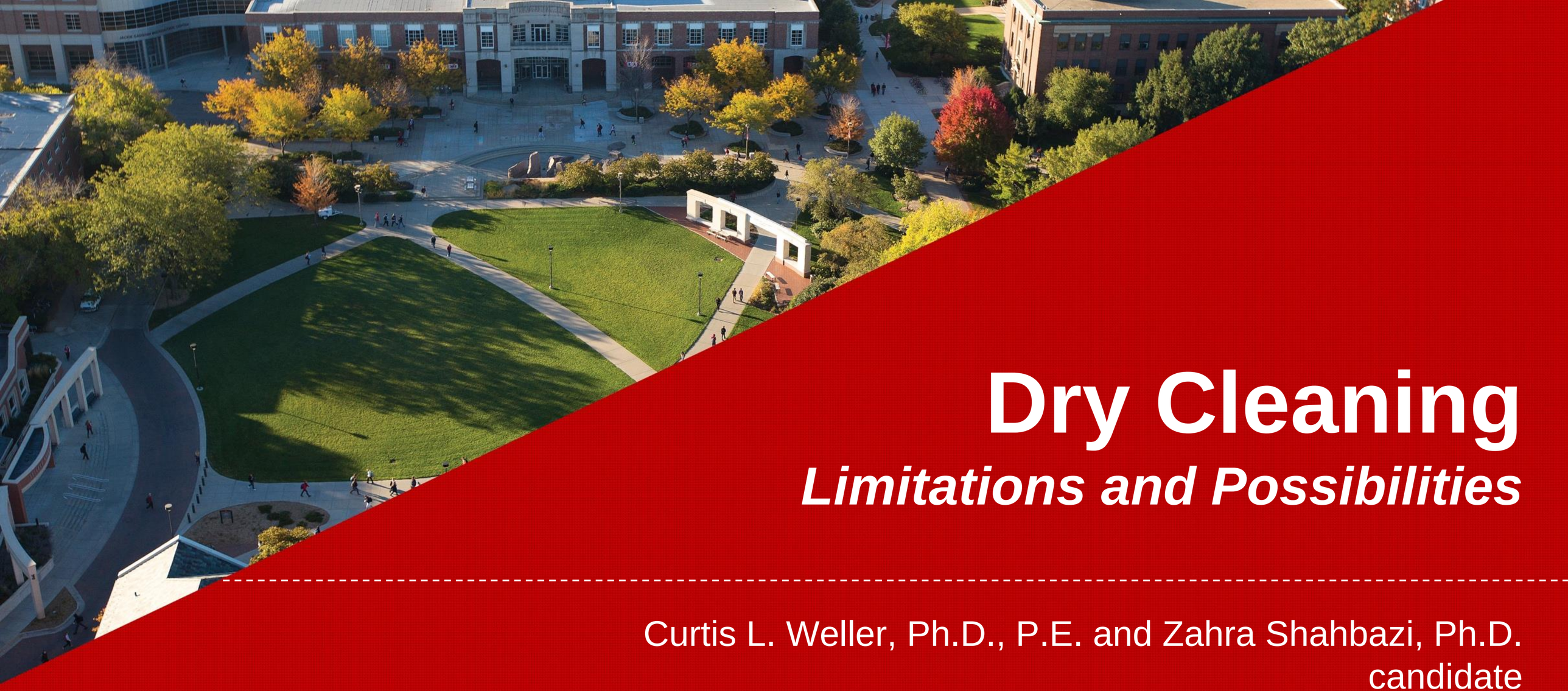

Dry Cleaning

Limitations and Possibilities

Curtis L. Weller, Ph.D., P.E. and Zahra Shahbazi, Ph.D. candidate

Design to Clean: Creating a Hygiene Focused Culture

3-A SSI Education Event • May 18, 2022 • Bloomington, MN USA

University of Nebraska Lincoln

Hygienic Design Process for Equipment

- Define Intended Uses & Risks
- Define Cleaning Methods
- Define Product Surfaces
- Select Approved Materials of Construction
- Design & Build to Meet Hygienic Criteria
- Third Party Verification (TPV)

Hygienic Design Process for Equipment

Main Points

- Published definitions of “clean” and what differentiates “dry” cleaning from “wet” cleaning
- Types of “dry” cleaning in use and practical limits between these types for removal of microbes, allergens and other materials during “dry” cleaning
- Current state of the art for measuring residual microbes, allergens and other material, and existing measurement challenges
- Gaps in knowledge associated with “dry” cleaning that can be closed with a little applied, publishable research

CLEAN – Is it hard to define?

