FH CAMPUS WIEN
UNIVERSITY OF APPLIED SCIENCES

DIE HOCHSCHULE, DIE MEHR KANN.

Nachhaltigkeit und Verpackung

FH-PROF. IN DR.IN VICTORIA KRAUTER

FH CAMPUS WIEN
UNIVERSITY OF APPLIED SCIENCES

DIE HOCHSCHULE,
DIE MEHR KANN.

Fachbereich Verpackungs- und Ressourcenmanagement

APPLIED LIFE SCIENCES

BAUEN UND GESTALTEN

GESUNDHEITSWISSENSCHAFTEN

PFLEGEWISSENSCHAFT

SOZIALES

TECHNIK

PUBLIC SECTOR

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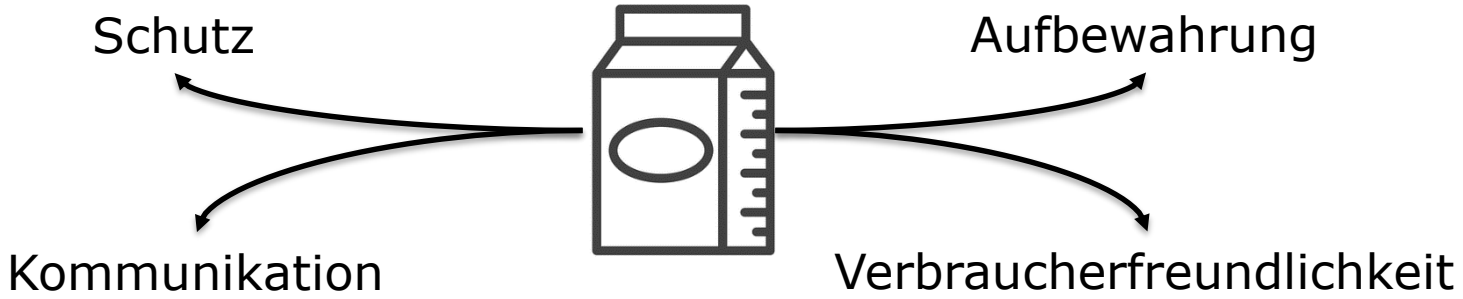
Verpackungen

> **Allgegenwärtig und wesentlich**
> Koordiniertes **System** zur Vorbereitung von Waren für den Transport, Vertrieb, Lagerung, Einzelhandel und Verwendung
>Komplexe, dynamische, wissenschaftliche, künstlerische und kontroverse Funktion



> **Service** Funktion, die nicht alleine existieren kann; es braucht ein Produkt!

Fundamentals of Packaging Technology – The definite resource on packaging technology, 2014, 5th edition, Institute of Packaging Professionals, Chapter 1, Perspective on Packaging, p. 3 – 21
https://pixabay.com/en/milk-icon-food-drink-design-2389222/
Food Packaging: Principles and practice, Gordon L. Robertson, 3rd ed., CRC Press, Introduction to Food Packaging, p. 1-2

