The Consumer Voice in Europe

HALF BAKED: EU FOOD PACKAGING LAWS NEED A RETHINK TO KEEP CONSUMERS SAFE

A consumer test of chemicals leaching from silicone bakeware

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BEUC The European Consumer Organisation

Silicone bakeware: easy-to-use, safe-to-use?

The global pandemic – and increased time spent at home – led many consumers to re-discover simple pleasures – such as home cooking and baking. Silicone baking moulds are a widely popular, often in-expensive alternative to metal forms, due in part to their non-stick properties, durability, and heat-resistance. Silicone is however not inert and may inadvertently add 'chemical ingredients' to cakes and other baked goods that consumers neither expect – nor want.

New findings by nine BEUC members thus document how silicone baking moulds can release chemical contaminants when used in contact with fatty or oily foods. In total, 23% of sampled products were found to release their chemical constituents either in high or increasing amounts, suggesting that products are not suitable for repeated use. In addition, the analysis detected substances of concern[1] in 82% of samples, albeit at low levels. Several products finally missed adequate use instructions, often displayed exclusively through obscure pictograms.

Unlike plastic materials, no detailed EU rules exist to ensure that silicone products meant for food contact are safe for consumers. These new findings highlight that the EU must act now to improve consumer protection. This fact is also recognised in the 2020 Farm to Fork Strategy[2] in which the European Commission commits to revise EU food packaging legislation to improve food safety and public health.

Europe's regulatory patchwork for silicone baking moulds

Silicone is widely used in direct contact with food, for example to coat paper packaging to make it water and fat resistant. In households, silicones are common as baking moulds and kitchen utensils, such as spoons, coasters, and pan gloves. Brightly coloured silicone tableware, containers and bibs are often popular items for children.

EU legislation[3] requires all silicones used for food contact to be safe and inert – that is, not influence the food in a negative way. Unlike plastic materials,[4] detailed EU rules to determine compliance with this generic requirement do not exist, however. Consequently, it is often challenging to demonstrate that silicone – and other non-plastic materials intended for food contact are safe, as the European Parliament highlighted in 2016.[5] Parliament notably concluded that this lack of EU rules is detrimental to public health and consumer trust.

While the absence of EU rules allows Member States to adopt their own national rules, only five countries have such measures in place for silicone; and, the overlap between these rules is limited: of an estimated 336 chemicals covered across Europe, only 37 substances (11%) are regulated by two or more Member States, according to a 2017 review by the Joint Research Centre.[6] None of the national rules addresses specific contaminants released

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1 Such as suspected endocrine disruptors, or substances classified as carcinogenic, mutagenic or reprotoxic under EU chemicals legislation.
2 European Commission. *Farm to Fork Strategy*. May 2020.
3 Regulation (EC) No 1935/2004 on materials and articles intended to come into contact with food.
4 Commission Regulation (EU) No 10/2011 on plastic materials and articles intended to come into contact with food.
5 See further BEUC. *Reform EU food packaging to better protect consumers*. May 2019.
6 Joint Research Centre. *Non-harmonised food contact materials in the EU: regulatory and market situation. Baseline study*. January 2017.

from silicone products, focusing instead on the starting substances used in the manufacturing process.[7]

This regulatory patchwork in short implies that European consumers are not guaranteed the same level of protection depending on where they live. Recognising this concern – along with the regulatory framework's broader shortcomings – the European Commission in 2020 committed[8] to revise EU food packaging legislation, with preparatory work on a legislative proposal currently ongoing.

Known unknowns: chemicals leaching from silicone bakeware

Silicone, a rubber-like material, is a polymer made up of individual building blocks, known as siloxanes. During the production process, additives such as plasticisers or colorants are used to achieve specific functions, e.g. flexibility or colour.[9] Production is not perfect however, and various volatile compounds, used either as starting materials or formed as by-products during the polymerisation process, can still be present in the final product.

When used in contact with food, silicone can release these volatile compounds along with other chemical constituents into the food. The potential for release increases with certain use conditions, such as temperature, microwave, and even long-time reuse. The amount of potentially migrating substances can be reduced through post-curing or heat treatment of the final silicone material; as post-curing is an energy intensive, and hence expensive process, it is however not consistently performed by all manufacturers.[10]

Relatively little is overall known about the complex mix of chemicals that migrate from silicone materials, including their toxicological effects due to long-term ingestion.[11] To date, three individual siloxanes[12] have been classified as Substances of Very High Concern (SVHC) under REACH due to their persistent properties; with additional concern raised over suspected endocrine disrupting and reprotoxic effects. Further research is however needed to determine whether exposure to the mostly unknown compounds released from silicone materials presents a risk to food safety and public health.