CLEAN – You know what it isn't!

phxequip.com

CLEAN – You know what it isn't!

phxequip.com

CLEAN – Yet DO you know it when you see it?

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Why Do We Clean?

- To prevent the transfer of flavors and odors from one batch of product to another
- To ensure the efficient operation of plant and equipment; for example, to attain maximum heat transfer efficiency
- To eliminate soil contamination which may harbor micro-organisms responsible for spoilage or which represent a public health risk
- To improve working environment
- To meet legal requirements

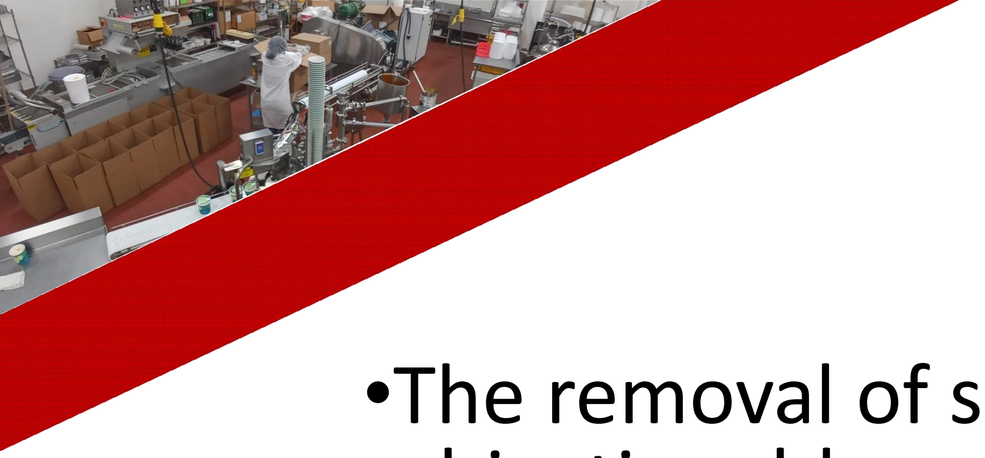
The Practical Brewer – A Manual for the Brewing Industry, 3rd Ed. MBAA, 1999

Defining *Clean*

(*adjective*) **a:** free from dirt or pollution; **b:** free from contamination or disease; **c:** relatively free from radioactive fallout *Webster's New Collegiate Dictionary 1973*

Free from soil *EHEDG Glossary Version 2020/08.G04*

A condition achieved by removal of dirt, residues, detergents, or other surface contaminants *ASME BPE-2019 Standard*



Cleaning & Cleanability

- The removal of soil, food residues, dirt, grease or other objectionable matter. *CXC 1-1969. 2020*
- The removal of soil (e.g., food residues, dirt, grease or other objectionable or unwanted matter) *EHEDG Glossary Version 2020/08.G04*
- Removal of product and residual soil *3-A SSI Module 4. Basics of Cleaning and Sanitizing*
- Made of such materials, so finished, and so fabricated that soil may be effectively removed by normal cleaning means *(ANSI/ASB/Z50.2-2015 (R2020) - FINAL) American National Standard for Bakery Equipment – Sanitation Requirements*

Close but NOT the Same

- **Disinfection** - Reduction by means of biological or chemical agents and/or physical methods in the number of viable microorganisms on surfaces, in water or air to a level that does not compromise food safety and/or suitability. *CXC 1-1969. 2020*
- **Sanitation** - A process applied to a cleaned surface capable of reducing the numbers of the most resistant human pathogens by at least 5 $\log_{10}$ reductions (99.999%) to 7 $\log_{10}$ reductions (99.99999%) by applying accumulated hot water, hot air, or steam, or by applying an EPA-registered sanitizer (USA) according to label directions. *EHEDG Glossary Version 2020/08.G04*
- **Hygienic** - of or pertaining to equipment and piping systems that by design, materials of construction, and operation provide for the maintenance of cleanliness so that products produced by these systems will not adversely affect human or animal health. *ASME BPE-2019 Standard*