Shelf life

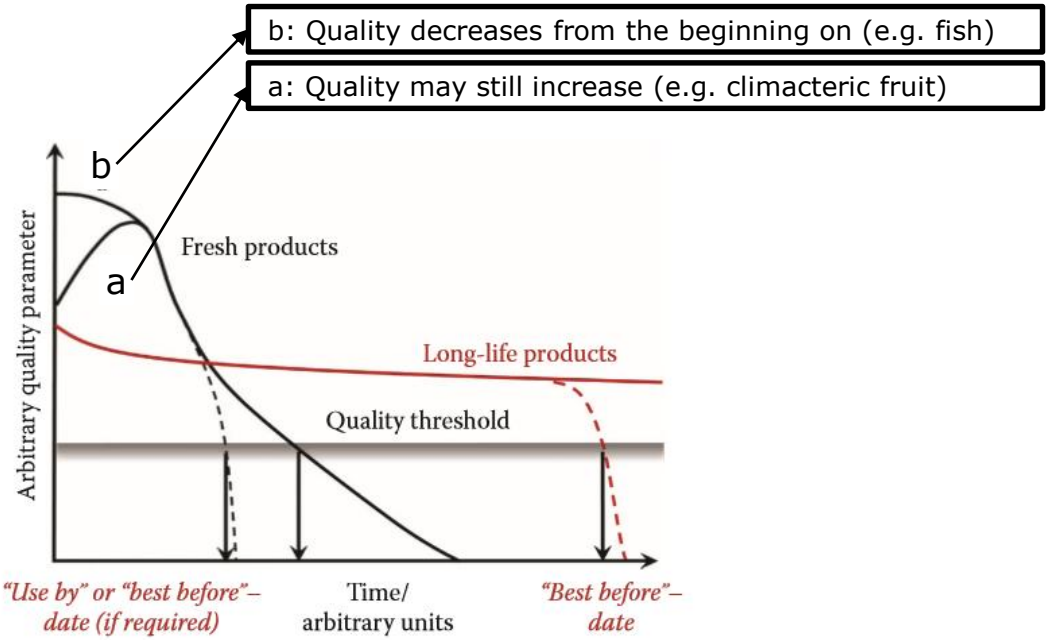


Figure 2.1 Quality decay of fresh and long-life food products, schematic. Straight lines indicate a steady decay, whereas dotted lines symbolize fast decay after exceeding a critical limit.

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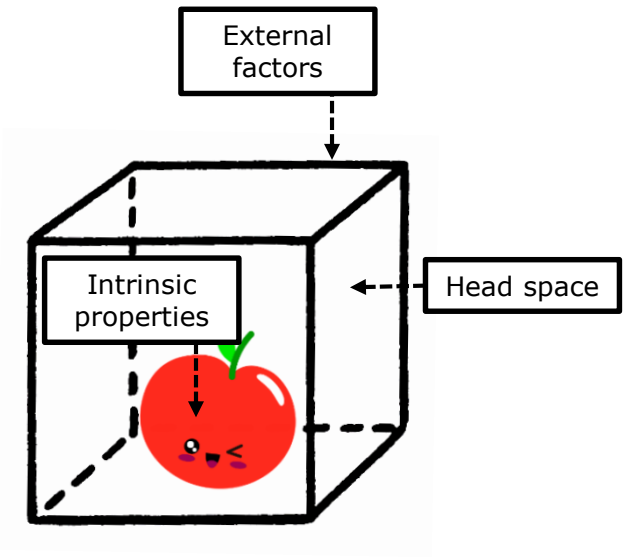
Factors from product, package and environment

- **Intrinsic properties**
  - >E.g. sensitivity to oxidation, initial microbial population
  - >Responsible for the **nature of decay** mechanisms
- **External factors**
  - >E.g. climate, illumination, presence of contaminants
  - >Determine reaction **rate of decay** process
- **Packaging**
  - >**Mediator or separator** between product and environment (depending on properties like substance permeation and light transmission)
  - >Note: Gas filled space between product and packaging (**head space**) can not be assigned to external conditions or intrinsic properties. It's composition may change over time. Intrinsic properties, external conditions and packaging determine the gas composition)



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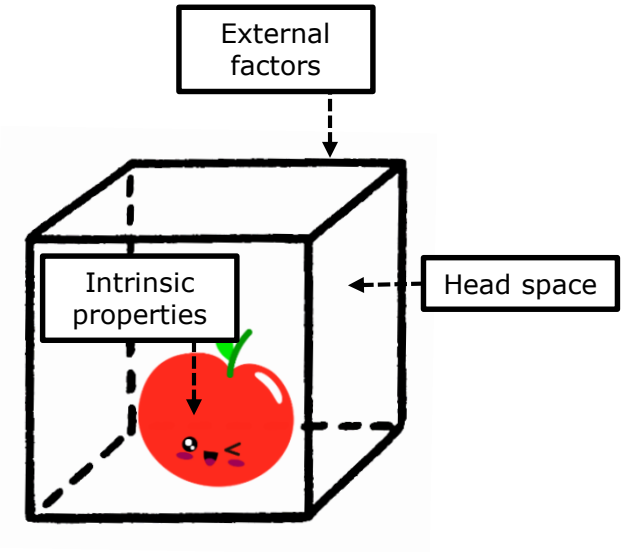
Decay processes of packaged food products

