REUSABLE PACKAGING PILOT:
effects of frequent cleaning

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YOYO.BoostReuse for the KIDV Community of Practice on Reusable Packaging

KIDV is The Netherlands Institute for Sustainable Packaging, www.kidv.nl

YOYO.BoostReuse is your key partner for circular take-away packaging solutions. YOYO return system and reusable take-away tableware helps organisations make a smooth transition from single-use to reuse model. www.yoyoboostreuse.com

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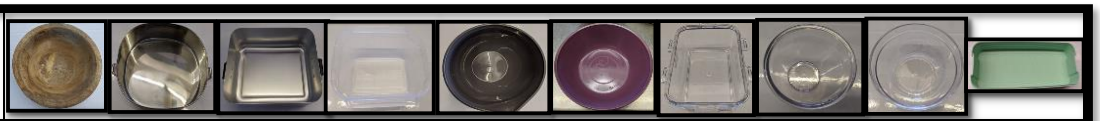
Scope

Upon request of KIDV Community of Practice on Reusable Packaging ("KIDV Community") YoYo measured how dishwashing impacts reusable meal containers. The objective of this experiment is to gain practical knowledge about potential risks and benefits related to industrial dishwashing of reusable meal containers.

YoYo tested containers made of ten different material types, which are listed below:

- Mango Wood (weight approx. 111g; volume 300ml)
- Stainless steel (weight approx. 193g; volume 750ml)
- Aluminium (weight approx. 97; volume 1000ml)
- PP – transparent (weight approx.46g; volume 500ml)
- PP non-transparent (weight approx. 82g; volume 500ml)
- PBT- non-transparent (weight approx. 113g; volume 600ml)
- Tritan– transparent (weight approx. 93g; volume 600ml)
- SAN- transparent (weight approx. 85; volume 300 ml)
- PC- transparent (weight approx. 58; volume 350ml)
- Wheat-straw + PP ("wheat straw") (weight approx.37g; volume 300ml)

Summary of Findings

CONTAINER										
MATERIAL / EFFECT	Wood	Stainless steel	Aluminium	PP transparent	PP non-transparent	PBT non-transparent	Tritan transparent	SAN transparent	PC transparent	Wheat straw + PP
Major damage	•		•							
Deformation	•									
Scratches		•	•	•	•		•	•	•	•
Smell	•	•	•	•	•		•			•
Discolouration	•			•		•	•			•
Stains	•	•	•	•	•	•	•	•	•	•

*dots indicate whether a certain condition occurred on specific material type of the container, if it never occurred or was negligible the dot was not added.

Wooden and aluminium containers have been highly impacted (damages, smell[1], stains, deformations) by dishwashing cycles. As a result, the above-mentioned two types of containers appear to be the only boxes not suitable for post-trial usage.

Stainless steel and aluminium, were containers which were most sensitive to handling (putting in and taking out food of the container). Large and long scratches on these two containers were highly visible. On the other hand, transparent boxes were visibly affected by small but multiple scratches.

Smell of the material that box is made of was strong and immediately recognizable after washing, especially for wheat straw, wooden, and aluminium boxes. On the other hand, food smell has been highly perceptible on all boxes except for those made of SAN, PC and PBT.

Food storage caused discolouration and colour stains particularly on wooden, PP-transparent and PBT and wheat straw containers, whereas oily/water drops stains were mostly visible on transparent containers, making them look a slightly unclean.

[1] During research we observed two types of smell: material and food smell. Material smell was related to characteristic scent of the respective material that box was made of, for example plastic or metallic scent. Food smell was related to tomato or curry smell kept in the box prior to washing.

Furthermore, containers which held food were affected differently by each food type. Highest impact of curry was visible on PBT, wheat straw, tritan, whereas tomato on PP-transparent boxes.

Washing Conditions

Tests were conducted using a 'hood-type' industrial dishwasher that is common for canteens and restaurants.

Washing was conducted in 62°C and rinsing was performed at 84°C. Washing cycles lasted 90 seconds. The liquid rinsing agent was from the Dr.Schnell Mafors brand[2] (common for restaurants) and the detergent with chlorine was from the Dr.Schnell Perotex Super H brand.

