are on average made 90% of synthetic materials (Van den Bossche, 2020) and therefore incorrect disposal endangers the marine environment through plastic waste and the creation of micro plastics. In contrast to that, tampons are made, up to 95% out of cellulosic material. In Germany the predominantly used menstruation products are tampons which are used by 71% of women closely followed by pads with 62% according to a study conducted in 2020 (Sparwelt GmbH, 2020). Only 7% of the study participants use sustainable alternatives to conventional single use menstruation products (Sparwelt GmbH,

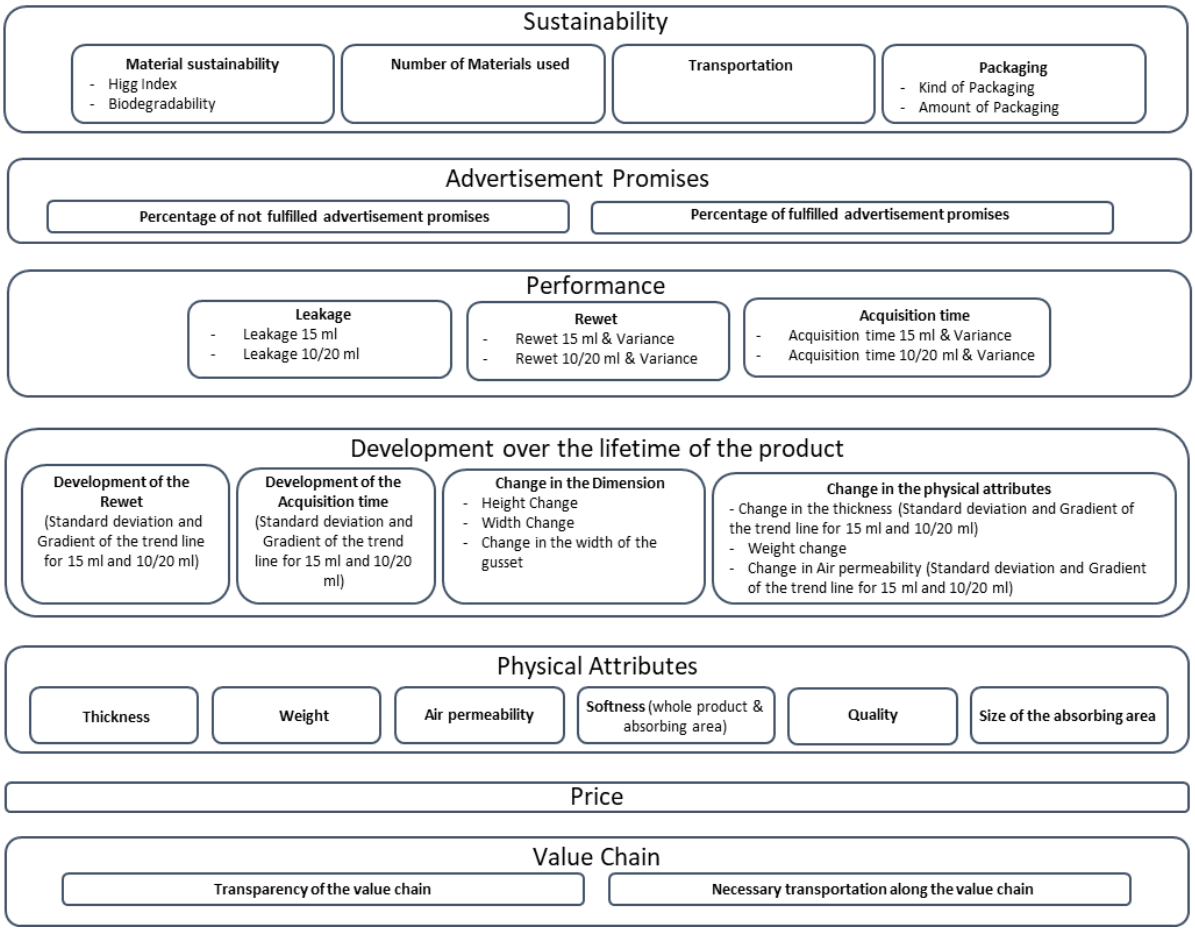

Figure 1: *Categories for the evaluation of the competitor product test of the menstruation pants*

2020). The main influencing factors found during the study for the use of sustainable products are the amount of the salary and the age of the woman. Women with a salary over 1500 Euro per month and an age between 20 and 29 are more likely to use sustainable alternatives (Sparwelt GmbH, 2020).

