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IMPROVEMENT OF THE CARBON FOOTPRINT WITH THE IMPLEMENTATION OF 100% RECYCLED PET IN CARBONATED BEVERAGE BOTTLES

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Most carbonated drink bottles are made for a single use. The global beverage industry uses mostly virgin materials. Being aware of the negative environmental impact of single-use plastics, any project that aims to improve the recycling and reuse of these materials is of crucial importance. The methodologies have been defined, the necessary tests have been developed and the existing technology has been adapted to allow the use of 100% recycled polyethylene terephthalate (PET) in the manufacturing process of bottles for carbonated beverages. The result has been the elimination of virgin material in the manufacture of bottles and replacing it with 100% recycled PET. Additionally, in order to ensure that this recycled material, used as raw material for the remanufacturing of bottles, can remain in the country's deposit system, new methods and quality monitoring indicators have been established. These indicators are aligned with the strategies between the different stakeholders of the value chain, involving from the producers of PET pellets, the manufacturers of bottle preforms and the bottlers, to the material collection, deposit and recycling system, favoring the circular economy.

Keywords: recycled PET;deposit system;botling;circular economy

MEJORA DE LA HUELLA DE CARBONO CON LA IMPLEMENTACIÓN DE 100% PET RECICLADO EN LAS BOTELLAS DE BEBIDAS CARBONATADAS

La mayoría de botellas de bebidas carbonatadas son de un solo uso. La industria de bebidas mundial utiliza mayoritariamente materiales vírgenes. Siendo conscientes del impacto medioambiental negativo de los plásticos de un solo uso, todo proyecto dirigido a mejorar el reciclaje y reúso de estos materiales es de crucial importancia. Se han definido las metodologías, desarrollado los test necesarios y se ha adaptado la tecnología existente, para que permita la utilización de politereftalato de etileno (PET) 100% reciclado en el proceso de fabricación de botellas para bebidas carbonatas. El resultado ha sido la eliminación del material virgen en la fabricación de las botellas y reemplazarlo por el PET 100% reciclado. Por otro lado, para poder asegurarnos este material reciclado como materia prima para la refabricación de botellas pueda permanecer en el sistema de depósito del país, se han establecido nuevos métodos e indicadores de seguimiento de la calidad. Estos indicadores están, alineados con las estrategias entre las diferentes partes interesadas de la cadena de valor involucrando desde los productores de los pellets de PET, los fabricantes de las preformas de botella y los embotelladores, hasta el sistema de recogida, depósito y reciclaje del material, favoreciendo la economía circular.

Palabras clave: PET reciclado; sistema de depósito; embotellado; economía circular

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1. Content

1.1 Introduction and objectives

The use of 100% recycled polyethylene terephthalate (PET) for the manufacture of bottles to sell carbonated drinks has been introduced on the market in Sweden. The global beverage industry continues to use mostly virgin materials that offer fewer difficulties in their industrial use. Welle, F. (2011, p.1) explained "(PET) has become the most favourable packaging material world-wide for beverages. The reason for this development is the excellent material properties of the PET material, especially its unbreakability and the very low weight of the bottles".

Incorporating recycled materials into the production system must necessarily be linked to their collection once used. Therefore, it will be interesting to understand the impact that the initiative has at a social and market level.

Achieve a reduction in the carbon footprint in the production and sales of bottled beverages by converting PET used to produce the bottles of beverages in Jordbro site to 100% recycled PET content. By using new or different materials, as well as source origins and industrial processes before filling them with carbonated beverages.

Materials must allow to keep using the circular model for pet bottles existing in Sweden, and be compliant with the current regulations for recycling PET. As Gopalakrishna, K. G., & Reddy, N. (2019, p.1)) stated :

> Considerable efforts are being made to reduce disposal of PET and promote recycling and reuse. However, difficulties in collecting, presence of various contaminants and their potential persistence in recycled bottles coupled with various other reasons technical and economic reasons have led to constraints on recycling PET bottles. However, realizing the environmental and economic importance of recycling PET, several countries have enacted regulations on the use and recycling of PET bottles.

We want to evaluate if this action will have impact on the valuation of the product in the market by customers and consumers.