Approach

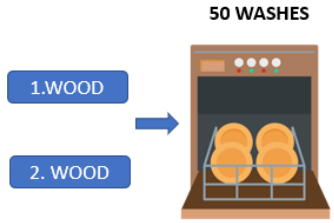
In order to test impacts of washing and food storage on different container types, six different tests were conducted. The first set of tests (test 1, 2 and 3) measured the effects of washing cycles and food storage of used containers[3]. The second set of tests (test 4,5 and 6) measured the effects of washing cycles and food storage of unused[4] containers. In total 80 meal containers were used for this experiment.

Two different food types were applied, curry[5] and tomato[6] sauce. Food was put in and taken out of containers with a stainless steel basting spoon.

[2] Acid rinse aid for commercial dishwashers. PH value 2-3. HACCP certififed.
[3] "Used" containers are boxes which were pre-washed for 50 wash cycles
[4] "Unused" containers were new, and not pre-washed nor used prior to trial
5 Ingredients: Madras curry powder, coconut milk, fish sauce, maizena, noodles
6 Ingredients: Tomato 75%; tomato concentrate 16%; herbs, water, salt

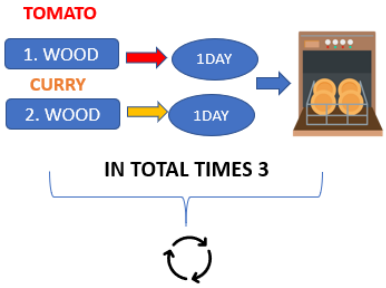
During all test, each box was assessed against the following criteria: major damage; deformation, scratches, smell, colour, stains. Each box was measured pre-trial, during and after trial.

Test 1 – 50 washes



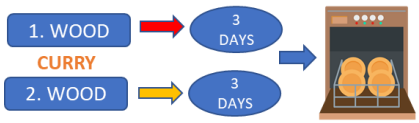
Two boxes of each material type (1-10) were washed 50 times.

Test 2 – 1 day food storage test for boxes after 50 washing cycles



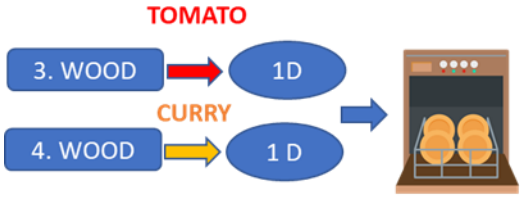
10 boxes used in test 1, were filled with tomato sauce and another 10 boxes with curry sauce. All 20 boxes stored food for one day. Afterwards boxes were washed and filled with food again. This activity was repeated 3 times. Each box was covered with a lid or aluminium foil and stored in a sealed large container for overnight.

Test 3 – 3 day food storage for boxes after 50 washing cycles



10 boxes used in test 1 and 2, were filled with tomato sauce and another 10 boxes with curry sauce. All 20 boxes stored food for 3 days. Afterwards all boxes were washed.

Test 4 - 1 day food storage test of unused boxes

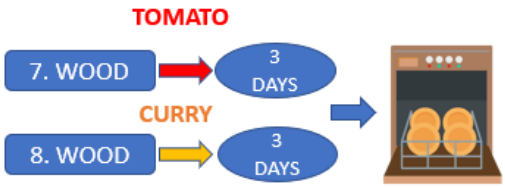


10 unused boxes were filled with tomato sauce and another 10 boxes with curry sauce. All 20 boxes stored food for one day, afterwards were washed, and filled with food again. This activity was repeated 5 times.

Test 5 - 1 hour food storage test of unused boxes

10 unused boxes were filled with tomato sauce and another 10 boxes with curry sauce. All 20 boxes were stored food for one hour, afterwards were washed, and filled with food for 1 hour again. This activity was repeated 5 times.

Test 6 - 3 day food storage of unused boxes



10 unused boxes were filled with tomato sauce and another 10 boxes with curry sauce. All 20 boxes were stored with food inside for 3 days and subsequently washed.

Main observations[7]

Findings per test type

Test 1 – 50 washes

Highest impact of dishwashing occurred on wooden, aluminium and wheat straw boxes. Impact was mostly related to damages of the wooden and aluminium boxes and high material smell of wheat straw box.