The competitor product analysis rates the products against each other in the categories sustainability, performance, physical attributes, development over the lifetime of the product, fulfilment of the advertisement promises, price and value chain. Each category is split up in sub-categories as displayed in figure 1. The categories performance and sustainability are graded double as they are the main interest of this paper.

The best product is rated with one point and the worst with 10. The brands were selected after an analysis of the worldwide market of period pants has taken place. In total 83 companies selling such products could be found in April 2021. The main markets identified are North America (21 companies) and Europe (56 companies) whereby France (30 companies) has the highest number of competing companies in the market. The overall period pant market is made up mainly by Start-Ups. Recently also more established brands are entering the market. This shows the rising trend towards more sustainable solutions in menstruation management. Especially large brands offer period pants that are only suitable as backup used together with a tampon or a menstruation cup. Especially in the European market, it has been observed that a transparent and local value chain is very important and that brands often engage in social projects regarding period positivity or saving the environment. The two most used advertisement categories worldwide are Sustainability/Environment and Comfort & Convenience. Possible new future market potentials can be seen in Asia especially in China and India as both countries have a growing population and a cultural climate that stigmatizes invasive menstruation products. In addition to that, Scandinavia and South-East Europe are not included in the period pants market so far but can have a huge market potential.

Criteria for the selection of the companies for the competitor product test are the reach on social media especially Instagram and Facebook, the online and offline retail, the location of the brand and that production on industrial scale can be detected.

The final rating of the competitive product test can be seen in table 1. The performance values of the winning German company are an average acquisition time of 3.73 seconds and an average rewet value of 3.77 g at a test liquid volume of 15 ml. Nevertheless, almost none of the products can performance wise compete with conventional pads. It is also noticeable that there is a huge variance in all measured values of the period pants over the testing span of 26 washing cycles which equivalents two years of usage. In addition to that there is a lack of a consistent unit for the amount of liquid a product can absorb. As a result, it is very difficult for consumers to choose the right product. Uncertainty is created which prevents women from trying period pants as an alternative to conventional products.

Table 1: *Evaluation of the competitor product test of the menstruation pants*

Position	Country of the brand	Sustainability	Advertisement promises	Performance	Lifetime Development	Physical Attributes	Price	Value Chain	Final Points
1	Germany	4.00	2.5	1.33	3.26	5.75	8	2.5	3.49
2	Spain	1.75	6.5	5.25	3.63	3.83	1	2	3.73
3	Germany	4.00	1.5	3.33	4.82	5.25	5	4	3.78
4	Canada	5.38	4	3.75	3.60	4	2	4.5	3.99
5	Germany	3.50	2	5	3.83	4.33	9	2	4.00
6	France	4.63	4	3.17	4.72	7.17	3	2.5	4.15
7	France	3.63	4	5	5.64	4.42	10	2	4.63
8	France	3.38	7.5	4.5	6,67	3.67	6	2	5.07
9	France	6.13	7.5	4.58	5.79	4.33	4	6	5.67
10	USA	5.25	6.5	6	5.76	5.33	7	5	5.85