Objectives are:

a) Move to 100% rPET bottles
b) Evaluate the impact in customer perception

1.2 Methodology and case study

Virgin or recycled materials must undergo an extrusion process to form the precursor preform of the bottle. The preform must undergo a hot blowing process to shape the final bottle for use on the market. Different materials give rise to different extrusion and blowing qualities, as well as different results in particle migration and retention of carbon added to the beverage. Likewise, these materials will influence the blowing process in energy consumption and in the parameters to be used in the equipment.

Recycled PET to be used in different sectors, has been largely studied. There are uses as Foti, D. (2013, p.2) explains "PET strips could be considered as reinforcement of concrete in substitution of steel" (p.2), among others. But this is out

of scope of this study. We will focus only on materials to be reused in food industry, in concrete in soft drink carbonated beverages.
There are evidences that the mixture of virgin and recycled materials presents a decrease in the viscosity of the final material. The studies showed that the intrinsic viscosity and molecular weight decreased as the blend ratio of recycled PET (rPET) was increased. Oromiehie, A. & Mamizadeh, A. (2004. P.1). "Thermal cycles of the processes used for recycling PET and its blending specimens with virgin PET show the importance of the thermal treatment in the improvement of mechanical strength and increased crystallinity. Nevertheless, the properties of the functionalized blends were improved" .

rPET conversion must involve validation and approval of a new combination of resin mix, 50% flakes and 50% Mopet. Both resins approved accordingly to the European Food Safety Authority as reflected in the Scientific Opinion on the safety assessment of the process "MOPET-FLAKE" used to recycle post-consumer PET into food contact materials (2014), for food uses purposes.

100% flakes is not feasible due to the plastic properties. For example, flake tend to give black spots on preforms.

To obtain the 100 % rPET preform it was found and tested a whole new plastic combination with external laboratory testing trials, on food safety and physical properties, needed to be compliant before commercial usage.
Type of preforms into the scope of the study is the one belonging to 1,5lt bottle 38g preform, made 50% flakes 50% Mopet.

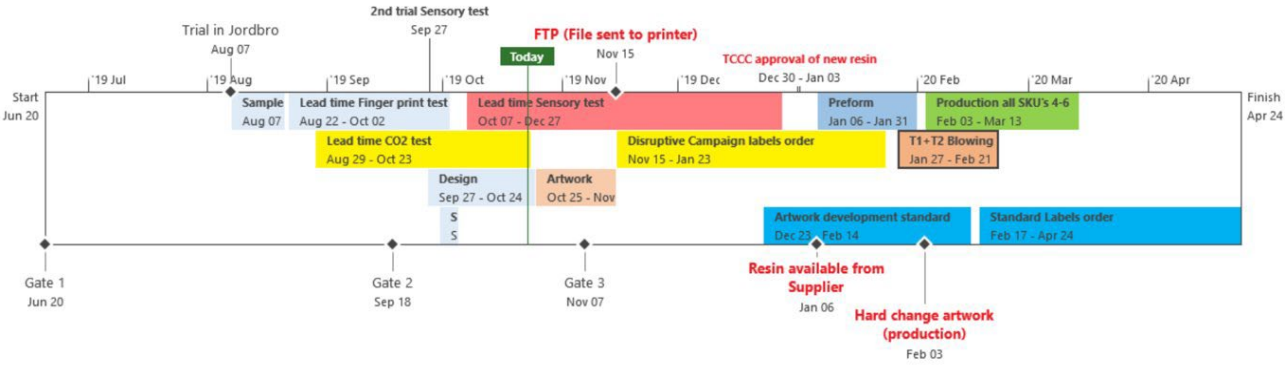
Industrial trials and laboratory quality testing's on Food safety and physical properties needed to be compliant before commercial usage. Approvals were required before the material could be used commercially in the market. The samples were tested against the Specification for Non-Refillable Plastic WER-SP-210 (Revision: 12-Aug-2019) and NR Plastic bottles Packaging PK-RF-1155 (Revision: 08-Jan-2018) and the diagram (K X-Z00-08-7464) as shown in figure 1.