During this test, major damages were observed only for wooden box (holes, pieces going apart, scratched surface) after 5 washing cycles. Stainless steel, PC, SAN, wheat straw, PP transparent and PP non-transparent boxes already had minor scratches pre-trial, but did not get more scratches during the washing. Size of the pre-trial scratches was negligible. It is likely they occurred during transportation or handling at the retailer premises were boxes were purchased from. The aluminium box got new scratches on its surface during washing. PBT and Tritan containers remained without scratches.

Pre-trail none of the containers had material smell, whereas after first two washes, wooden, aluminium, PP non-transparent and wheat straw box had light to medium material smell.

Test 2 - 1 day food storage test for boxes after 50 washing cycles

Highly impacted were wooden, aluminium and wheat straw boxes.

Wooden box absorbed colour of food, especially curry, strong smell of food and was damaged even further, with parts falling apart in one of the boxes.

The aluminium container got a high number of scratches inside and outside the box. In addition, the box began to rust from the inside. Smell of curry was stronger than of tomato.

In this test, it was observed that each container reacted differently to each food type. For example PP transparent, SAN, stainless steel, tritan and aluminium boxes had stronger tomato smell than curry. On the other hand, the wheat straw box had stronger curry smell. PC and PBT boxes did not have any food smell or it was negligible. PP non-transparent container had equally light tomato and curry smell.

Test 3 – 3 day food storage for boxes after 50 washing cycles

The most severely impacted box was made of aluminium, scoring highest in number of scratches, stains and major damages. High impact was also identified in wooden boxes which were discoloured by food, with a strong mould smell. Followed by stainless steel with high number of scratches and also unpleasant mould smell. To conclude all boxes developed mould smell but strongest smell remained after washing on wooden, aluminium and stainless steel containers.

Test 4-1 day food storage test for unused boxes

The most severely impacted were wood (smell and colour), aluminium (scratches) and wheat straw (colour and stains) boxes. PP transparent container was visibly coloured by both tomato and curry sauce. SAN and PC boxes got number of small scratches and stains from water drops and fat/oil remains.

Test 5 - 1 hour food storage test for unused boxes

Food stuck to surface of aluminium and stainless steel boxes, in contrary to other boxes. Pouring food in and out of the box caused a high number of scratches, especially on aluminium and stainless steel boxes. Traces of discolouring were identified the most on the PP transparent box, followed by wheat straw, wooden, tritan and PBT boxes. SAN, tritan, PC containers were not coloured but remained with many water and oily stains after washing, which gave a feeling of not fully clean container.

Test 6 - 3 day food storage for unused boxes

All boxes except for PC and PBT had light to medium food smell. Large discolouration was observed on wooden box and light discolouration on PBT, PP transparent and wheat straw ones. All boxes except from PC, had a light or strong food smell.

7 All observations are based on box condition after washing

Findings per assessment criteria[8]

Major damages (from highest impact to lowest): Wood; Aluminium

Wooden and aluminium containers had major damages.

Deformation: Wood

Only wooden containers were deformed. Remaining boxes did not experience deformations caused by heat or handling.

Scratches (from highest impact to lowest): Aluminium; Stainless steel; Tritan; PC; SAN; Wheat straw.

Largest number of scratches were recorded on aluminium, stainless steel, tritan, PC, SAN, and wheat straw boxes. Mostly due to handling (putting in and taking out food with a stainless steel spoon) as well as multiple washing cycles.

It is worth noting that pre – trial, PP non -transparent box had largest number of scratches, which did not increase during testing.

Smell (from highest impact to lowest): Wood; Aluminium, Stainless steel; Wheat straw; PP-transparent; Tritan; PP non-transparent

Aluminium, wooden, stainless steel and wheat straw boxes had the strongest material smell, especially when box was heated.

[8] Pre-trial images are available in Annex 1

Wooden, wheat straw, PP transparent boxes had the strongest food smell had. It was easily recognizable what type of food these boxes held especially after duration longer than 1 hour.

Discolouration (from highest impact to lowest)[9]: Wood, PP transparent; Wheat straw; PBT; Tritan.

It was observed that discoloured were wooden, PP transparent, wheat straw and PBT boxes.