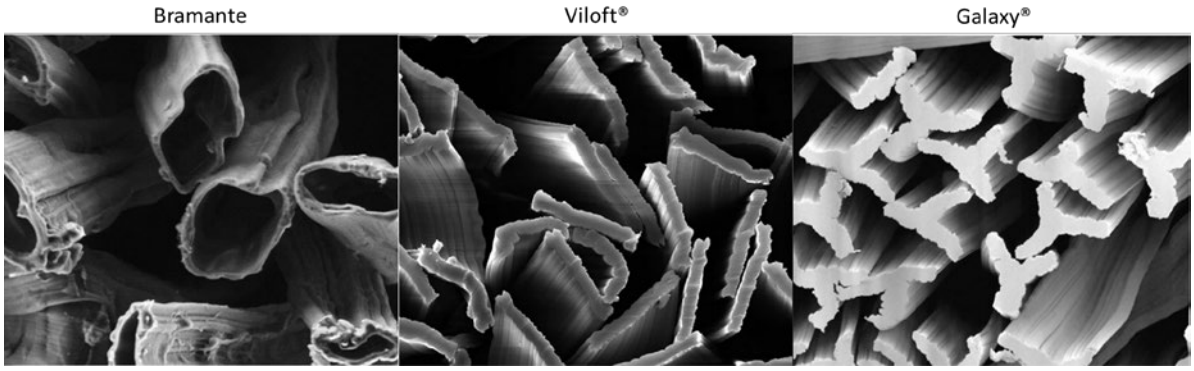

Figure 2: *Cross-sections of the Bramante, Viloft® and Galaxy® viscose fibres*

In order to develop a new, more sustainable product test with different materials and prototypes are carried out. The aim is to find an ideal material for each layers of menstruation pants. Menstruations pants are structured in four layers, the Topsheet, the ADL, the Absorbent Core and the Backsheet. The material tests aim to find the ideal fibre composition and textile structure for each of the first three layers. The prototype tests on the other hand target the Backsheet and the overall product assembly of the menstruation pants.

In figure 2 an ideal composition of a menstruation pant can be seen. It is assumed that the combination of the materials in the shown knitting structures will have an improved performance. In addition to that, the quality and the performance can be further increased by using the right manufacturing and seam technologies. In general, viscose is perfectly suited for the use in menstruation pants as it has a high water absorbing capacity. Another benefit is its biodegradability and the possibility to modify the fibre. The performance can be increased especially through the implementation of functionalized fibres. For the Topsheet a combination of CELLIANT® Viscose and Danufil® Viscose in a loose knitted structure with ideally implements tucks to create a perforation would be suitable. CELLIANT® Viscose is created by incorporating CELLIANT® powder into the viscose fibre. The Fibre has advanced well-being properties as it reflects the body heat back to the body in the form of infrared light. This property can help the wearer to a better wearing sensation even when period cramps occur. The ADL can be made from Galaxy®, a trilobal viscose fibre with good liquid transportation properties. Through the addition of an ADL using Galaxy® fibres the rewet value can be reduced and the pant has dry and improved wearing comfort. The Absorbing Core can be made from Bramante mixed with Viloft. Bramante is a hollow fibre ideal for the storage of liquids. As the textile construction using Bramante fibres cannot only store liquid in the fibre cavities but also inside of the fibre, more liquid can be absorbed. Furthermore, it enables the fibre to hold the liquid even under pressure which prevents leakage and creates and improved safety for the wearer. In addition to that a loop knitted structure is best suited for the absorbing core. In order to have a biodegradable Backsheet three options have been tested and should further be investigated. First using a PLA foil as a barrier layer, second a merino wool fabric woven under tension and third using sustainable finishing or coating chemicals offered by a German textile chemical company. However all three options have still some challenges that have to be overcome. The PLA foil rustles when sewn into a pant, the woven wool fabric is very expensive and the coating only showed washing permanence of up to 20 washing cycles. In the prototype an ADL is implanted. This layer is used frequently in conventional menstruation pads, but was not included in any of the tested reusable menstruation pants. Moreover, to avoid leakage in the menstruation pants a special seam design is used as shown in figure 3 in order to avoid penetrating the waterproof Backsheet.

In addition to that, Danufil® and Viloft are ideally suited as mixing components as the complement the function of the functionalized fibres. Viloft as a blending component for Bramante ensures that the Bramante fibre has enough space to expand during the liquid uptake and reach its full absorbency potential. In addition to that, both fibres help to optimize the processability of the specialized viscose fibres in the spinning and knitting process. Summarized it can be said that a product using a combination of different functionalized viscose fibres can be superior to other products as it can be designed thinner and more sustainable than currently available products as it enables the substitution of various synthetic and natural materials like cotton or polyester.

