Microbiological profile of food waste amended animal feed using a solar drying process

K. Lasaridi, S. Fortatos, E. Terzis, C. Chroni, M. Kyriakou, K. Abeliotis, F., Galliou, T. Manios,

Food waste, a Greek perspective

- An estimated 430,000 tonnes of food waste is produced annually by businesses and commercial enterprises in Greece.

- Of these, more than 380,000 tonnes come from commercial enterprises (hotels, restaurants, food retail and wholesale, etc.), while about 50,000 tonnes are produced by the food processing industry.

- The hospitality and food service sectors dispose of an estimated **100,000** tonnes of food waste annually, almost 6% of the total food waste generated in Greece and 27% of the food waste generated by the commercial activities and services. Of this, almost **65,000** tonnes comes from hotels, 17% of all the food waste generated by the commercial businesses in Greece.

Selected hotels in the intervention area (Heraklion-Hersonissos)

The food waste source separation scheme

Food waste separate collection from rooms, kitchen, bars and restaurant of the participating hotels

70 litres bins and bags

Road containers of 120 and 240 litres

Temporary storage (cold room)

Waste collection refrigerating vehicle (3 tonnes)

Solar drying/ Pasteurisation Pilot Unit

Microbiological characterisation of food residues

Factors affecting microbial growth in food

a) Intrinsic factors:

These are inherent in the food. They include:

- Hydrogen ion concentration (pH),
- moisture content,
- nutrient content of the food,
- antimicrobial substances ad
- biological structures.

Factors affecting microbial growth in food

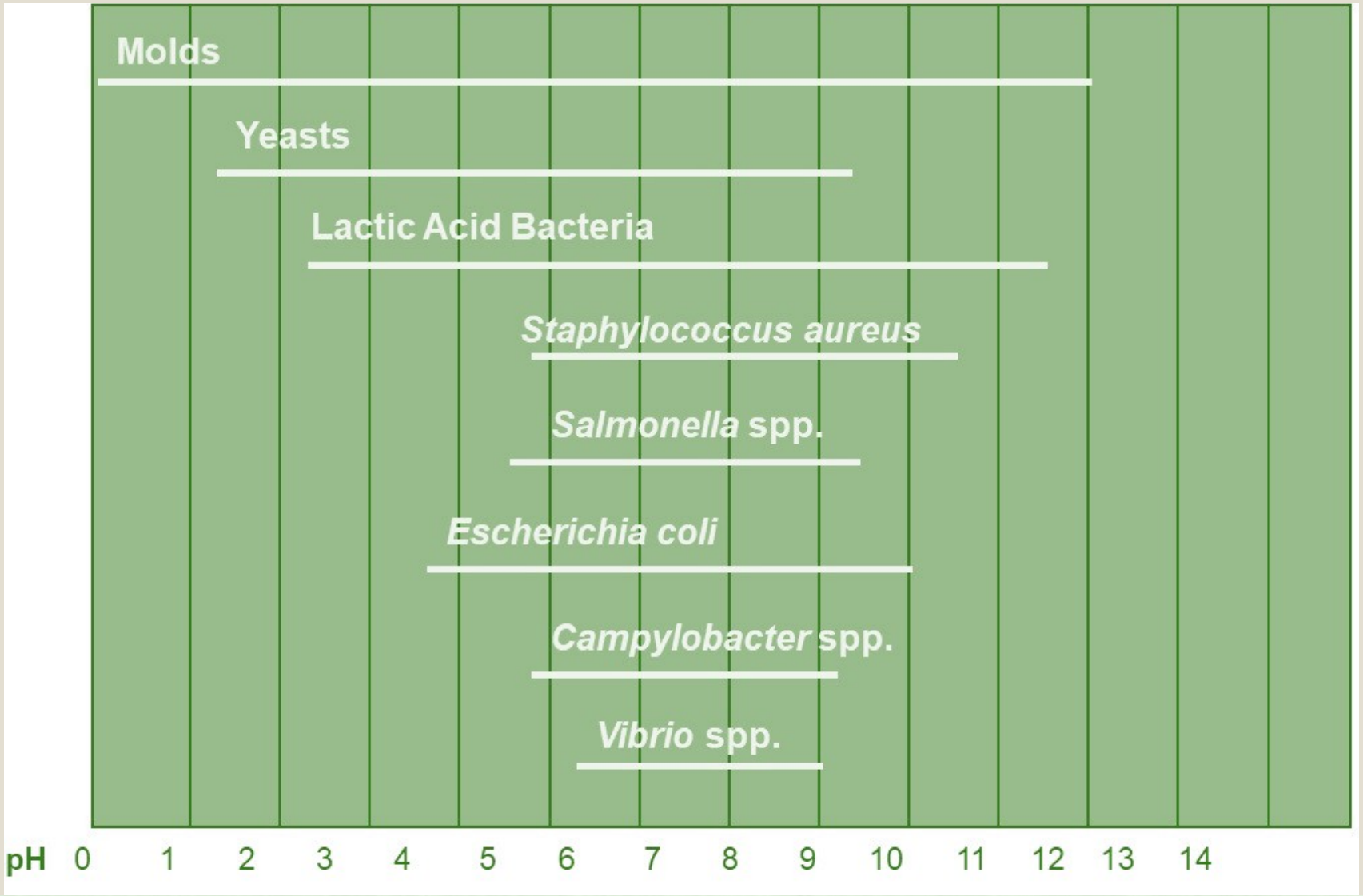
b) Extrinsic factors:

These are factors external to the food that affect microbial growth.

They include:

1. Temperature of storage,
2. Presence and concentration of gases in the environment
3. Relative humidity of food storage environment.

pH – Growth Range in Foods



Moisture content

(a) The effect of moisture is in terms of water activity: -the amount of free water in a food medium.

(b) The amount of free water is important for growth of microorganisms.

(c) If there is lack of this free water microorganisms will not grow.

(d) Water activity is defined as the vapour pressure of a food substance to that of water (water activity = 1) at the same temperature.

$Aw = VP_{Food} / VP_{Water}$

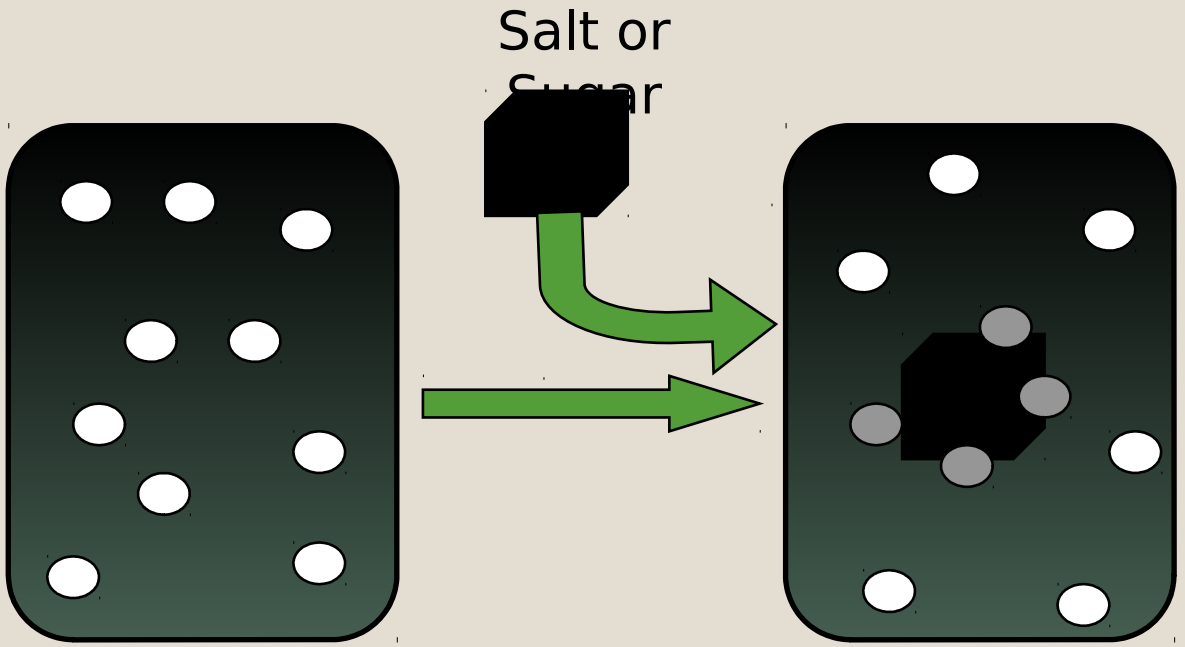
e) Food products have a water activity of less than 1.0.