Impact of curry sauce was visible on PBT, wheat Straw, and tritan boxes and tomato sauce mostly impacted PP-transparent container.




[9] The pre-trial images available in Annex 1

Stains (from highest impact to lowest)

It was observed that aluminium, wooden and wheat straw containers had highest number of colour stains from food (both tomato and curry).

On the other hand, stains from usage, such as dried water drops, detergent, oil were observed on aluminium, PC, SAN, PP transparent, stainless steel and tritan boxes.

Dishwasher

Due to the settings of the dishwasher, most of the boxes were displaced during washing cycle, as shown in picture A. Displacement has been avoided during subsequent washing cycles by placing a washing rack on top of the containers. This way the containers remained in the same position during washing, as shown in picture B.

Picture A

Picture B

Differences observed between unused[10] and used[11] boxes undergoing similar tests

Used vs unused boxes "3-day food storage"

Stronger and unpleasant smell of old food and mould was observed on boxes that were previously washed 50 times, in comparison with unused boxes, which had much lighter smell after storing food for 3 days.

Stronger discolouration was observed on the boxes that have been through test 1 and 2 prior to 3-day food storage, than boxes that were not used before.

Used vs unused boxes "1-day food storage"

Impacts were approximately equal, on both unused and used boxes. It was also observed that 50 washing cycles impacted mostly the used PBT box, which was a lot more discoloured than the unused PBT box.

Unused boxes "1-day vs 3-day food storage"

Stronger discolouration on unused boxes has been observed on boxes after repeated 1-day food storage and washing cycles, in comparison with one-off 3-day food storage (this refers especially to PBT and Wheat straw boxes).

Unused boxes "1 hour vs 1 day food storage"

Stronger discolouration and food smell on unused boxes has been observed on boxes after repeated 1 day food storage, in comparison with 1 hour food storage (this refers especially to curry on PBT, wheat straw, tritan and PP transparent boxes and tomato on tritan, wheat straw, PP transparent, aluminium boxes).

Summary of observations

GENERAL FOR ALL BOXES IN ALL TESTS	Wood	Stainless steel	Aluminium	PP transparent	PP non-transparent	PBT non-transparent	Tritan transparent	SAN	PC transparent	Wheat straw + PP
Major damage	MOULD, HOLES, ROUGH SURFACE		RUST, HOLES, DETERIORATED LOOK							
Deformation	SEPARATED PARTS									
Scratches		DUE TO FOOD HANDLING, NOT WASHING; APPEAR INSIDE THE BOX	DUE TO WASHING AND HANDLING FOOD; APPEAR ON ALL SIDES OF THE BOX	VISIBLE PRE-TRAIL AS WELL AS DURING FOOD HANDLING, NOT DURING WASHING	VISIBLE MAINLY PRE-TRIAL; APPEAR INSIDE THE BOX		DUE TO FOOD HANDLING, NOT WASHING, APPEAR INSIDE THE BOX	DUE TO FOOD HANDLING, NOT WASHING; MANY PRE-TRAIL; APPEAR INSIDE & OUTSIDE THE BOX	DUE TO FOOD HANDLING, NOT WASHING; MANY PRE-TRAIL; APPEAR INSIDE AND OUTSIDE	DURING FOOD HANDLING, NOT WASHING; MANY PRE-TRAIL; APEPAR OUTSIDE THE BOX
Smell (Material/Food)	MATERIAL-PLASTIC/GLUE; FOOD, STRONG	MATERIAL-METALLIC, MEDIUM	MATERIAL-METALLIC; FOOD, MAINLY TOMATO, MEDIUM	FOOD, STRONG	FOOD, MINOR		FOOD, MINOR			MATERIAL & FOOD, STRONG
Discolouration	FROM CURRY & TOMATO, RED AND YELLOW			MAINLY FROM TOMATO, RED		MAINLY FROM CURRY FOOD, YELLOW	MAINLY FROM CURRY FOOD, YELLOW			MAINLY FROM CURRY FOOD,YELLOW
Stains	FROM FOOD, RED AND YELLOW	FROM FOOD, WATER DROPS, MINOR	FROM FOOD, WATER DROPS, DETERGENT	FROM WATER DROPS	FROM FOOD, FAT/ OIL, MINOR	FOOD, MINOR	WATER DROPS, DETERGENTS, OIL/FAT FROM FOOD	WATER DROPS, DETERGENTS, OIL/FAT FROM FOOD	WATER DROPS, DETERGENTS, OIL/FAT FROM FOOD	FROM FOOD, RED AND YELLOW