> Basic **decay mechanisms**
  >Chemical
  >Physical
  >Biotic

> **Effects on product** life
  >Quality-related
  >Declaration-related
  >Safety-related



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Note: Importance of packaging

Table 2.1 Overview of Predominant Mechanisms that Influence Food Lifetime (Shelf Life or Safe Life) Together with Determining Factors and the Influence of Packaging

Basic Mechanism (specific examples for effects [and products])	Factors Inside the Package (intrinsic product properties, headspace atmosphere)	Transfer through Package Involved	External Conditions	Overall Influence of Packaging
	Quality-related effects on product life → *shelf life*			
Chemical mechanisms				
Oxidative decay (autoxidation, rancidity [sunflower oil] photooxidation, rancidity, color changes [olive oil, meat products])	*Specific product composition* *Oxygen in product and headspace*	*Oxygen transfer, light ingress*	Temperature, *illumination*	*High*
Other oxygen–food interactions (unwanted color changes [fresh meat])		*Oxygen transfer*	Temperature	*High*
Other photochemical processes (light struck taste [dairy products, beer, etc,.])	*Specific product composition* Oxygen in product and headspace	*Light ingress*, oxygen transfer	*Illumination*	*High*
Physical mechanisms				
Water-related textural changes (water uptake, loss of crispiness [bakery products], water loss, drying [meat])	*Water activity and initial water content of product* *Water content of the headspace*	*Water transfer*	*Temperature, humidity*	*High*
Structural changes without water exchange with the outside (crystallization [ice cream, powders], agglomeration [powders])	*Local temperature, water activity, and water content of product*	Heat transfer	*Temperature*	Low
Permeative/sorptive loss or access of substances (loss of flavors [flavored products], admission of off-odors (powdery products, dairy products)	*Specific product composition*	*Flavor/odor transfer*	*Temperature, presence of odor substances*	*High*

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Table 2.1 *(Continued)* **Overview of Predominant Mechanisms that Influence Food Lifetime (Shelf Life or Safe Life) Together with Determining Factors and the Influence of Packaging**

Basic Mechanism (specific examples for effects [and products])	Factors Inside the Package (intrinsic product properties, headspace atmosphere)	Transfer through Package Involved	External Conditions	Overall Influence of Packaging
Quality-related effects on product life → *shelf life* (continued)				
Biotic mechanisms				
Growth of nonpathogenic (spoilage) microorganisms (smear, visible growth, and off-odor [fresh meat, fresh produce])	*Germ colonization/ contamination* Gas composition of headspace	Gas transfer	*Temperature*	Medium
Decay of metabolic cells of the product (senescence, softening, and staining [fresh produce])	*Water activity and water content of product, composition of headspace*	*Gas transfer, water transfer*	*Temperature*, humidity	medium
Declaration-related product life → *shelf life*				
Chemical mechanisms				
Decay of indicated constituents (oxidative loss of vitamins [fruit juices, milk])	*Specific product composition Oxygen in product and headspace*	*Oxygen transfer, light ingress*	*Temperature, illumination*	*High*
Physical mechanisms				
Global water loss (reduction of volume or weight [beverages, dairy products, produce])	*Water activity and initial water content of product*	*Water transfer*	*Temperature, humidity*	*High*
Safety-related effects on product life → *safe life*				
Biotic mechanisms				
Growth of pathogens, formation of toxins (health risks [meat and dairy products])	*Initial germ contamination/ colonization* Composition of headspace	Gas transfer	*Temperature*	Medium/low

Note: Factors of high effect are italicized.