f) A saturated salt solution has a water activity of 0.75.

g) Salting and drying reduces the water activity of a food product.

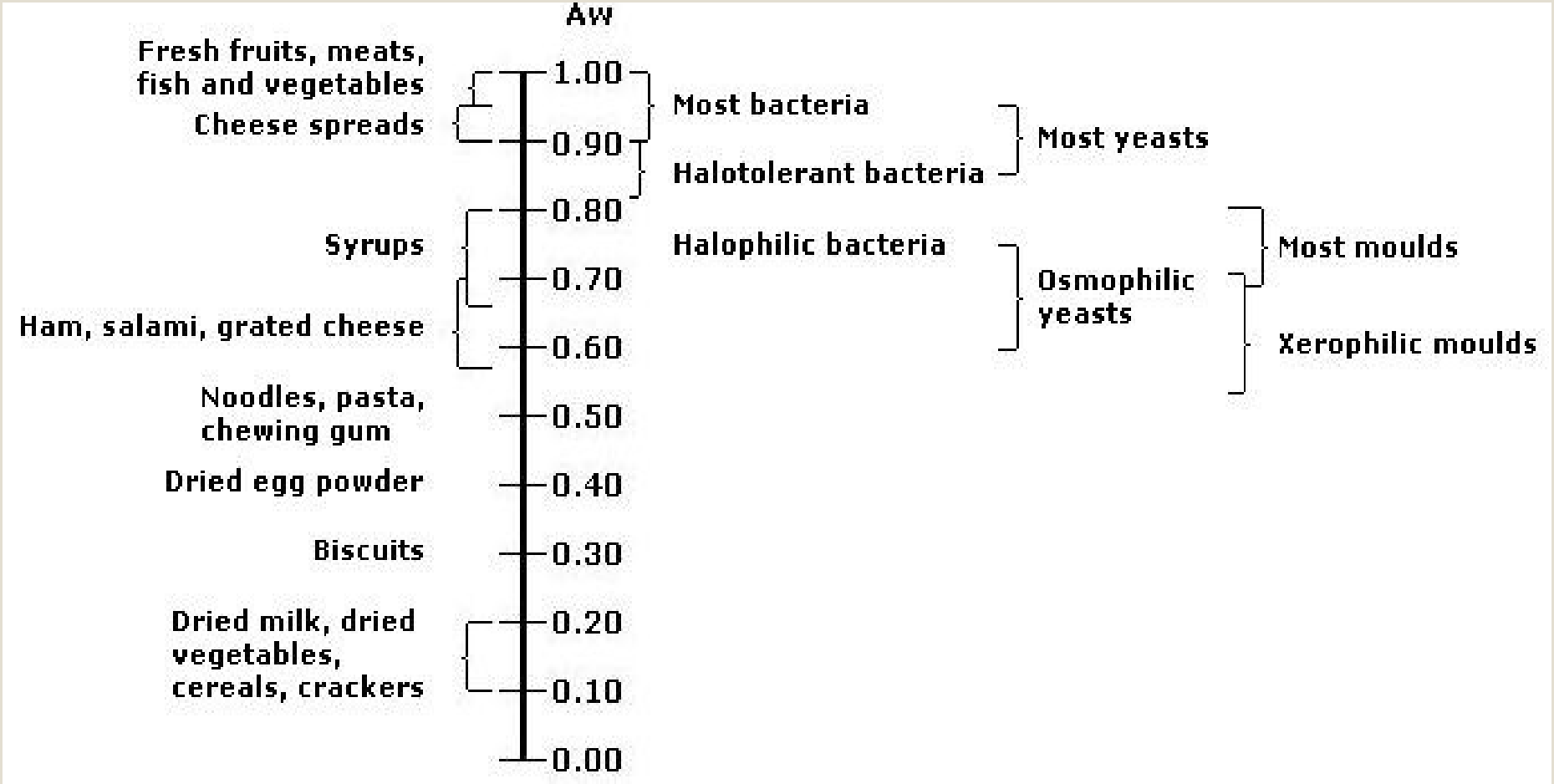
Water Activity

- ✓ A_w is affected by the presence of solutes (sugars and salts)