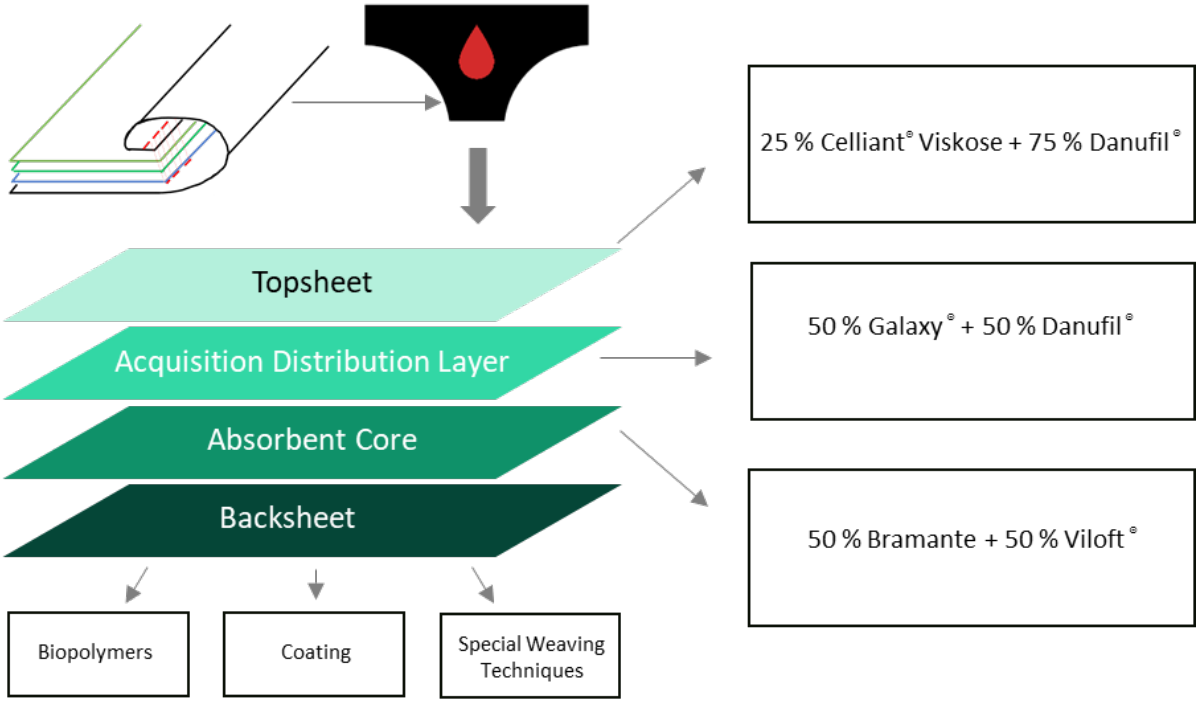

Figure 3: *Possibilities for an ideal composition for sustainable period pants*

To improve the prototype further tests have to be done for the Backsheet as well as for the other layers. In order to increase the performance, different knitted and woven structures have to be tested. In figure 3 an overview over possible knitting structures that might be suitable in a menstruation pant is given.

Using the material compositions shown in figure 2 and the knitted structures in figure 3 it is possible to find an ideal combination for a period pant. Advantages of the functionalized viscose fibres are that the thickness of the product can be decreased, the fibres are biodegradable and the number of different materials used in the product can be reduced drastically. In addition to that, the whole menstruation pant can be designed industrially biodegradable or recyclable. Furthermore, there are some possibilities to increase the sustainability of the product even further. When using Viscose fibres it is possible to produce spin dyed fibres by adding pigments to the spinning mass. With this technology the entire water intensive dyeing process can be skipped. Of course, the choice of pigments should be considered under environmental and human health aspects as well.

