Assessing the sustainability of juice bottles made with recycled rPET plastic

Report on a change of juice bottling material at Nourish'd café

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Scope and goal

This report presents basic assessments on alternative bottle materials, specifically, glass and recycled PET (hereafter referred to as rPET). Published research articles and existing Life Cycle Assessments (LCAs) are used to draw conclusions. The environmental and socio-economic impacts of each material are addressed using both international and local sources. Furthermore, this report intends to communicate to the business, Nourish'd Café and Juicery (hereafter referred to as Nourish'd), and their customers, the environmental impacts of the life cycle process of two juice bottling options. The goal is to determine the most sustainable, efficient and economical takeaway juice containers for Nourish'd, while also offering best practices for bottle design, bottle End of Life (EOL) management and education campaigns. This report aims to assess the carbon footprint and environmental impact of using rPET plastic bottles, rather than glass. Further, the report only investigates PET and rPET, rather than presenting findings on the impact of plastics as a whole.

Introduction and problem statement

Nourish'd operates two stores in Cape Town, one in Kloof Street, and the other in Observatory. Nourish'd was founded with the awareness of what is healthy for both people and our planet. Being a vegan eatery, they are passionate about reducing their carbon footprint while educating, encouraging and nourishing Capetonians.

The fresh juice products are currently packaged in 375 ml glass bottles with aluminum lids. This packaging represents a considerable overhead to the business, both in management and cost. The bottles are purchased from Consol and collected in the Northern Suburbs of Cape Town, which requires the hiring of a forklift. The bottles are transported to the label printers in as many as seven car trips and then, in a corresponding number of trips, to storage units around Cape Town.

To recycle the bottles, in line with their minimal waste ethos, Nourish'd offers an in-store credit for the return of their bottles for reuse. To ensure absolute cleanliness and sterility, each bottle has three washes and rinses as well as a cycle in a heavy-duty dishwasher. Nourish'd has reported a relatively low (~40%) return rate as they continuously need to purchase new glass bottles, despite attempting to adopt a returnable bottle model.

Packaging

Global packaging trends have taken many turns through the last century. The development and commercial acceptance of plastics in the 1950s led to a revolution across a wide range of industries (Lintsen et al., 2017). Plastic is durable, malleable, shatter resistant and lightweight, and has allowed for massive progress in the food and beverage, clothing, packaging and construction industries. Despite its utility, the vast scale of production has been detrimental to the environment. For instance, with 32% of plastic waste generated annually in coastal regions classified as mismanaged (Geyer et al., 2017), much of this ends up in the ocean, with negative impacts on marine life and ecosystems. One thing for certain is that the problem is receiving worldwide attention from governments and scientists, with moves to tighten legislation and many recent innovations in the plastic waste sector. There is an ever-growing demand for food-grade recycled plastic, which has bolstered plastic recycling infrastructure and facilities around the world and in South Africa (Green Cape, 2020).

The most common packaging contenders for liquids are plastic, glass, aluminum and tetrapak cartons. With significant competitive industry involved with each material, there is much conflicting information available to the concerned consumer. *Which is the least impactful packaging material? Less impactful for the environment, society or economy? Less impactful on natural resource use, on marine litter, greenhouse emissions or on the ozone layer?*

PET (Polyethylene terephthalate), identified with a MIC (material identifier number) of 1, is increasingly used as the material of choice for drinks manufacturers. It is versatile, durable, cost effective and can be easily recycled. However, to improve its circular economy credentials, more investment and demand for bottle-to-bottle recycling technology is needed. Consequently, we should then see improvements in the environmental impact of plastic bottles.

Plastic

The plastics sector in South Africa is well developed throughout the whole value chain, from raw material production to recycling and reuse (WFF SA, 2020). The process is energy intensive, but

the use of recycled material drastically reduces the overall energy consumption and demand for raw materials. Since most of the production chain happens in South Africa, this boosts the local economy and reduces the effect of import carbon emissions. South Africa has a good record when compared to many developed and developing countries. Developed countries mainly export their post-consumer plastics to developing countries for recycling (where there is little to no available capacity to recycle); and most African (developing) countries primarily import finished products instead of producing locally (WWF SA, 2020).

Plastic waste also has the highest market value in South Africa i.e. price paid by recycler, meaning there is greater incentive to divert it from landfill (CSIR, 2014). That said, the CSIR (2014) report provides the latest data but may be outdated and thus should not be taken as the true value in today's market.