Figure 1. Analysis description, internal source, trial done by DAkks for CCEP

Analysis Description				
Attribute	**Parameter**	**Method CCEP DE**	**Version**	**Specifcation**
General Appearance	General Appearance	KA-CSL-QS-AA011	6	PK-RF-1155
Dimensions - Exterior	Height (empty bottle)	KA-CSL-QS-AA008	5	PK-RF-1155 / bottle diagram
	Dimension (empty bottle)			PK-RF-1155 / bottle diagram
	Base Clearance (empty bottle)*			WER-SP-210
	Perpendicularity (empty bottle)			PK-RF-1155
Wall Thickness Distribution	Wall Thickness Distribution	KA-CSL-QS-AA008	5	-
Bottle Burst	Bottle Burst	KA-CSL-QS-AA031	1	WER-SP-210 / bottle diagram
Sidewall Rigidity	Sidewall Rigidity	KA-CSL-QS-AA010	5	-
Thermal Stability	Bottle Thermal Stability - Rocker Bottom (Base Clearance)	KA-CSL-QS-AA008	5	WER-SP-210
	Bottle Thermal Stability - Pinch Ratio (only Contour)			PK-RF-1155
	Bottle Thermal Stability - Expansion (Height, Diameter)			PK-RF-1155
	Bottle Thermal Stability - Perpendicularity			WER-SP-210
*= No nominal specification has been specified for this parameter.The specification is used for Bottle Thermal Stability - Rocker Bottom (Base Clearance > 0 mm).				

A detailed plan for the overall project and trials were conducted in the production line. The timeline is showed in figure 2.

Figure 2: Comparison of TDCs According to Approach Applied, author figure



1.3 Results

Sweden did a first trial of 4 hours production in the autumn and later before the conversion, a second trial was done with 450,000 bottles, in the combination of the launch into the market.

Increasing the recycled material in the bottling process will not improve the reusability of PET if it is not linked to a collection and reuse system. It is necessary to continue collecting the material to reuse it. Regarding the objective of keeping the material in the circular recycling system, was clearly stated by Butiksnytt (2020,para 6) "Achieving a circular economy for packaging requires collaboration across the value chain. I am grateful to all the actors who show such a great commitment to increasing fundraising in Sweden. We have a fantastic return system where most of all bottles are collected, which greatly allows our release".

Therefore, It was decided to take action in the messages in the labels and Nilsson, T. (2020,para 2) was eco of the fact by saying "When Coca-Cola in Sweden now launches PET bottles made of completely recycled plastic, it chooses to pay attention to it by issuing a call to pawn on the bottles". Similar said by Petersson M. (2019, para 5) "In cooperation with local and national partners and through communication, Coca-Cola in Sweden works to ensure that all packaging is collected and pledged so that they can be used again".

Regarding the objective to get impact on the consumers opinion, a prelaunch communication plan was created to explain the objective of the change. As example Barbiroglio, E. (2019, para 1) published "Coca-Cola Sweden will make all its plastic bottles from recycled material from next year on, the company announced last week. In this way, it will become the first market in the world to make all its plastic bottles from 100% recycled plastic" . Similar post from Ringström, A. (2019). Another example in Connecting comPETence (petnology.com) (2019, para 1) "Coca-Cola in Sweden is the first market in the world to switch to 100 percent recycled plastic for the entire locally produced portfolio. The changeover will commence during the first quarter of 2020 and concerns all PET bottles produced in Jordbro" . Some of them estimated even the impacts on achieving such project, as Barbiroglio, E. (2019, para

1) “the switch will eliminate 3,500 tons of virgin plastic each year and that it will mean 25% fewer CO2 emissions”.

Across Europe the project was well received, as it is reflected in Marketeer.pt (2019) in Portugal, or in Daily Mail - MailOnline UK (2019) in England.

Equally, the economics markets publishers as Investing (2019) or technical sector publishers as Packaging Insights (2019) and Recycling magazine (2019) o British plastics and rubber magazine (2019).

We could also found it published in business ethics as for instance Mitchell, S. (2019) Ethicalmarketingnews.

Market studies mentioned by Ferrer, B. (2019, para 10) showed that “Consumer and regulatory demand for the scaling back of virgin plastic use continues to intensify. Six out of ten European consumers (62 percent) say they would be willing to pay more for food products that contain less plastic packaging in a recent survey by UK-headquartered DS Smith. A similar number (59 percent) indicate that they sort and recycle more than they did five years ago.

The different trials and tests performed during the study, had results into the expected specs. They are presented in figures 3, 4, 5 and 6 and show the results in the laboratory , as well in the production line.