A consumer test: chemicals leaching from silicone baking moulds

To further explore this issue, nine BEUC members[13] decided to investigate silicone baking moulds available in different European countries. Coordinated through International Consumer Research and Testing (ICRT), the test focused on silicone bakeware, given that their repeated use at high temperatures, often in contact with fatty and oily foodstuff, is expected to result in higher risks of migration. In total, the test sampled 44 different

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[7] Liu *et al*. 2021. Influence of cooking conditions on the migration of silicone oligomers from silicone rubber baking molds to food simulants. *Food Chemistry* 347.
[8] European Commission. *Farm to Fork Strategy*. May 2020.
[9] Food Packaging Forum. *Dossier – Silicones*. May 2015.
[10] See e.g. Asensio *et al*. 2022. Analysis of potential migration compounds from silicone moulds for food contact by SPME-GC-MS. *Food and Chemical Toxicology* 165.
[11] See e.g. Food Packaging Forum. *Dossier – Silicones*. May 2015.
[12] That is, octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5) and dodecamethylcyclohexasiloxane (D6).
[13] Altroconsumo (Italy), Deco (Portugal), Forbrugerrådet TÆNK (Denmark), Organización de consumidores y usuarios (Spain), Sveriges Konsumenter (Sweden), Test-Achats/ Test-Aankoop (Belgium), UFC-Que Choisir (France), Verein für Konsumenteninformation (Austria), and Zveza Potrošnikov Slovenije (Slovenia). *Note: this document has been amended in February 2023 to clarify that nine, instead of ten as mentioned originally, national consumer organisations took part in the research*.

silicone baking moulds, purchased in physical shops, including discount stores, in web shops, and on marketplaces, such as AliExpress or Amazon.

All 44 samples were sent to a laboratory for analysis. Building on previous research,[14] the analysis combined migration tests using food simulants with identification and quantification of individual substances released from the samples. In line with the requirements for plastic materials intended for repeated use, migration tests were carried out three times (M1, M2, and M3) on a single sample using another portion of food simulant on each occasion.[15]

In the absence of detailed EU rules regulating silicones, samples were evaluated against three criteria inspired in part by the Plastic Regulation and rated using a 'traffic-light' scale:

1. **Amount of volatile compounds** released during the third migration test. The Plastic Regulation requires that plastic materials shall not transfer their constituents to food simulants in quantities exceeding 10 mg/dm^2 or 60 mg/kg. As the analysis only measured the release of volatile compounds, not total migration, an adapted limit was used, rating samples as 'green' (<10 mg/kg), 'yellow' (10-30 mg/kg), or 'red' (>30 mg/kg).
2. **Material stability**: In line with the Plastics Regulation, three migration tests (M1, M2, and M3) were carried out. An increase in the amount of volatile compounds released between the first and third migration test indicates that the material is insufficiently stable and therefore not suitable for repeated use. Accordingly, samples were rated as 'green' (M1>M3), 'yellow' (M1=M3) and 'red' (M1<M3).
3. **Substances of concern** detected in the third migration test. The analysis sought to identify individual compounds released from the silicone material, including siloxanes classified as Substances of Very High Concern and structurally similar compounds. As no limit values in most cases exist for such substances, samples were rated only as either 'green' (no substances of concern detected) or 'yellow' (substances of concern detected).

The final evaluation relied on a conservative approach, whereby a product's overall rating was determined by the lowest rating on each of the three criteria. For example, a product receiving a 'red' rating due to high releases of volatile compounds (>30mg/kg), also received a 'red' rating overall (see Annex I for an overview).

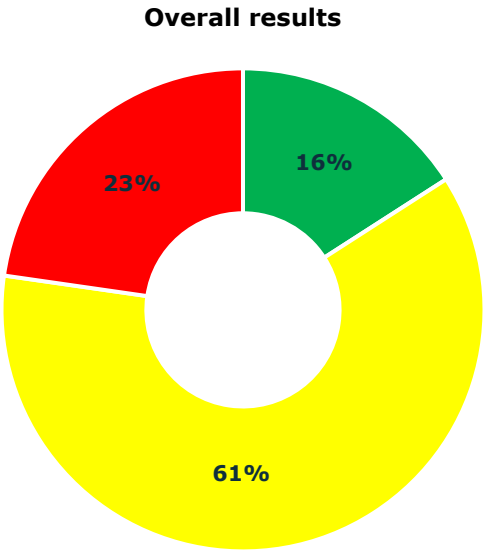
Results: chemicals leaching from silicone bakeware

The overall results for the 44 samples are summarised in the graph below. In total, 10 samples (23%) received the lowest rating (red), either due to overall high releases of volatile compounds or an increase in the amount of such compounds released between the first and third migration test. A further 61% (27 samples) were rated as 'yellow' due either to moderate releases of volatile compounds, similar results between the first and third migration tests, and/or the release of substances of concern, such as the SVHC octamethylcyclotetrasiloxane (D4).