Wet Cleaning vs Dry Cleaning

- **Wet cleaning** removes food residue with water and chemicals; match cleaning chemical and method to surface and soil *Appendix 5, FSPCA Preventive Controls for Human Food Participant Manual, 1st Ed., 2016*
- **Dry cleaning** removes food residue with mechanical action; dry processing environment precludes use of water *Appendix 5, FSPCA Preventive Controls for Human Food Participant Manual, 1st Ed., 2016*

Cleaning Method – Order of Preference

1. No cleaning needed
   a. Redundant or dedicated equipment
2. Purge (next product or inert material)
3. Dry clean
4. Dry clean w/chemicals
5. CIP (Clean in Place)
6. Controlled wet clean – out of place
   a. Automated washer
7. ACS (Assisted Cleaning System)
8. Controlled wet clean – in place
9. Flood cleaning

Thorson, K. FPSA Webinar - Bakery Food Safety Innovations: Where We've Been & Where We Need to Go, Jan 26, 2022

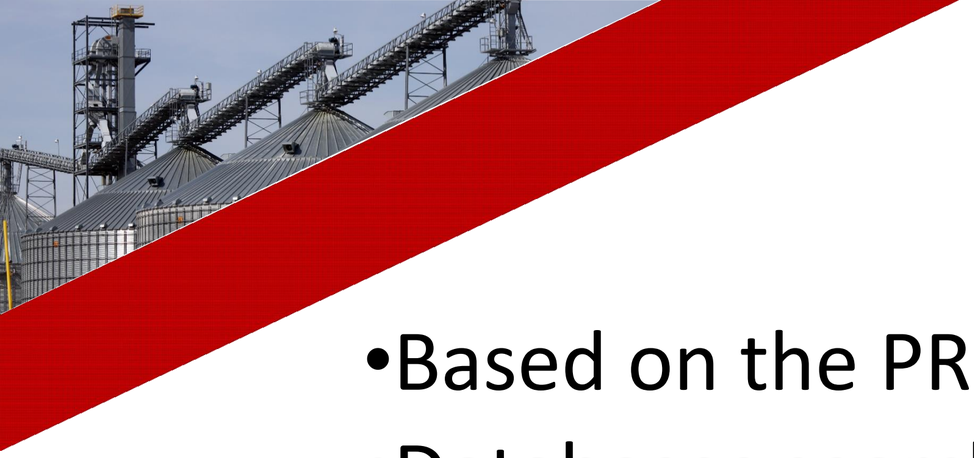
FPSA
Food Processing Suppliers Association

Major Characteristics

- Cleaning, which does **not** involve any use of **water**. *EHEDG Glossary Version 2020/08.G04*
- Cleaning with a **vacuum cleaner** and/or **dry brushes** and **other tools** manipulated by hand. *3-A SSI Module 4. Basics of Cleaning and Sanitizing*
- Use of an effective cleaning procedure **without** notable use of **water** (including aqueous solutions, aqueous suspensions, or steam). *Burnett, S.L. and R. Hagberg. Dry Cleaning, Wet Cleaning, and Alternatives to Processing Plant Hygiene and Sanitation, Springer Science+Business Media New York 2014 85. J.B. Gurtler et al. (eds.), The Microbiological Safety of Low Water Activity Foods and Spices, Food Microbiology and Food Safety, DOI 10.1007/978-1-4939-2062-4_6*

Factors Affecting Type Used

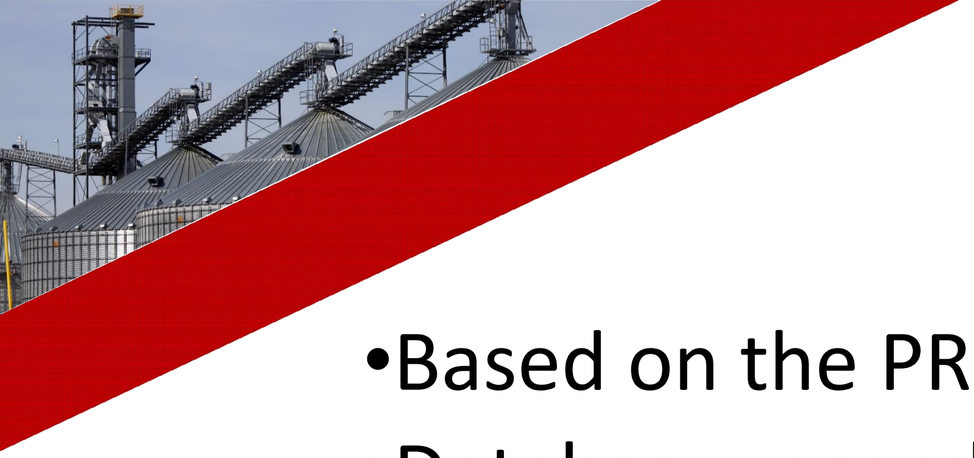
- Type of surface needing to be clean
- Nature of soil
- Type of soil
- Soil examples – microorganisms; viruses; food residues including allergens; residues of cleaning and disinfection agents; lubricants; fouling
- Soil - Any undesirable or objectionable material on surfaces in the equipment or process environment *EHEDG Glossary Version 2020/08.G04*
- Soil – Unwanted organic residue or inorganic matter *3-A SSI Module 4. Basics of Cleaning and Sanitizing*