Glass

The main components of virgin glass are silica sand, soda ash and limestone. Raw materials for glass are generally imported, mainly from China (Wesgro, 2018). The silica sand is often excavated from beaches and rivers and this can severely impact ecosystems.

Glass is heavy, and transporting it is a major disadvantage. One kilogram of raw glass can make between two and eight 300 ml glass bottles, while 1 kg of raw PET makes up to 100 plastic bottles i.e. one glass bottle can weigh up to 40 times more than a comparable PET bottle.

Glass is fragile, so bottles need to be packaged securely in bulky wrapping in order to protect them. This means the associated secondary packaging is often plastic and wasteful.

About 44% of glass is recycled in South Africa (The Glass Recycling Company, 2020). So, while glass can be endlessly recycled and its carbon footprint reduced by recycling, the rest is still lost to landfill. The recycling of glass is more energy-intensive than plastic (Morris, 2005), which means that unless the facility is using renewable energy sources, glass recycling has a greater impact on non-renewable and fossil fuel resource use.

There have been a number of challenges to the glass industry. Volatile exchange rates and the weaker rand can result in price increases which are often passed on to customers. Imported finished glass products are, in general, cheaper than locally produced products which is detrimental to local producers and has a greater effect on import carbon emissions (Wesgro, 2018).

PET and rPET

Plastic is lightweight, so the transportation of the plastic packaging products results in lower carbon emissions than the glass or metal packaged equivalents. Plastic is also durable and shock resistant, which can prevent food from spoiling or packaging breaking during transit and handling

(WWF SA, 2020). Its stronger package integrity protects the product, saves resources, reduces waste as well as the carbon and water footprints generated during the life cycle of a product.

Food-grade bottles are made out of PET, and thus would be the material used by Nourish'd. This report only refers to bottles made with a *mixture* of recycled PET and virgin PET, generally termed rPET bottles. Bottles made with PET and rPET are safe for human use, but it is probably best to be cautious and not microwave a PET bottle or reuse it over and over.

PET is the most widely collected and recycled of plastics in South Africa, with a PET bottle recycling rate of 60% (and on track to meet a goal of 70% by 2022; PETCO, 2021). The PET is recycled locally, which diverts plastics from landfills, improves waste reclaimer's income opportunities and diminishes transportation carbon emissions.

Recycled PET is food-grade approved and South Africa has one state of the art facility for complete Bottle-to-Bottle recycling in Johannesburg. This is a great step in the direction of "closing the loop". Greenhouse emissions and fossil fuel consumption is significantly less when using rPET for new bottles rather than 100% virgin PET (Figure 1; Shen et al., 2011; Benavides et al., 2018; NAPCOR, 2020). For example, **using 35% recycled content in a PET bottle results in between 20% and 73% lower climate impact** compared to 100% virgin PET bottle (Benavides et al., 2018).

Recycled PET is also used to make polyester fibre. This fibre fills pillows, duvets, makes reusable shopping bags, jeans and shoes etc. PET recycling infrastructure has improved so much in recent years that it is now no longer necessary to import polyester fibre into South Africa – we are self-sufficient (PETCO, 2018). This reduces the carbon footprint associated with cross continent transport and has great benefits for the local economy. The quality of polyester made from rPET is as good as virgin polyester, but it requires less energy and resources to make. Using rPET means that we are no longer as dependent on natural resources such as crude oil and gas. It also diverts bottles from landfill, with less soil contamination, and air and water pollution.

Resin production for plastic accounts for 61% of plastic Greenhouse Emissions (GHE) (Zheng and Suh, 2019). Through a greater input of recycled material, there will be a decrease in the reliance on non-renewable resources, and a significant decrease in the total GHE in plastic production.

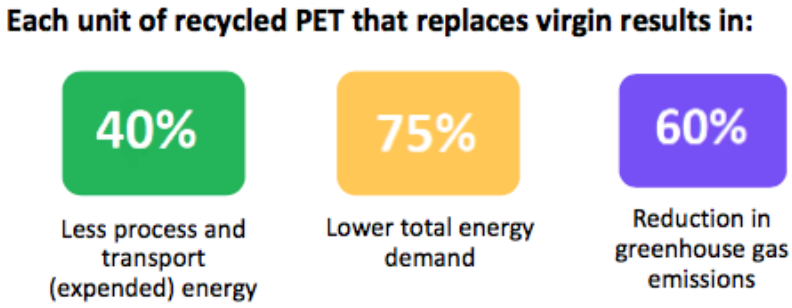

Figure 1: Savings in energy and greenhouse gas emissions when using rPET instead of virgin PET (NAPCOR, 2020)

The demand (and therefore price) of rPET fluctuates depending on the cost of crude oil and virgin PET. It has been highlighted that creating a more consistent demand for rPET will be crucial for the feasibility of the facilities and processes of recycling (WFF SA, 2020). Therefore, Nourish'd pledging to source and sell bottles made with at least 50% rPET contributes to stabilising the demand in the market and increases the feasibility and profit margins for those producers. This also boosts the local economy.