[10] Boxes which were pre-washed for 50 washing cycles
[11] Boxes which were new and not used nor washed prior the trail

Conclusions

Based on the findings per each container type and assessment criteria there is no clear winner. For example, some boxes that don't get deformed have smell effects. Most of the containers are resistant to deformations and major damages, but many are sensitive for example to scratches. To summarize, the choice depends on what is important for the user.

In addition, based on the observed impact of food storage on boxes that were first prewashed 50 times versus boxes that stored food but were unused prior to trial, we note that the more a box is used, the more sensitive to colouring it becomes. As a conclusion, not only the amount of time food is stored in a box matters but also the frequency of usage.

To summarize, the main learnings are:

- ✓ Wooden and aluminium containers[12] are not suitable for washing and long-term food storage
- ✓ PP non-transparent, PBT and SAN[13] containers are most suitable for washing and food storage
- ✓ To maintain a high quality of the product, it is advised to wash containers in less than 24h to avoid food smell and strong discoloration
- ✓ To avoid unnecessary scratches, it is advised to use soft and non-metallic cutlery during handling
- ✓ Frequent washing and food storage affects all type of containers

[12] Meeting the parameters described in chapter 1
[13] Meeting the parameters described in chapter 1

Annex 1. Pre-trial condition of containers vs post-trial with high-level summary

Each table above post-trial images, indicates impact level of each criteria (major damage, deformation, scratches, smell, discolouration, stains). The severity of impacts is presented by three levels: high (red), medium (orange), low (blue). Non occurring or negligible level of impact is indicated with green colour.

1. Wood

Pre-trial

Post-trial

Major damage	high
Deformation	high
Scratches	
Smell (Material/Food)	high
Discolouration	high
Stains	high

2. Stainless steel

Pre-trial

Post-trial

Major damage	
Deformation	
Scratches	high
Smell (Material/Food)	medium
Discolouration	
Stains	low

3. Aluminium

Pre-trial

Post-trial

Major damage	high
Deformation	
Scratches	high
Smell (Material/Food)	medium
Discolouration	
Stains	high

4. PP transparent

Pre-trial

Post-trial

Major damage	
Deformation	
Scratches	low
Smell (Material/Food)	high
Discolouration	medium
Stains	low

5. PP non-transparent

Pre-trial

Post-trial

Major damage	
Deformation	
Scratches	low
Smell (Material/Food)	low
Discolouration	
Stains	low

6. PBT

Pre-trial

Post-trial

Major damage	
Deformation	
Scratches	
Smell (Material/Food)	
Discolouration	medium
Stains	low

7. Tritan

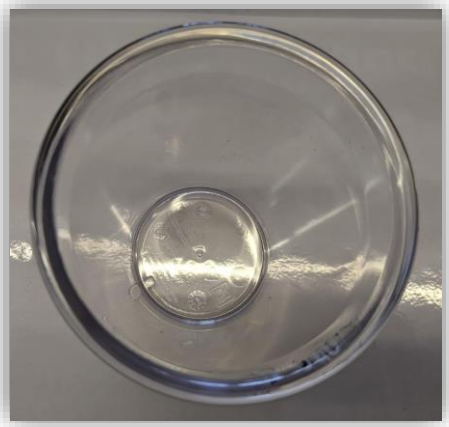
Pre-trial

Post-trail

Major damage	
Deformation	
Scratches	medium
Smell (Material/Food)	low
Discolouration	low
Stains	low

8. SAN

Pre-trial



Post-trail

Major damage	
Deformation	
Scratches	medium
Smell (Material/Food)	
Discolouration	
Stains	low

9. PC

Pre-trail

Post-trial

Major damage	
Deformation	
Scratches	medium
Smell (Material/Food)	
Discolouration	
Stains	low

10.Wheat straw/PP

Pre-trial

Post-trail

Major damage	
Deformation	
Scratches	low
Smell (Material/Food)	high
Discolouration	medium
Stains	medium