Scoping Review

- Based on the PRISMA method*
- Databases searched February 2022
  - ✓AGRICOLA
  - ✓Biological Abstracts
  - ✓CABI
  - ✓Scopus
  - ✓Web of Science Core Collection, 1900-present
- Search terms: *dry cleaning, dry sanitation, dry disinfection, steam cleaning, ozone cleaning, UV cleaning, wiping, purging, dry heat cleaning, brushing and scraping*

*Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. International Journal of Social Research Methodology, 8(1), 19-32.



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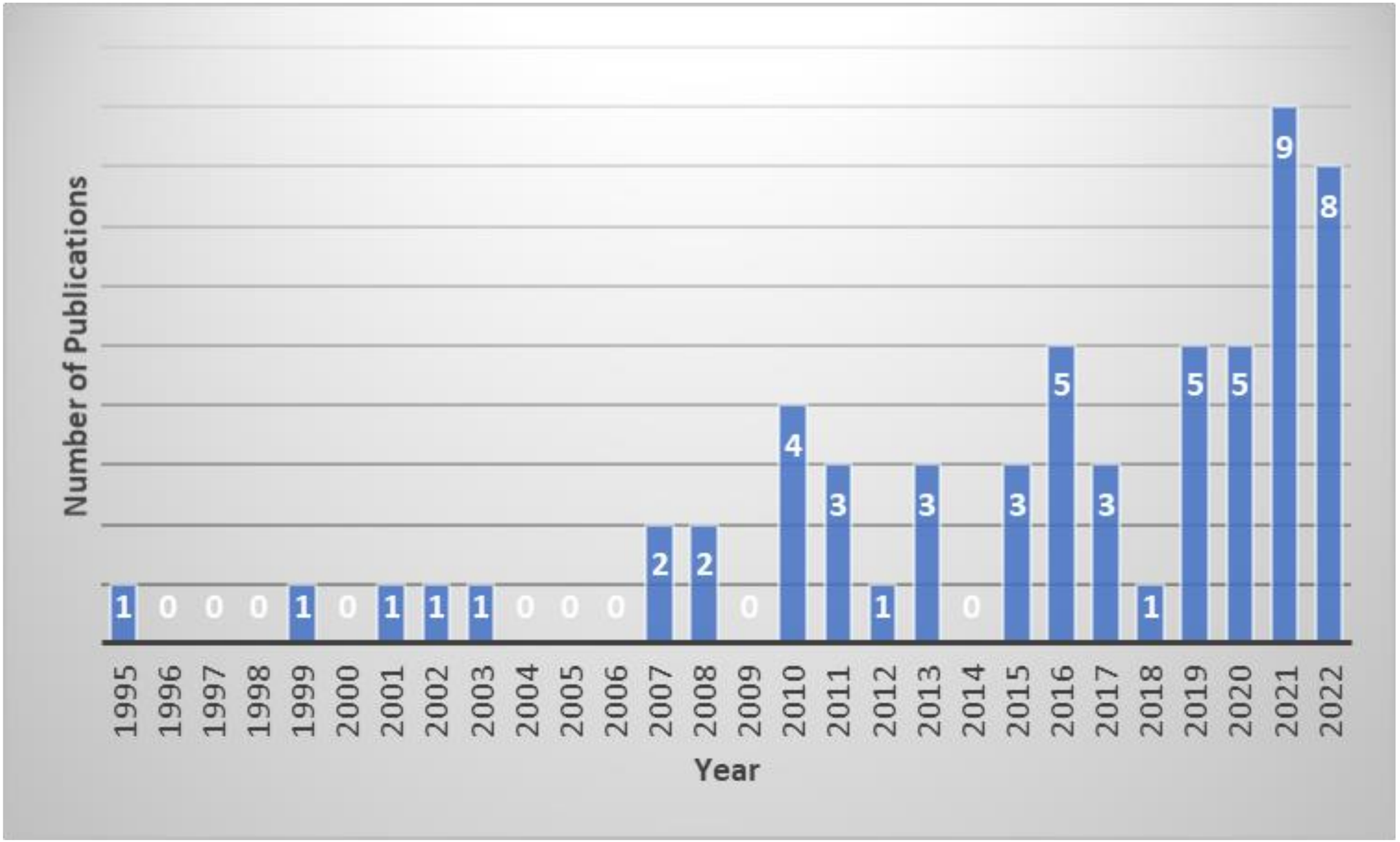
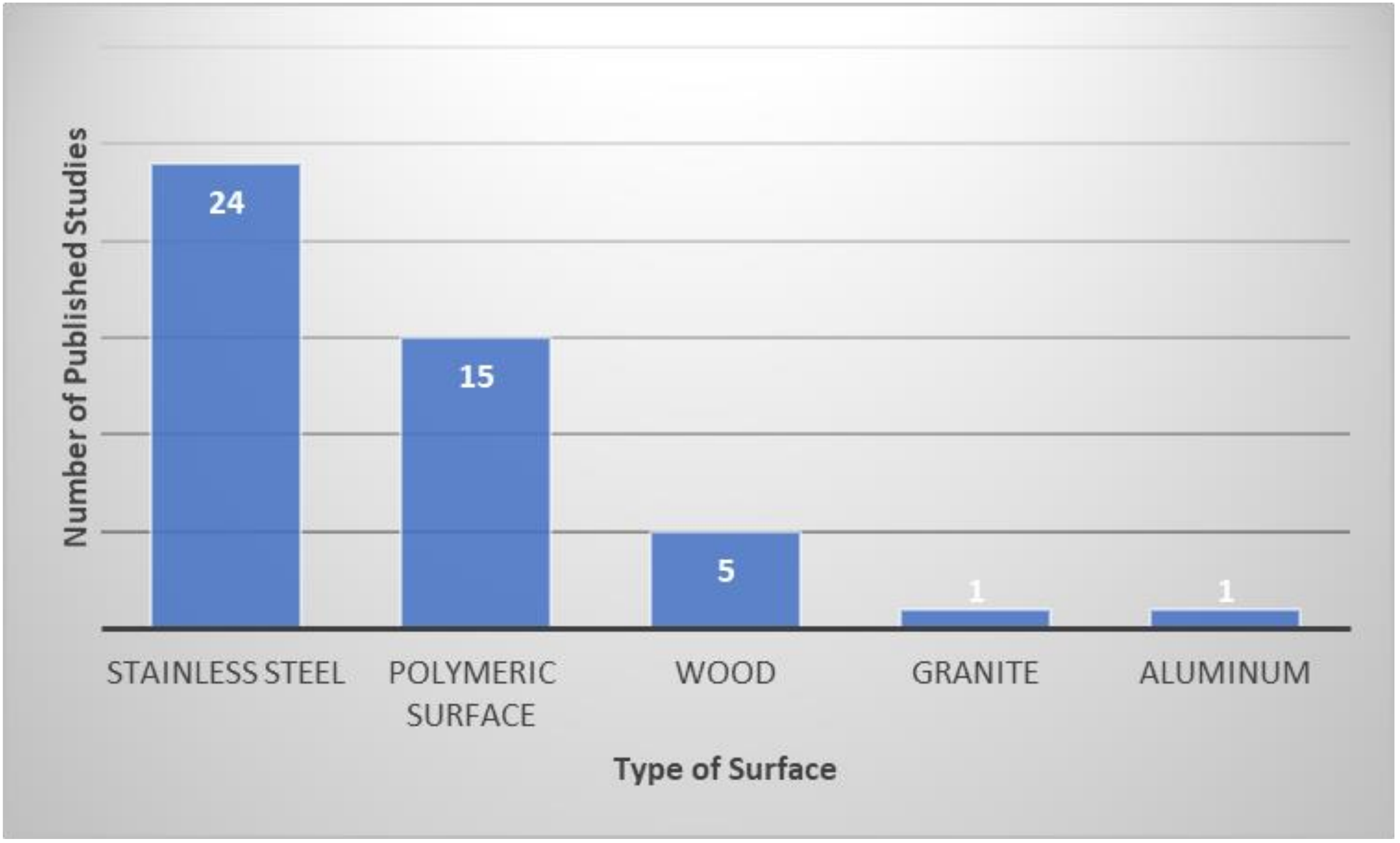
59 studies out of 4,695 possible