Associated studies

A recent journal article (Stefanini et al., 2020) explores Life Cycle Assessment (LCA) of glass and PET bottles. The study looks at returnable and non-returnable glass versus virgin PET and rPET in an Italy. An LCA is a methodology used to assess the impacts associated with a product or process on human health, ecosystem heath and the use/availability of resources throughout its life cycle (Accorsi et al., 2015). The Stefanini et al. (2020) results indicate that rPET bottles yield the lowest contribution to global warming, ozone depletion, acidification, fossil resource depletion, water consumption and human carcinogenic toxicity (Figure 2). This is due to the saving of virgin materials, lightweight characteristic and lower energy consumption in production and transport phases. The findings indicate that for every indicator used in the study (except marine litter), rPET has the lowest impact (Figure 2). Non-returnable glass is found to be the most detrimental packaging option due to high energy requirements during production, and its weight in the transport process. **A returnable bottle would need to be reused between 8 and 27 times for the same product (e.g., juices at Nourish'd) for it to have a comparable impact to rPET bottles.** A glass bottle would need to be reused at least three times for it to be environmentally equivalent to virgin PET bottles (Amienyo et al., 2013). However, if 60% of PET bottles are recycled, the glass bottle would need to be reused 20 times to make their carbon footprints comparable (Amienyo et al., 2013). The latter recycling value is applicable in South Africa.

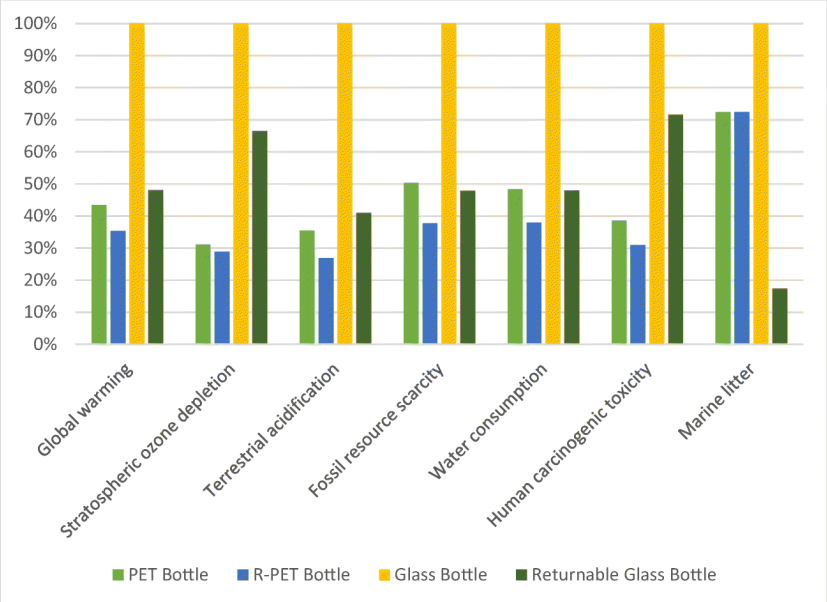

Figure 2: Indicators results of each bottle material (Stefanini et al., 2020). Here, a normalisation process has been done considering the highest scorer (glass) as 100%. The values of the other indicators illustrates what percentage of glass's impact that packaging option has. For example, a rPET bottle has 35% of glass's impact on global warming.

There is in some cases a dismissal of LCAs as they do not take into account the effect of the product if littered into the environment. This study did however consider the marine litter impact and found that, as expected, PET and rPET have high potential marine litter impact.

Another study (Accorsi et al., 2015) found 50% rPET bottles to have the least impact in terms of Global Warming Potential (GWP), non-renewable energy/fossil fuel consumption, eutrophication and acidification. Glass bottles were the most deleterious in terms of non-renewable energy/fossil fuel consumption, ozone depletion and acidification. Brook and Williams (2020) found that glass bottles used in the drink industry were ranked last out of five packaging options, this was due to the high resource and energy use, as well as the pollution and human harm caused during mining. They did not consider a bottle using recycled plastic, but it was concluded that virgin plastic had a significantly lower impact on global warming than glass. It must be noted that the two aforementioned studies did not analyse returnable glass. Many LCAs indicate that returnable glass can be the preferred option, however it is highly dependent on a high rate of consecutive returns by the customers i.e. customer behaviour.