Note: In packaging shelf-life issues dominate

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Table 2.4 Condensed Overview of Different Classes of Food Products, Their Decay Processes, and Their Structure, Together with Predominant Characteristics for Storage and Packaging

	Water Exchange with Environment		Oxidative Sensitivity				Growth of Microorganisms		Regular Cell Metabolism and Respiration	Structure			Specific Storage Conditions/ Specific Packaging Methods and Needs/Substance Transport through Package
Product Class	Water Uptake	Water Losses	Autoxidation, Spontaneous Oxidation	Photo-oxidation	Direct Light Effects	Uptake of Off Flavors	Spoilage	Pathogens		Liquid, Compact	Structured	Porous	
Dried or low-moisture food, low fat content	X		(x)	(x)		X	(x)	(x)			X	X	Dry storage/high barrier for moisture, often also gases, light, and flavors/LT
Dried or low-moisture food, high fat content	X		X	X		X	(x)	(x)			X	X	
Compact food, high fat content	X	X	X	X		X	(x)	(x)		X			Ambient or chilled storage/some moisture and gas barrier, high flavor barrier/LT
Beverages, sterilized dairy products		X	X	X	X	X	(x)	(x)		X			Ambient or chilled storage/high barrier for gases, light, moisture, and flavors/LT
Ready-to-eat food		X					X	X			X		Chilled storage/good moisture barrier/LT
Ready-to-cook/ convenience food		X	X	X			X	X			X		Often chilled storage/high barrier for gases or light and moisture/LT
Fresh/minimally processed meat/ seafood		X	X				X	X	X		X		Chilled storage/either: MAP with defined O_2 partial pressure and good oxygen barrier, or: atmospheric headspace, high gas permeability/LT or DT
Fresh/minimally processed produce		X					X	X	X	X	X		Chilled storage/MAP with defined O_2 and CO_2 partial pressures, high gas and moisture permeability/DT

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Table 2.4 *(Continued)* **Condensed Overview of Different Classes of Food Products, Their Decay Processes, and Their Structure, Together with Predominant Characteristics for Storage and Packaging**

	Water Exchange with Environment		Oxidative Sensitivity				Growth of Microorganisms		Regular Cell Metabolism and Respiration	Structure			Specific Storage Conditions/ Specific Packaging Methods and Needs/Substance Transport through Package
Product Class	**Water Uptake**	**Water Losses**	**Autoxidation, Spontaneous Oxidation**	**Photo-oxidation**	**Direct Light Effects**	**Uptake of Off Flavors**	**Spoilage**	**Pathogens**		**Liquid, Compact**	**Structured**	**Porous**	
Frozen food		**X**	X			X		(x)			**X**		Frozen storage/medium moisture barrier/LT
Fresh dairy products		**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**			Chilled storage/some moisture and light barrier/LT
Aged cheeses		**X**	**X**				**X**	X		**X**			Mostly chilled/often MAP or vacuum packs, medium gas and moisture barrier/LT
Retorted food		**X**	**X**	**X**	**X**	**X**	(x)	(x)		**X**			Ambient storage/high barrier for gases, light, moisture, and flavors/LT
Ready-to-bake food		**X**				**X**	**X**	(x)				**X**	Ambient storage/high CO_2 MAP, high barrier for gases, moisture, and flavors/LT
Fresh bakery products		X				**X**	**X**	(x)				**X**	Ambient storage/high moisture permeability/DT

Note: Ambient storage: temperate climatic conditions; MAP: modified atmosphere packaging; **X**: important property or mechanism; X: lower importance; (x): observed only sometimes. Specific storage conditions: LT, limited substance transport; DT, defined transport properties needed.

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Table 2.8 Selected Products and Related Permeability Values for Their Packaging Materials as Derived from Oxygen Tolerances, Admissible Changes in Water Contents, Typical Packaging Geometries, and Typical Figures for Indicated Shelf Life, with a Focus on the German Food Market