Figure 3: Test report 170-20 FL-CCEP-1,5l 38g-NR PET-Contour-Jordbro-Approval. Results QEOSH Service, internal source, trial done by DAkkS for CCEP

Results QEOSH Services

Parameter		Target	Tolerances		Results				
General Appearance		within spec.	Marketplace Packaging		within spec.				
SW 1	Sidewall Rigidity [kg] Label middle	**				0°	90°	180°	270°
					Min:	1,3	1,4	1,3	1,2
					Max:	1,5	1,5	1,4	1,5
					Avg:	1,4	1,5	1,4	1,4
SW 2	Sidewall Rigidity [kg] Pinch	**				0°	90°	180°	270°
					Min:	1,8	2,0	2,0	2,0
					Max:	2,0	2,1	2,2	2,2
					Avg:	2,0	2,1	2,2	2,1
Bottleburst CB [bar] (Bottle capacity > 1,0l)		Min: 8,6	none		Min:			10,8	
Bottle volume 1481 to 4000ml					Measurement point				
Dimension-Exterior [mm]		Target	Tolerances (Average)		0°	45°	90°	135°	Avg.
Ø 1	Diameter Position 1	94,75	Min: -1,00 Max: +0,75	Min: 93,75 Max: 95,50	93,90	94,05	94,28	94,31	94,14
Ø 2	Diameter Position 2	93,50		Min: 92,50 Max: 94,25	92,45	92,44	92,62	92,61	92,53
Ø 3	Diameter Position 3	93,50		Min: 92,50 Max: 94,25	92,51	92,46	92,69	92,65	92,58
Ø 4	Diameter Position 4	94,75		Min: 93,75 Max: 95,50	94,13	94,32	94,53	94,52	94,38
Ø 5	Diameter Position 5	83,50		Min: 82,50 Max: 84,25	83,58	83,76	84,02	83,91	83,82
Ø 6	Diameter Position 6	94,75		Min: 93,75 Max: 95,50	94,55	94,61	94,64	94,63	94,61
					Measurement point				
Wall Thickness position [mm]		Tolerances			0°	90°	180°	270°	
WS 1	Wall Thickness Position 1	****			0,23	0,23	0,23	0,23	
WS 2	Wall Thickness Position 2				0,25	0,25	0,25	0,25	
WS 3	Wall Thickness Position 3				0,26	0,26	0,26	0,26	
WS 4	Wall Thickness Position 4				0,26	0,26	0,27	0,27	
WS 5	Wall Thickness Position 5				0,30	0,30	0,30	0,31	
WS 6	Wall Thickness Position 6				0,28	0,28	0,28	0,29	
					Measurement point				
		Tolerances			0°	72°	144°	216°	288°
	Wall Thickness Base Corner [mm]	****			0,23	0,23	0,24	0,25	0,25
					Measurement point				
		Target	Tolerances		0°				
Base Clearance [mm]		>0	none		3,9				
		Target	Tolerances		Results				
Height (Bottle volume 1481ml to 4000ml) [mm]		311,00	Min: -1,50 Max: +1,20	Min: 309,50 Max: 312,20	310,98				
		Target	Measuring length	Results	Extrapolation to bottle size				
Perpendicularity (Bottle height from 221mm) [mm]		≤ 6,4	251,00	1,92	2,38				

** No nominal values/tolerances have been specified for the sidewall rigidity. The purpose of testing is to assess consumer perception of new bottle.
*** No nominal values have been specified for the section weight. The purpose of testing is to assess and optimise the blowing process.
**** No nominal values/tolerances have been specified for the wall thicknesses. The purpose of testing is to assess and optimise the blowing process.

All results are Averages; all individual measurement results have been tested taking into account the form deviation.

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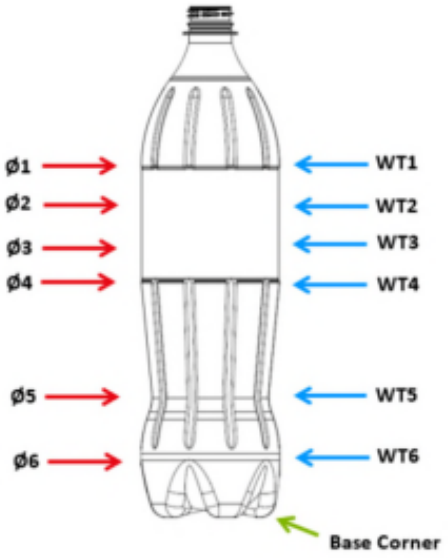
Figure 4: Test report 170-20 FL-CCEP-1,5l 38k-NR PET-Contour-Jordbro-Approval: Results of dimension after blowing, internal source, trial done by DAkkS for CCEP