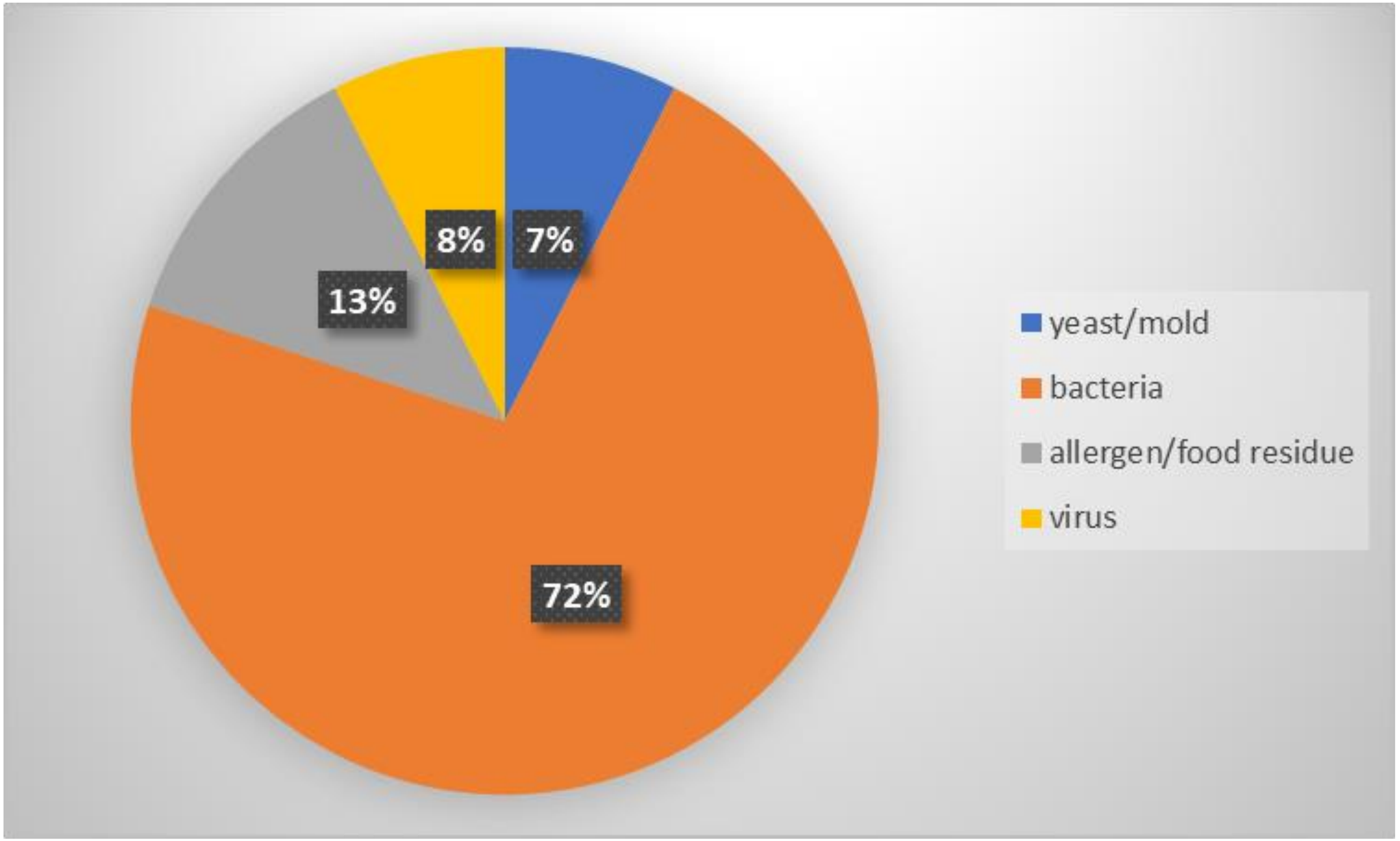
*Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. International Journal of Social Research Methodology, 8(1), 19-32.