Product	O_2 Tolerance, Consolidated[a]/ mg/kg	Admissible Uptake (+) or Loss (–) of Water[a]/g H_2O per kg of Product	Contents-to-Surface Ratio/ kg m^{-2}	Typical Indicated Shelf Life	Average Difference in a_w (Inside vs. Outside)	Required O_2 Permeability $Q_{r\ O2}$/cm^3(STP)/(m^2 d bar) @ 23°C	Required H_2O Transmission Rate $TR_{r\ H2O}$/g/(m^2 d) @ 23°C, 85 → 0 % r.h.
High moisture products, a_w > 0.9							
Beer[b]	0.5–1	–30	9.8–10.9 (0.5 l) 8.3 (0.33 l)	6–12 months	0.5 with sufficient accuracy	0.045–0.200.038–0.15	1.4–3.01.2
Wine[b]	1–5[c]	–20 (0.75 l) –15 (3 l bag-in-box)	11 (0.75 l) 20.7 (3 l bag-in-box)	not required (calculated for 12 months)		0.10–0.50[c]0.19–0.95[c]	1.0 1.4
Fruit juices, soft drinks	10–40	–15	10–14.6	1 to 18 months		0.61–61.4	0.47–12.2
UHT milk	1[d]–8b	–15	14.6	10 to 20 weeks		0.35[d]–5.6[b]	2.7–5.3
UHT cream	0.8–1.2[b]	–15	14.6	10 to 20 weeks		0.28–0.83[b]	2.7–5.3
Hard cheese (cool storage)	100[b]–400[c]	–45	5.3	2 months		86–345[e]	50[e]
Retorted food (vegetables, baby food, …)	15	–45—20	9.1 (pouch) 10 (cup) 13 (jar, can)	3–12–36 months, lower for plastics, higher for metal or glass		0.59–5.0	0.40–7.6
Fats	20–200	–45—30	9.3 butter 11 margarine	3 months		6.8–80	5.2–9.2

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Table 2.8 *(Continued)* **Selected Products and Related Permeability Values for Their Packaging Materials as Derived from Oxygen Tolerances, Admissible Changes in Water Contents, Typical Packaging Geometries, and Typical Figures for Indicated Shelf Life, with a Focus on the German Food Market**

Product	O_2 Tolerance, Consolidated[a]/ mg/kg	Admissible Uptake (+) or Loss (–) of Water[a]/g H_2O per kg of Product	Contents-to-Surface Ratio/ kg m^{-2}	Typical Indicated Shelf Life	Average Difference in a_w (Inside vs. Outside)	Required O_2 Permeability $Q_{r\ O2}$/cm³(STP)/(m² d bar) @ 23°C	Required H_2O Transmission Rate $TR_{r\ H2O}$/g/(m² d) @ 23°C, 85 → 0 % r.h.
Dry or low moisture products, $a_w < 0.6$							
Nuts, snacks, chips	15–75	20–50	1.2–3.5	3 to 12 months	0.55–0.6	0.16–9.6	0.093–3.0
Coffee (instant or ground)	20	25–30	7.1	12 to 18 months	0.45	0.87–1.3	0.61–1.1
Other dried/ powdery foods	5–15	20–50	3–6	12 to 24 months	0.4–0.5	0.068–0.82	0.14–1.7
Oils	20–200[f]	n. r.	14	> 12 months	n. r.	2.6–26[f]	n. r.→ 30[g]

Note: n.r., not relevant.

[a] Based on literature sources, shop surveys, and internal measurements.
[b] Stored dark.
[c] Depending on sulfite addition.
[d] Stored under illumination.
[e] Estimated for storage conditions of 6°C and 50% r.h., permeation values changed accordingly.
[f] Depending on oil type and illumination.
[g] Value for PET taken as basic requirement.