It should also be noted that while plastic has the lower impact in many cases, these attributes are usually more significant in larger volume bottles (UNEP, 2020). Larger PET bottles are environmentally preferable to smaller ones (Amienyo et al., 2013).

Another key player in the fight against plastic pollution is the Plastic Pact. Many countries, including South Africa, have developed an agreement that encourages industry and stakeholders to reduce their 'plastic footprint'. As members of the Pact, businesses and organisations set the example by demanding more recycled content in their packaging and certification that the packaging is reusable or actually recycled in SA. As a result, the value of the material will increase, and it will create more business and investment opportunities.

Nourish'd can aim to align with the **SA Plastics Pact** goals, which are:

- Eliminate problematic or unnecessary plastic packaging through redesign, innovation or alternative (reuse) delivery models
- 100% of plastic packaging to be reusable, recyclable or compostable*
- 70% of plastic packaging effectively recycled
- 30% average post-consumer recycled across all plastic packaging

*in the case of compostables, this is applicable only in closed-loop and controlled systems with sufficient infrastructure (i.e. not entirely possible with takeaway products).

Nourish'd should also pledge to be transparent about recycled content, bottle recyclability and encourage other stores to do the same.

Designing for recyclability

Well-designed bottles are 100% compatible with the recycling infrastructure in South Africa and can be recycled into feedstock for new bottles. This is crucial for the abatement of plastic waste in the environment and landfills, and the reduction of carbon emissions associated with generating virgin plastic. Nourish'd should make sure that bottles are 100% recyclable and comply with most appropriate bottling and labeling standards.

The guidelines for 100% PET bottle recyclability are as follows (PETCO, 2019):

- Bottles should be clear – yields most valuable recyclate and the only food-grade application at the moment.
- Lids should make use of a plastic material that is easy to separate. For example, PP, PE-HD, PE-LD or PE-LLD which float so they can be separated from the PET, which sinks.
- The number indicating plastic polymer (MIC) should be clear and legible.
- Additives to the plastics should be avoided.
- Bottles should not be printed on directly as it contaminates the plastic and can deem it unrecyclable.
- Polyethylene and polypropylene labels/sleeves are preferred as they can be separated from the bottles and are also 100% recyclable.
- Self-adhesives, paper or metallised/foil labels are not ideal – they cause problems in conventional recycling.

After-use management

PET and rPET have a high potential marine litter impact. **For this reason and that we are a coastal city, there should be great focus on waste management at Nourish'd.** To play their part in mitigating the impact of plastic, it is suggested that Nourish'd places a clearly marked collection bin in the café for their plastic juice bottles (the bottles do not have to be perfectly clean to be acceptable at most recycling depots (PETCO, 2018)) and sends the bottles to a responsible recycler who recycles 100% of the bottles. The bottles should have a clear message indicating that they are 100% recyclable and should encourage customers to recycle. There should also be a strong recycling message in-store and on online platforms.

Customer perception

There is a growing body of work regarding the public's perception of packaging. This report does not deal with this, but it is commonly believed that glass is the most eco-friendly option, mostly due to the evidence of plastic in the environment. We hope, though, that this report has achieved a more rounded view on the impact and value of rPET.

Another important aspect in the perception of plastic is concern about some plastics as endocrine disrupters. However, thankfully, BPA and orthophthalate (the nasty one) are not used in the production of PET (identified with a 1), nor is it used as a building block for any of the other materials used in the process. There is a good deal of research into these chemicals and South Africa is one of the countries that banned the use of BPA in all food packaging. Current research also suggests that PET does not contain or leach any endocrine disruptors.

Biodegradable, compostable, bio-based and oxo-degradable plastics

There is a lot of confusing information regarding biodegradable, compostable and bio-based plastics. As awareness and usage increases, so does the confusion surrounding the associated environmental claims (Plastics|SA, 2013).

Bio-based plastics are made using polymers derived from plant-based sources e.g. starch, cellulose, oils, lignin etc. This is opposed to fossil-based plastic made from a wide range of polymers derived from petrochemicals, which are referred to as conventional plastics.

Biodegradable plastics are degradable due to the action of micro-organisms and enzymes. A common biodegradable alternative used in food or drink packaging is PLA plastic. PLA plastic is both bio-based and biodegradable, but it is still a plastic. The building block of PLA is lactic acid, obtained by fermentation of plant-derived sugars. Generally, the degradation can only occur under very specific industrial facilities, of which there are very few in SA.