Number of published studies dealing with dry cleaning in food industry from 1995 to 2022



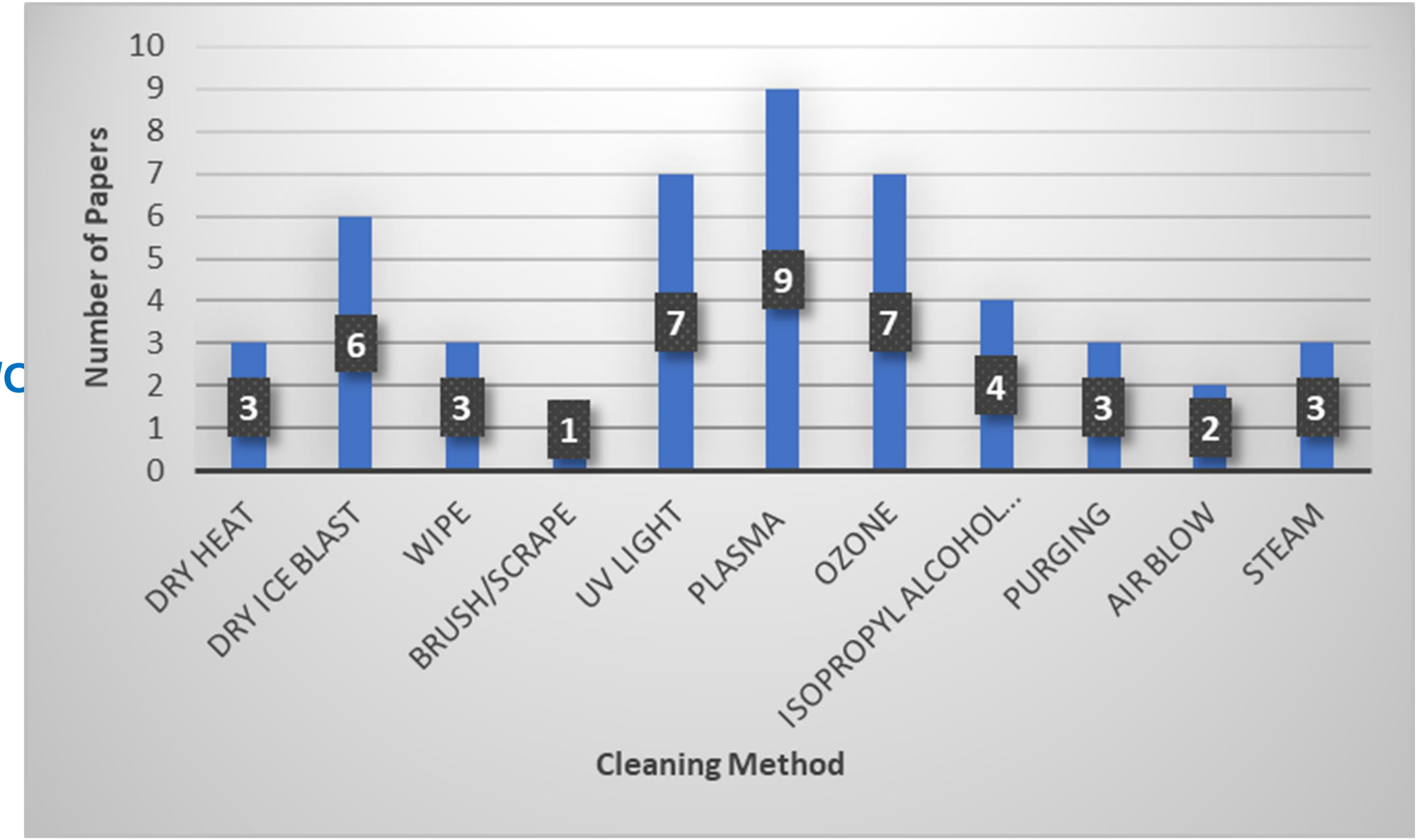
Number of published studies by type of food contact surface in dry cleaning from 1995 to 2022



Percentage of published studies by type of soil in dry cleaning from 1995 to 2022

Types of Dry Cleaning

- Wiping
- Scraping
- Brushing
- Sweeping
- Blowing Air/Plasma/C
- Vacuuming
- Purging/Flushing
- Heating/Steaming
- Dry Ice Blasting
- Lighting