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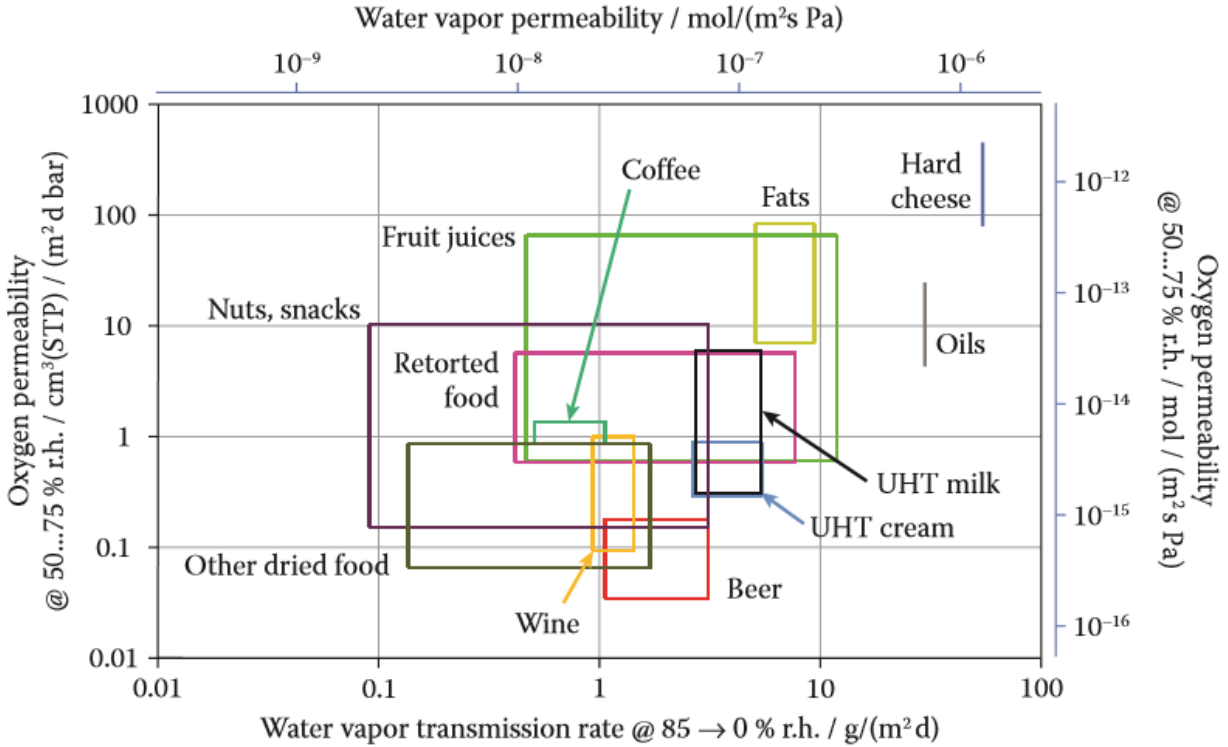

Figure 2.12 Graphical representation of Table 2.8. Guidance values of required oxygen and water vapor permeability and of water vapor transmission rate for a reference temperature of 23°C, for selected products.

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Sie erfüllt die Funktionen
- Aufbewahrung
- Schutz
- Kommunikation
- Verbraucherfreundlichkeit

und ist auf die Eigenschaften des jeweiligen Lebensmittels abgestimmt
- Verwendung geeigneter Materialien: Glas, Kunststoff, Metall, Papier und Pappe sowie Verbundwerkstoffe

Sie ist nach dem Minimalprinzip gestaltet
- Ressourcen
- Abfall
- Emissionen
- …

Sie fügt sich in den natürlichen oder stofflichen Kreislauf ein
- Abfallhierarchie
- Recycling
- Biobasierte / bioabbaubare Materialien

Sie ist sicher für Mensch und Umwelt
- Umweltfreundlich
- Schadstofffrei
- …

Referenzen: Verghese, K., Lewis, H., Fitzpatrick, L. (2012): Packaging for sustainability. Springer. Robertson, G. L. (2012). Food Packaging: Principles and Practice. CRC Press. PreetiSingh, Ali Abas Wani, Horst-Christian Langowski(2017).Food Packaging Materials: Testing & Quality assurance. CRC Press.

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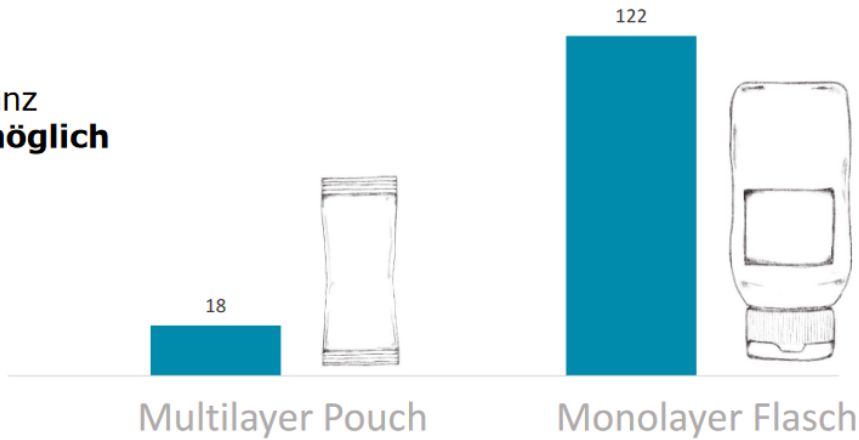
Zielkonflikte - Beispiel