- ✓ Lowering a_w will reduce the ability for microorganisms to grow

Water Activity: Food and Microbial Growth



Temperature

- The growth of microorganisms is affected by the environmental temperatures.
- Various microorganisms can grow at certain temperatures and not others.
- Bacteria can therefore be divided into the following groups depending upon their optimum tmperature of growth.

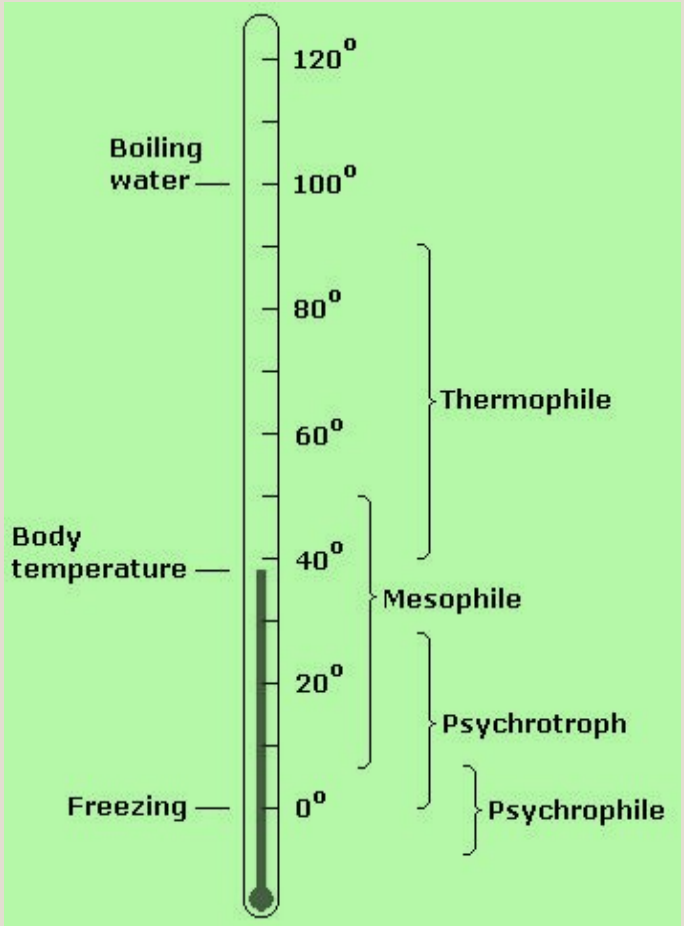
Temperature and Growth

☞PSYCHROPHILE:
Grow from 1-20°C
EXAMPLES: *Pseudomonas*, *Flavobacterium*, *Alcaligenes*

☞PSYCHROTROPHIC:
Grow best at 37°C, but can grow at refrigeration (3-7°C)
EXAMPLE: ***Listeria monocytogenes***

☞MESOPHILE:
Optimum temperature 20-40°C
Group containing most human pathogens
EXAMPLES: ***E. coli***, ***Salmonella***, ***Clostridium botulinum***

☞THERMOPHILE:
Optimum temp >45°C
EXAMPLE: *Bacillus stearothermophilus*



The effect of temperature on microbial growth also depends upon other environmental conditions such as, growth factors in the nutrient medium, pH of the food, and water activity.