Number of published studies by each type of dry-cleaning method from 1995 to 2022

Observed Levels for Bacterial Soils after Use of Various Dry-Cleaning Methods

Cleaning Method	Soil	Medium	Surface	Observed Levels
Superheated steam	Bacteria	Peanut butter	Aluminum	Approximately 5 $\log_{10}$ reduction at 30 seconds, 125↓↑C and a_w 0.8 and 7 $\log_{10}$ reduction at 15 seconds, 250↓↑C and a_w 0.8
Flushing	Bacteria	Essential oil blend and rice hulls with 10% medium-chain fatty acids	Common steel	Initial surface count of 1.3 CFU/g reduced to 0.1 CFU/cm^2 for rice hulls w/MCFA and 0.0 CFU/cm^2 for essential oil blend
Dry ice blasting	Bacteria		Tile, wood, PC, PE and metal	Remaining CFU (% of initial CFU) ranged from 2% to 14%
UV light	Bacteria		Stainless steel	>5 $\log_{10}$ CFU reduction

Observed Levels for Fungal Soils after Use of Various Dry-Cleaning Methods

Cleaning Method	Soil	Medium	Surface	Observed Levels
Gaseous ozone	Bacteria and yeasts	Red wine	Stainless steel	<10 CFU/mL for bacteria; 2.0-3.5 $\log_{10}$ CFU/mL for yeasts
Cascaded dielectric barrier discharge in air	Mold		PET	2.6 $\log_{10}$ reduction
Dry ice blasting	Bacteria and yeasts	Wine	Oak wood	97.8–100% reduction of microbial load

Observed Levels for Allergens and Organic Matter after Use of Various Dry-Cleaning Methods

Cleaning Method	Soil	Medium	Surface	Observed Levels
Wiping	Allergen	Peanut-, milk- and egg-containing foods	Textured PE, stainless steel and maple wood	LOD of LFD: 2 µg of peanut per 100 cm^2; 20 µg milk per 100 cm^2; 10 µg egg per 100 cm^2
Brushing and scraping	Allergen	Wheat flour and non-fat dry milk powder	Stainless steel	Two to four passes of the brush or scraper were necessary to achieve the “clean state”
Dry vapor steam cleaning	Organic matter		Stainless steel	Visual inspection of cleaned surface showed uniform removal with no evidence of visible contamination on the surface

CLEAN – At what point does a piece of equipment or system become <u>clean</u>?

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Reality of the Situation

- It is not the intent of the FDA (*USDA also*?) to set acceptance specifications or methods for determining whether a cleaning process is validated
- Rationale for any limits of residual product and/or soil established should be logically based on the manufacturer's knowledge of the materials involved and be practical, achievable, and verifiable
- It is important to define the sensitivity of the analytical methods in order to set reasonable limits
  - ✓limits from the literature
  - ✓analytical detection levels such as 10 PPM
  - ✓biological activity levels such as 1/1000 of the normal therapeutic dose
  - ✓organoleptic levels such as no visible residue
- Understand the manner in which limits have been or are established

Huitt, W.M. 2016. Bioprocessing Piping and Equipment Design: A Companion Guide for the ASME BPE Standard. New York, N.Y: The American Society of Mechanical Engineers.

Dry Cleaning Facts

- Its reputation

  …dry cleaning methods cannot remove all traces of product (including allergens) or destroy microorganisms, including viruses. Sweeping with disposable high-alcohol wipes is the only dry cleaning method that can reduce the number of infectious virus particles on surfaces. *DOI: 10.1111/1541-4337.12899*

- Few studies relating resultant soil levels to dry cleaning methods exist in literature with even fewer conducted at the plant-scale level
- Not all detection methods of soil level are created equal
- Requires more mechanical action and manual labor than wet cleaning??
- Uses less water than wet cleaning and fosters drier working environment
- Can align well with marketing push to make “zero” and “green” claims

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Spot to push for more innovation?

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Be Mindful To…

- Use a combination of cleaning methods
- Be innovative how the methods are integrated
- Not overlook cleaning validation, monitoring and verification
- Keep abreast of changes in levels of detection so soil limits (acceptance criteria) for cleaning can be updated as appropriate
- Seek assistance as needed in setting soil limits (acceptance criteria) per cleaning method
- Facilitate greater understanding of sensitivity of analytical methods used for detecting levels of soil

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