Oxo-degradable plastics degrade when exposed to heat and/or light. The molecules break apart causing the plastic to weaken and fragment, but the time taken for these materials to completely degrade can take a very long time.

Biodegradable plastics are not necessarily compostable plastics. The latter also only degrades when it meets the appropriate composting standard, temperatures of at least 60°C, and does not completely cover home composting (CGCSA, 2019). There is a lack of clarity concerning standards that define the biodegradability of biodegradable or compostable plastics in any environment. There is also a particular lack of evidence on the behaviour of these materials in water, and there is a need to understand biodegradation at ambient temperatures. Therefore, it is very difficult to accurately assess environmental impact of the biodegradable and compostable plastic packaging.

There is also little difference with regards to energy and resource consumption in the production of conventional plastics and degradable plastics. Interestingly, using fully or partially bio-based alternatives in a plastic bottle has between 152% and 489% higher water consumption than 100% or partially virgin PET bottles (Benavides et al., 2018).

Plastics|SA (2013) have indicated that the impact of degradable additives on recycling streams and the quality of recycled plastic is a real concern, and support a banning of oxo-degradable plastics. The Ellen MacArthur Foundation, a key player in promoting and driving the global transition to circular economy, is also against the claim that biodegradable plastics are a solution to plastic pollution and indicate that the material does not fit in a circular economy. Their statement (2019) indicates that the plastic, in fact, contributes to microplastic pollution and poses an environmental risk due to their fragmentation rates. It does not fit in a circular economy because it is not suited for reuse or recycling and thus the material becomes very low value once used. The Ellen MacArthur Foundation is supportive of a ban on oxo-degradable plastic.

The main reasons against the use of degradable plastics:

- PLA is identical in appearance to PET, meaning if it enters the recycling stream it contaminates the batch.
- It may encourage littering if the public have a sense that the material will “disappear”.

- Often degradation leads to fragmentation, making it harder to collect the material.
- Even if the plastics don't degrade until they end up in landfill, they should not degrade once there. Degradation is accompanied by (for example) methane and CO_2 release.
- The promotion of degradation of any kind moves us away from a circular economy and back towards a "make, take, dispose" process.

Looking to the future

Nourish'd is committed to striving towards as low a carbon footprint as possible. To do this, continued research and growing partnerships will be invaluable. A start-up called Imagined Earth is aiming to provide incentive for recycling. They provide reverse vending machines to which the public can earn money for the recycling material they deposit. Nourish'd is looking to partner with Imagined Earth to provide the public with a deposit station in the City Bowl.

The first label-free 100% rPET water bottle launched in Singapore in March 2021. This innovation makes great inroads to sustainable packaging. While it is an ideal solution, South African technology is not yet mature enough. However, this option can be further investigated in the future.

Nourish'd can also look to practices which will reduce their carbon footprint and benefit the environment as a whole. For instance, by supporting organisation such as Greenpop and The Sun Exchange or by organising beach clean ups and other community awareness initiatives, Nourish'd can continue to do their part in protecting the environment.

Conclusion and recommendations

Plastic stakeholders and any sector that consumes plastics currently sit in a difficult situation. There is increasing customer resistance towards plastic as well as an unequivocal demand due to its versatile usage and price. There are trade-offs all around us in our daily lives and making the best decisions should always be a priority. Plastic is a valuable material but in order to mitigate the negative impacts, there should be a focus on integrated solutions and a circular and looped plastic economy. Plastic should not be viewed as waste, but rather as a resource with value. Through designing for recyclability, landfill diversion, increasing demand for recycled material, integration of informal waste reclaimers and investment in recycling facilities there should be great successes and impact mitigation.

Provided the bottles do not end up in the environment or in landfill, the rPET bottles are a good solution in reducing carbon emissions, global warming potential and environmental impact. In order to strive for the best end of life (EOL) outcome, Nourish'd should put effort into encouraging the best after-use action from their customers. This can be in the format of recycling education campaigns, talks and workshops, providing a bin in-store for customers to drop off their bottles and be assured that they will be recycled appropriately, taking audits of bottles returned and aiming to meet recycling goals.

Nourish’d should pledge to design for recyclability, use a minimum of 50% recycled plastic, collect and recycle bottles and encourage behavioural changes through education campaigns. By continuously researching and learning, the business is taking the necessary measures to mitigate their carbon footprint and will be a local leader in this regard.

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