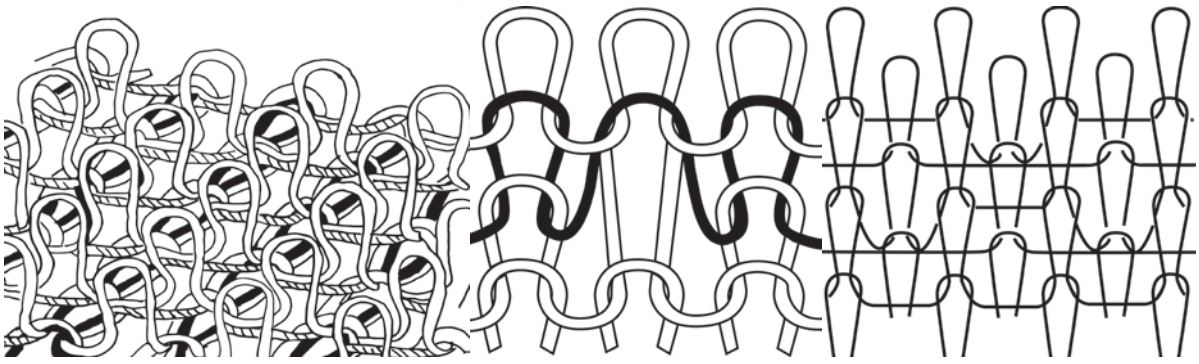

Figure 4: *Knitted structures probably suitable for the use in a menstruation pant: (1) pile loop knitted structure for the absorbing core; (2) Tuck knitted structure to create a perforation effect in the Topsheet; (3) Double pique knitted structure for the ADL layer*

The market potentials for a sustainable menstruation pants is high, as the menstruation pant market is expected to grow from a market volume of 79 million USD in 2018 (Jagtap, 2020) to the size of 180 million USD in 2021 (Future Market Insights, Department Consumer Product, 2021) and 580 million USD in 2025 (Jagtap, 2020). In addition to that, there are still countries in Europe that have not entered the menstruation pant market yet and could hold a potential for growing sales volumes. Especially Italy and the Scandinavian countries can be important in the next years. As mentioned before the SUPD can also be a driving force for more sustainable menstruation products on the European market. Outside of the core markets, China and India are expected to have a huge potential for period pants. However, when implementing reusable products like period pants it is important to educate the users accordingly on how to wash and clean them. As menstruation is highly stigmatized in these countries a risk can be seen for inadequate cleaning and drying of the product which might lead to increased bacteria growth.

The development of sustainable menstruations pants using predominantly biodegradable and renewable materials is a promising application that should be investigated further to minimize waste and to create a circular approach. However, it is important not to compromise on performance and comfort. The before described composition represents menstruation pants that combine sustainability, comfort and performance. The product is designed industrially biodegradable and can be seen as an example for a circular textile product. However, this path should not be limited to period pants but can be transferred to products in the incontinence and diaper market as well as to other textile applications.

References

European Parliament (2019) Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment

Future Market Insights. (2021, January 19). *www.futuremarektinsights.com*. Retrieved July 14, 2021, from https://www.futuremarketinsights.com/press-release/period-panties-market

Jagtap, P. (2020, April 4). *www.medium.com*. Retrieved July 14, 2021, from https://medium.com/@pravinjagtap1812/global-period-panties-menstrual-underwear-market-2020-modest-condition-size-research-findings-5b6e75ad503c#:~:text=The%20global%20Period%20Panties%20(Menstrual,THINX%20Inc

Mengel, V. (2020, April 3). *Quarks.de*. Retrieved June 7, 2021, from https://www.quarks.de/gesundheit/medizin/alles-was-du-ueber-die-periode-wissen-musst/

Sparwelt GmbH. (2020, June 18). *Presse Portal*. Retrieved June 7, 2021, from https://www.presseportal.de/pm/75733/4627852

United Nations. (2019, August 28). *population.un.org*. Retrieved May 4, 2021, from https://population.un.org/wpp/Download/Standard/Population/

Van den Bossche, C. (2020). *www.wecf.org*. (P. f. Women Engage for a Common Future (WECF), Ed.) Retrieved May 4, 2021, from https://www.wecf.org/wp-content/uploads/2020/10/ToxicFreePeriods-lowres.pdf