While none of the tested products in isolation may endanger human health, the test results illustrate that there is technical room for manufacturers to improve: 7 samples (16%) thus received a 'green' rating as overall the amount of volatile compounds released was low

[14] See e.g. Asensio *et al*. 2022. Analysis of potential migration compounds from silicone moulds for food contact by SPME-GC-MS. *Food and Chemical Toxicology* 165.
[15] Further details on data and methods are available upon request.

(<10 mg/kg), and decreasing between the first and third migration. Also, no substances of concern were detected in the analysis of these products.



Legend:

Green: Amount of released volatile compounds <10 mg/kg, M1>M3, and no substances of concern detected.

Yellow: Amount of released volatile compounds = 10-30 mg/kg, M3=M1, and/or substances of concern detected.

Red: Amount of released volatile compounds >30 mg/kg and/or M1<M3.

Amount of volatile compounds

All samples released volatile compounds, but with significant variations: of the 44 samples, 5 were found to release volatile compounds in high amounts (>30 mg/kg), with two products purchased on Amazon exceeding the overall migration limit of 60 mg/kg established in the Plastics Regulation. A further five samples released volatile compounds in the concentration range 10–30 mg/kg, and so received a 'yellow' rating.

Material stability

Most samples (86%) showed a decrease in the amount of volatile compounds released between the first and third migration test, suggesting that the material is sufficiently stable to be used repeatedly. For six samples, the analysis however showed an increase between the first and third migration test, indicating that the products are not suitable for repeated use.

Substances of concern

36 samples were found to release substances of concern. This included the three siloxanes classified as Substances of Very High Concern (SVHC) under REACH, as well as their chemical cousins, that is, other cyclosiloxanes. In some samples, the analysis detected substances that are classified as Carcinogenic, Mutagenic or Reprotoxic (CMR) or are suspected endocrine disruptors, such as benzophenone or dibutyl phthalate.

For all 36 samples, substances of concern were however detected at low levels, suggesting the absence of an immediate concern for consumer health. Still, the long-

term impact of (repeated) ingestion of these substances merits further attention. In parallel, the test results also illustrate that there is room for manufacturers to improve as no substances of concern were detected in eight samples.

Overall, the results demonstrate that silicone baking moulds release volatile compounds – including in some cases specific substances of concern – that migrate into food and thus can be ingested by consumers. While none of the tested products in isolation may endanger human health, relatively little is also known about the identified compounds and their possible long-term toxicological effects. Sadly, much of this exposure could be avoided if manufacturer consistently invested in curing their silicone materials before placing them on the market to ensure that the amount of migrating substances is kept to a minimum.

Obsure pictograms and insufficient information

Clear labelling and usage information are essential to enable consumers to use silicone bakeware correctly. A previous market survey by five German consumer associations nonetheless found[16] that use instructions frequently were given exclusively in the form of pictograms without further wording. The pictograms were however rarely self-explanatory and often difficult to read because the imprint was blurred and kept in the same colour as the product. This may result in risky consumer practices, for example if the mould is used at temperatures above the intended range.

The present test confirms this concern, as many of the sampled products provided only hard to read use instructions, including through obscure pictograms (see pictured example in figure 1). Two silicone baking moulds purchased on AliExpress and on Wish failed to provide any use instructions, while most samples bought on online marketplaces did not include the manufacturer's contact details – thus making it impossible for consumers, and enforcement authorities, to contact the responsible company in case of a complaint. These findings therefore strongly indicate the need for control authorities to focus more on such insufficient, ambiguous, or missing labelling.

Figure 1. Symbols directly printed in the mould

Half baked: time is ripe to rethink EU food packaging legislation

In Europe, over 8,000 chemicals are estimated to be used to produce and treat paper wraps, plastic packaging, silicone bakeware and other materials intended for food contact.[17] Food contact materials (FCM) and items however also contain and release chemicals that the manufacturer did not use intentionally. These are counted in the tens of thousands, only a fraction of which are known or studied. The risk that a few of these unknown

[16] Verbraucherzentrale. *"HEISSE" KÜCHENUTENSILIEN? Bundesweiter Marktcheck der Verbraucherzentralen zur Kennzeichnung von Lebensmittelbedarfsgegenständen aus Kunststoff*. July 2015.