Krones
X-Z00-08-7464
Created: 17.09.2020



	Dimension	Measuring position [mm]
	Height	311,00
Ø 1	Diameter Position 1	195,00-205,00
WT 1	Wall Thickness Position 1	206,00
Ø 2	Diameter Position 2	185,00
WT 2	Wall Thickness Position 2	185,00
Ø 3	Diameter Position 3	145,00
WT 3	Wall Thickness Position 3	145,00
Ø 4	Diameter Position 4	120,00-130,00
WT 4	Wall Thickness Position 4	123,00
Ø 5	Diameter Position 5	65,00-80,00
WT 5	Wall Thickness Position 5	73,00
Ø 6	Diameter Position 6	40,00
WT 6	Wall Thickness Position 6	40,00
	Perpendicularity	Ref.: 40,00 Mess.: 291,00
	Base Clearance	

Sidewall Rigidity:
Measuring position: label middle (6 bottles)
Pinch (6 bottles)

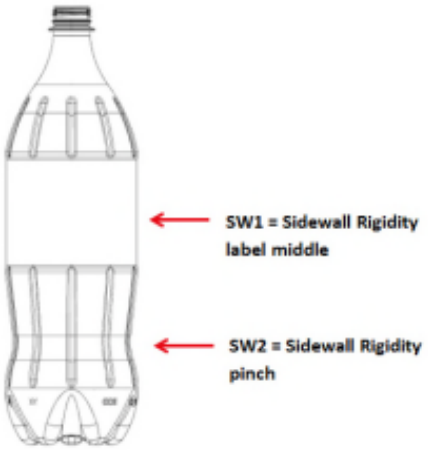


Figure 5: Test report 170-20 FL-CCEP-1,5l 38k-NR PET-Contour-Jordbro-Approval, results thermal stability, internal source, trial done by DAkkS for CCEP

Results Thermal Stability				
Expansion				
Parameter	**M1 [mm]**	**M2 [mm]**	**max Allowable deviation [%]**	**Results max deviation [%]**
Height	316,28	318,42	3,5	0,7
Diameter Position 1	95,17	95,93	3,0	0,8
Diameter Position 2	94,97	95,94	3,5	1,0
Diameter Position 3	94,85	95,79	3,5	1,0
Diameter Position 4	95,70	96,27	3,0	0,6
Diameter Position 6	95,46	95,58	3,0	0,1

Results Pinch Diameter to Heel Diameter					
	M1 [mm]	**M2 [mm]**	**Target Ratio**	**Ratio beforeTS**	**Ratio after TS**
Diameter min Pinch	87,90	89,63	≤ 94,0	92,1	93,8

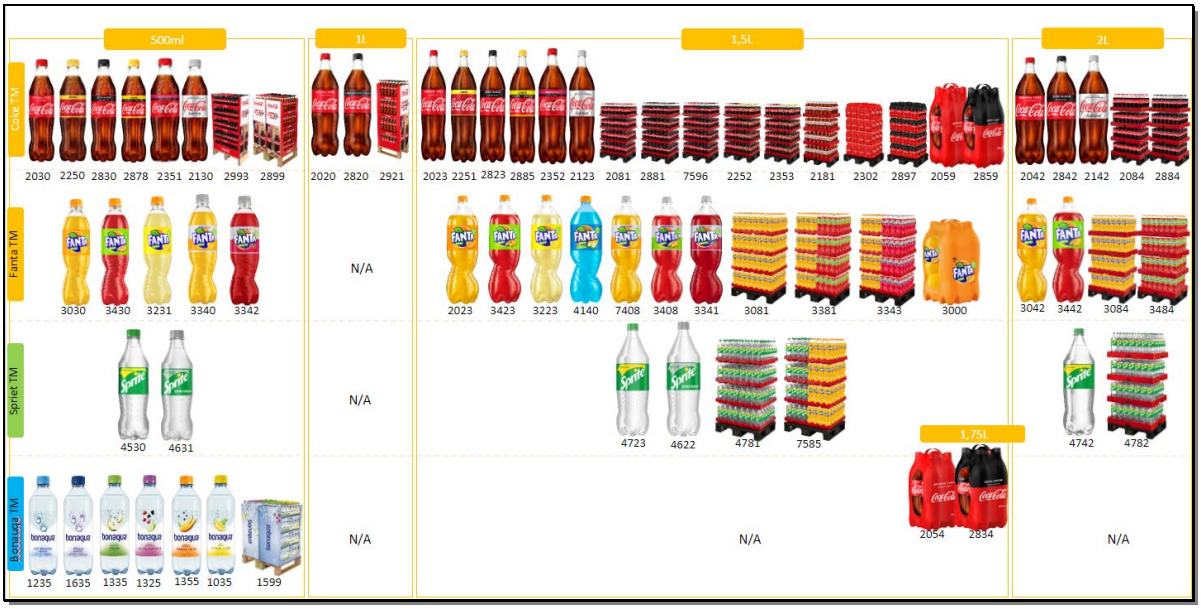
Stability		
Parameter	**Tolerances**	**Results**
Perpendicularity [mm]	< 4,0	1,2
Base clearance [mm]	> 0	0,5