Zielkonflikt Recyclingfähigkeit / Ökobilanz

Gramm CO_{2eq} pro 250 ml Lebensmittel

niedrige CO_2-Bilanz
Recycling **nicht möglich**



hohe CO_2-Bilanz
Recycling **möglich**

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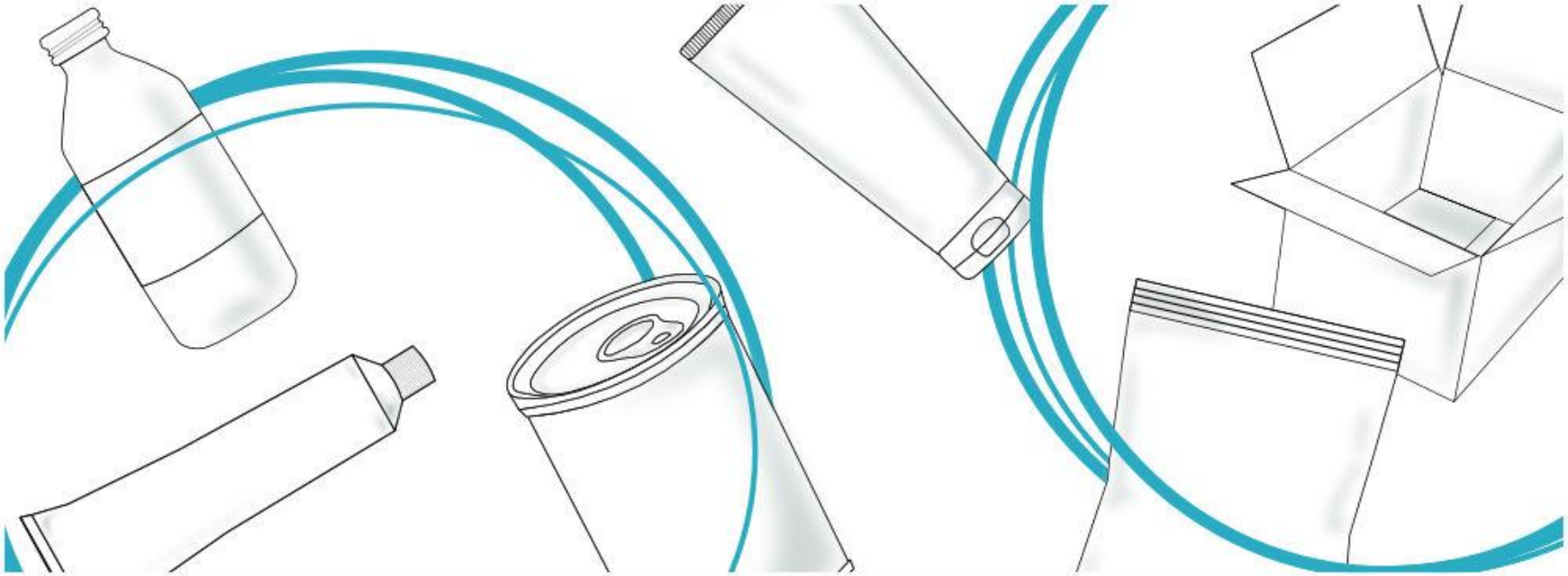
Circular Packaging Design Guideline



https://www.fh-campuswien.ac.at/circulardesign

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Projekt Circul-a-bility

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Projekt Circul-a-bility

- Nachhaltigkeit und Kreislauffähigkeit von Lebensmittelverpackungen im Mittelpunkt der europäischen Forschung
  - Netzwerkprojekt
  - Über 220 Expert*innen aus 37 Ländern
  - Interdisziplinarität
  - Zahlreiche Aktivitäten
    - Webinare, Konferenzen, Publikationen, Forschung, …

Vielen Dank für Ihre Aufmerksamkeit!

FH-Prof.in Dr.in Victoria Krauter

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