[17] J. Muncke *et al*. Impacts of food contact chemicals on human health: a consensus statement. *Environmental Health* 19. March 2020.

substances are harmful is significant. Chemicals leaching from FCMs may thus be the largest and least controlled source of food contamination.[18]

This disturbing situation is again illustrated by the present test which sheds new light on some of the chemical contaminants consumers may inadvertently be exposed to. It further drives home that the EU needs to rethink its regulatory approach to ensure that potential food contamination is minimised. This fact is also recognised in the 2020 Farm to Fork Strategy[19] in which the European Commission commits to revise EU FCM legislation to improve food safety and public health.

BEUC and its members strongly support these efforts. The revision presents a long overdue opportunity to build a comprehensive, future proof and enforceable regulatory framework that fully protects consumers against harmful chemicals. In view of the test results, **BEUC recommends[20] that**:

- **Strict EU rules for silicones and all non-plastic food contact materials are developed without delay**. Doing so will greatly improve consumer protection, while also facilitating efforts to control imported food packaging materials and items, as correctly observed by the Commission.[21] In support, the rules on Good Manufacturing Practices needs to be further developed to, for example, ensure that manufacturers cure their final silicone material, so as minimise the amount of chemical contaminants that could transfer into food. Member States must also significantly increase their resources for official controls to ensure that a revised FCM framework delivers real change for consumers on the ground.
- **Regulatory focus shifts towards the actual chemical mixtures that migrate from finished materials and products**. A similar, high level of safety for intentionally and non-intentionally added substances must be ensured. Consistent with EU food safety legislation, requirements to control all migrating substances are needed, while policy makers need to revisit the overall migration limit to align with the standards achieved in other sectors, such as for pesticide residues in food.
- **FCM labels are improved through coherent rules in relation to e.g. presentation, durability, and legibility of pictograms**. Existing obligations to provide safe use instructions need to be clarified to ensure that risk assessments correspond to actual consumer behaviour. In parallel, we strongly encourage the Commission and Member States to invest in awareness-raising campaigns to educate consumers about labels and chemicals in FCMs, so they better understand the correct use of specific food contact materials and products (e.g. repackaging, use in microwaves, etc.).
- **New tools to control online sales are introduced**. Consumers buy more and more products online, including through online marketplaces or web shops based outside of the EU. This trend presents new safety risks for consumers, as illustrated by this test: while not illegal, many of the products purchased through online marketplaces such as AliExpress or Amazon were among the worst performers in the test.

  This finding illustrates the need to build a future-proof, enforceable system, as correctly observed by the Commission.[22] Consequently, we recommend that a revised FCM framework introduces a possibility to hold these actors liable for non-compliance where

[18] Grob *et al*. 2006. Food Contamination with Organic Materials in Perspective: Packaging Materials as the Largest and Least Controlled Source? A View Focusing on the European Situation. *Critical Reviews in Food Science and Nutrition* 46.
[19] European Commission. *Farm to Fork Strategy*. May 2020.
[20] See further BEUC. *Time is ripe to Repackage Food Safely*. December 2019.
[21] European Commission. *Revision of EU rules on food contact materials (FCMs). Inception Impact Assessment*. January 2021.
[22] European Commission. *Revision of EU rules on food contact materials (FCMs). Inception Impact Assessment*. January 2021.

no other responsible economic operator can be identified. This should include an obligation on online marketplaces to verify the identity of the responsible person for products sold on their sites before the products are being placed on the market.

Annex I – results per product

Country	Sample bought	Amount of volatile compounds	Material stability	Substances of concern	Overall evaluation
EU	Amazon				
EU	AliExpress				
EU	Web shop				
EU	Web shop				
EU	Amazon				
EU	Shein				
EU	Amazon				
EU	Web shop				
EU	Web shop				
EU	Web shop				
EU	Amazon				
EU	AliExpress				
EU	Amazon				
EU	Amazon				
EU	Wish				
EU	Amazon				
EU	Web shop				
EU	Physical shop				
EU	Amazon				
EU	AliExpress				
Italy	Amazon				
Italy	Amazon				
Italy	Amazon				
Spain	Physical shop				
Spain	Physical shop				
Spain	Physical shop				
Austria/Denmark	Web shop				
Austria	Physical shop				
Austria	Web shop				
Austria	Physical shop				
Portugal	Physical shop				
Portugal	Physical shop				
Denmark/Sweden	Web shop				
Denmark	Web shop				
Sweden	Web shop				
Sweden	Web shop				
Belgium	Physical shop				
Belgium	Physical shop				
Belgium	Physical shop				
France	Web shop				
France	Physical shop				
France	Amazon				
France	Web shop				
France	Web shop				

Legend

Green: Amount of released volatile compounds <10 mg/kg, M1>M3, and no substances of concern detected.

Yellow: Amount of released volatile compounds = 10-30 mg/kg, M3=M1, and/or substances of concern detected.

Red: Amount of released volatile compounds >30 mg/kg and/or M1<M3.

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