Figure 6 : Internal report on the trials on the production line, trial done by Putoksnis for CCEP

TRIALS DURATION (start/end)	08:00-16.30
INFORMATION ABOUT TEST PROCESS	**FANTA 500ml bottle:** For a start, an old Fanta recipe was loaded into the machine. After an initial check, it was noticed that a preform temperature with old parameters is about 8°c higher. So the heating profile was adjusted accordingly. After a few more adjustments a continuous production was started. As there was no drawing for a new Fanta bottle, the specifications of Coca-Cola and Sprite bottles were used. Weight target for a base area 4g and bottom body area 4.5g were achieved. Upperparts of the bottle could not be measured properly, because the bottle cutter dimensions have to be readjusted. The burst test machine was also out of order, so the bottle strength tests were performed in the old fashion way – bottles were dropped from 2 meters height on the concrete floor. None of the bottles has cracked or exploded. After an hour of running a Fanta bottle, a new Fanta bottle drawing was introduced. It is completely different compared to the new shape of Coca-Cola and Sprite bottles. The base area target weight is 3,6g and the bottom body area target weight is 5.6g. The process was adjusted accordingly, but the bottle quality was a bit poor. Base area legs were very soft with 3.6g and can be bent inwards if the bottle is dropped on the floor. The center of a mass is quite high so the bottle was unstable. The wall thickness distribution was very uneven what can impact a higher and quicker loss of CO2. The process was readjusted once again to keep the base area at the maximum weight limit and area above it at the minimum weight limit. Bottle was much stronger and looked much better.

Portfolio affected is 69 Stock Keeping Unit (SKU) or products and over 200M bottles / year. Portfolio of products moved to 100% rPET in the market as shown in figure 7.

Figure 7: Shows the products in the market with 100%rpet bottles, internal source, author figure



Converting all PET bottles produced in Jordbro to 100% recycled plastic, achieved the final results of:

- Reduction CO2 emissions was 4,800 tonnes / year (this corresponds to a reduction of 25% of the current life cycle emissions from the considered bottles).
- 3500 tons less fossil material (virgin plastic) per year.