Microbiological analysis

- The microbiological characterisation was implemented through Waste Analysis Campaigns (WACs) prior to solar drying/ pasteurisation. The first waste collection and analysis campaign (compositional analysis and microbiological investigation) of the project took place during Autumn 2017 and another one followed in Spring/ Summer 2018 (May/June 2018). In Summer 2018 (July/ August), the third waste analysis campaign took place. The fourth and last waste analysis campaign (WAC) took place on the last week of Autumn 2018 (September/ October). During this period food residues from the hotels were collected and the microbiological parameters were determined.

Physicochemical parameters related to microbial growth

Parameters	Unit	Mean (±s)	Minimum	Maximum
Moisture	% w/w	77.30 (±5.19)	69.98	84.65
Density	Kg m^{-3}	569.3 (±48.8)	518.5	638.2
Water activity	-	0.78 (±0.03)	0.74	0.82
pH	-	4.85 (±0.23)	4.60	5.20
Material's Temperature during drying	°C	47.4 (±6.37)	37	54

Microbiological parameters

	Total *Coliforms*	*E. coli*	*Salmonella spp.*	*Yeast*
	CFU/g.dw (±STDEV)	CFU/g dw (± STDEV)	MPN/100ml	CFU/g.dw (±STDEV)
Autumn 2017	5.22×10^{6} ($\pm5.98\times10^{5}$)	2.90×10^{3} ($\pm1.85\times10^{3}$)	N.D.	-
Spring/ Summer 2018	2.90×10^{3} ($\pm1.85\times10^{3}$)	5.74×10^{3} ($\pm1.37\times10^{3}$)	N.D.	8.35×10^{7} ($\pm6.0\times10^{6}$)
Summer 2018	4.53×10^{6} ($\pm1.80\times10^{6}$)	1.58×10^{3} ($\pm2.24\times10^{3}$)	N.D.	5.83×10^{6} ($\pm4.40\times10^{6}$)
Autumn 2018	9.57×10^{6} ($\pm1.42\times10^{6}$)	1.09×10^{4} ($\pm2.73\times10^{3}$)	N.D.	1.42×10^{7} ($\pm3.64\times10^{5}$)

N.D. = Not Detected
CFU = Colony Forming Units
MPN = Most Probable Number

Microbiological parameters- Drying

	E. Coli	Salmonella spp.	Listeria spp.	Listeria monocytogenes	Clostridium perfingens	Staphylococcus aureus
	CFU/g (d.w.) (±s)	MPN/100ml (±s)	CFU/g (d.w.) (±s)	CFU/g (d.w.) (±s)	CFU/g (d.w.) (±s)	CFU/g (d.w.) (±s)
Raw matter	4.86×10^{6} ($\pm4.65\times0^{6}$)	N.D.	D	D	2.29×10^{4} ($\pm2.55\times10^{3}$)	3.94×10^{5} ($\pm1.80\times10^{5}$)
35 °C	5.83×10^{6} ($\pm4.13\times0^{6}$)	N.D.	D	D	3.39×10^{3} ($\pm9.03\times10$)	D
45 °C	N.D	N.D.	D	D	2.09×10^{2} ($\pm5.02\times10$)	D
55 °C	N.D.	N.D.	N.D.	N.D.	B.D.L.	B.D.L.
65 °C	N.D.	N.D.	N.D.	N.D.	B.D.L.	B.D.L.

BDL = Below Detection Limit; D = Detected; N.D. = Not Detected

Main findings

Microbiological analyses followed the gradual implementation of the pilot scheme.

- ✓ Absence of Salmonella spp., it is observed in all samples.
- ✓ The suspected presence of Listeria spp. and Listeria monocytogenes was not confirmed by biochemical analyses API, thus both indicators conforming to the regulation EC No.2073/2005.
- ✓ The hygiene indicators of E. Coli and Total Coliforms, despite the relatively small population, show unsatisfactory hygiene conditions of the raw material, probably due to inappropriate handling before the transportation and the natural microflora of the mixed raw material.

Main findings

The periodical appearance of Staphylococcus aureus indicates contamination from human handling. The presence of thermo-resistance Clostridium perfingens in the raw material prove faecal contamination and indicates a potential of further contamination on the dried products, as it is difficult to be treated only with heat treatment. Moreover, the presence of moulds and yeast, suggesting that the raw material has already entered the spoilage level.