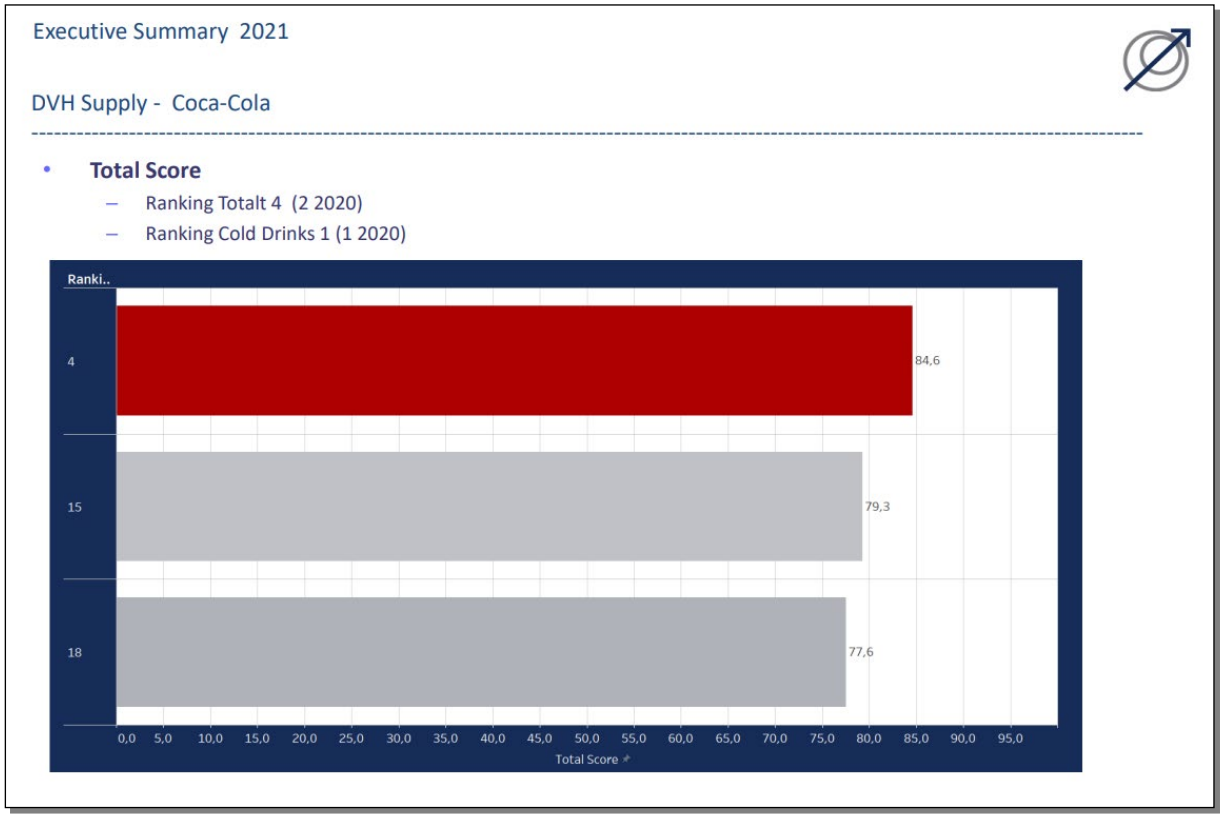
- rpet use the plastic that Sweden deposit system collects and this means that this material contribute to a circular economy. The material is circulated in a cycle

To keep the bottles into the current circular system, the label was changed and Schleicher, A. (2020, para 1) "newly launched 100 percent recycled PET (rPET) bottles will now arrive on Swedish shelves with labels reading "Panta mig igen," meaning "Recycle me again," " which was necessary to keep the attention on the consumer regarding the need to keep collecting the empty bottles.

With the early announcement of the intention of move to 100% rPET, there was a reaction in the market accordingly to Patel, I. (2019, para 4) "updated shareholders on their third quarter results, and gave an impressive update causing shares to rally", that clearly appreciate and support the initiative.

Additionally, we observe an improvement in customer perception. On all customers rank Coca Cola Europacific Partners (CCEP) as #1 in Sustainability, from #3 last year. They also rated the importance of this question higher versus previous year. In Gradient Handelsattityder (2021), DVH Supply Executive Summary 2021 Coca-Cola is ranked # 1 in Sustainability (7 Previous year), as shown in figure 8.

Figure 8: DVH Supply Executive Summary 2021 by Gradient Handelsattityder (2021),



Coca-Cola

1.4 Conclusions

Tests and methodologies have been developed and existing technology has been adapted to allow the use of 100% rPET in the manufacturing process of soft drink carbonated beverages. Eliminating in this way the use of virgin PET material. The impact in reducing the carbon footprint is confirmed as 25% of the current life cycle emissions.

All tested parameters correspond to the diagram, the requirements and the specs as shown in figure 3, 4, 5 and 6.

It has also been ensured that these materials can remain in the country's deposit system, which ensures their continuous and circular collection and reuse. New labels have been developed to ensure customer's understanding on the need to recycle.

After launch the product in the market, a communication campaign had its hub in television advertising, combining television, outdoor and social media with event marketing. Over the next two weeks after the product was in the market, there was a takeover at T-Centralen and Slussen metro stations in Stockholm, published by Rågsjö Thorell, A. (2020, para 4) 'Starting today, they will begin communicating the news through a nationwide campaign. The film gives glimpses of the production at the factory in Jordbro south of Stockholm and several of the company's employees participate in the campaign".

We can conclude that the initiative is of great interest at a social and commercial level, seeing the repercussion in the media, as well as in the evaluation of the customers.

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Communication aligned with the Sustainable Development Objectives