Technology and Sustainable Development

Sustainability assessment of Food And Beverage packaging

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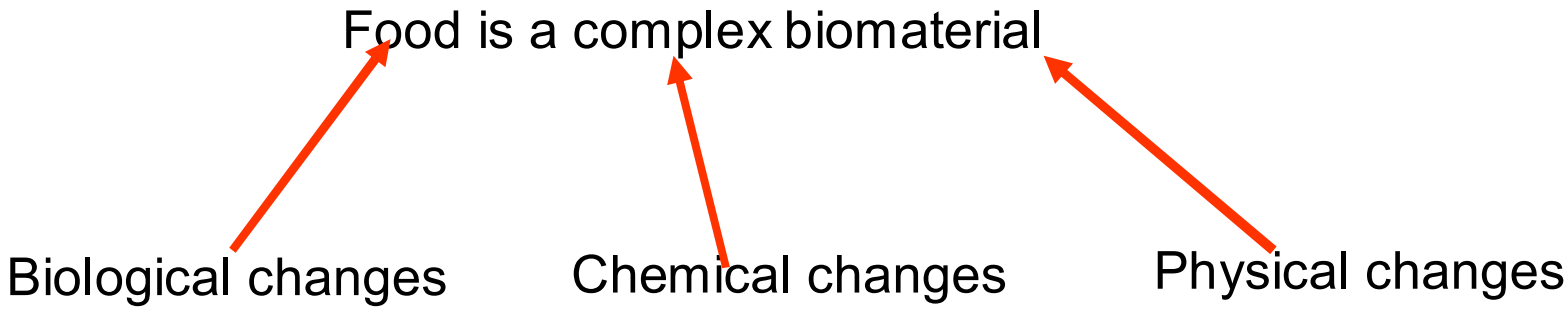
Layout

- Introduction about packaging
- What led to it ?
- Societal change due to use of food packaging, and misuses
- Sustainability in this context
- Morphology
- System Layout
- Simulation and results
- Conclusion



Food quality refers to the degree to which a food meets expectations including ***sensory characteristics*** (taste, odor, texture, and appearance), nutritional profile, convenience, storage shelf life, safety, and other attributes related to product acceptance

The challenge to retain food quality

Purpose of packaging

- Vital
- Essential
- Desirable

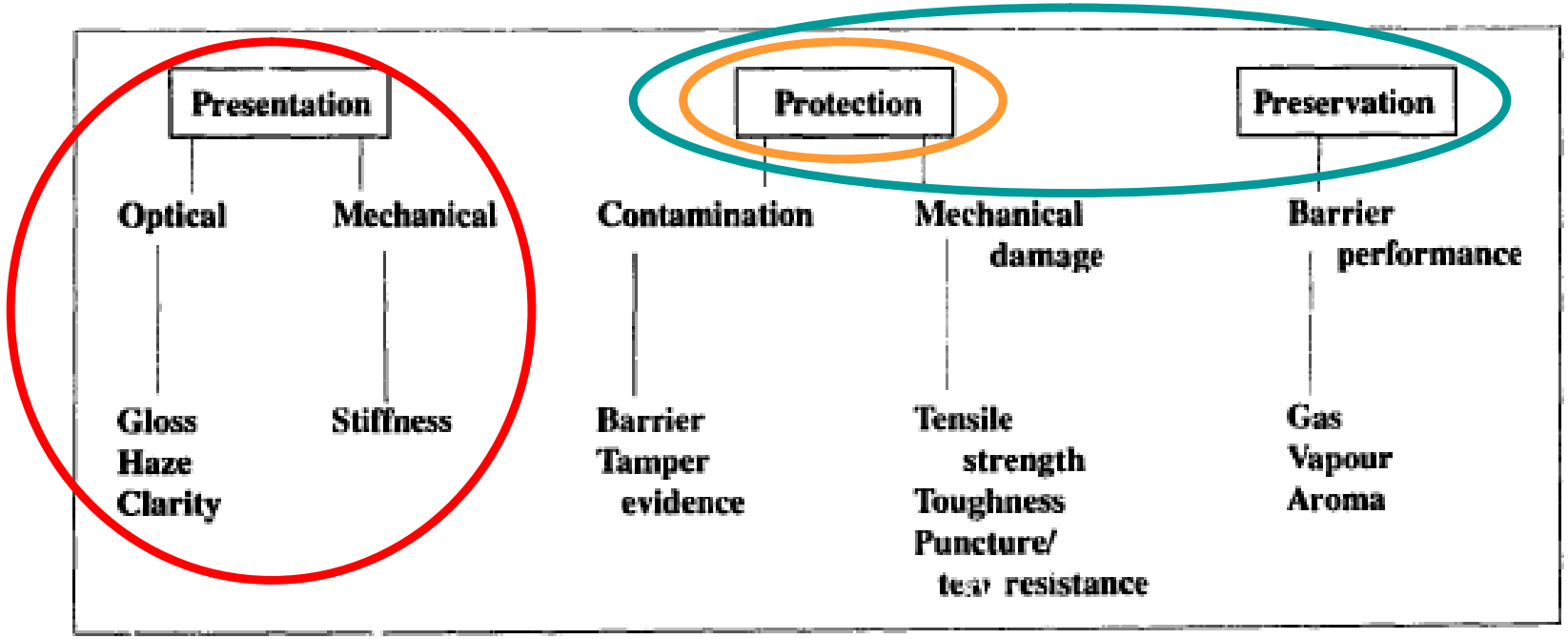
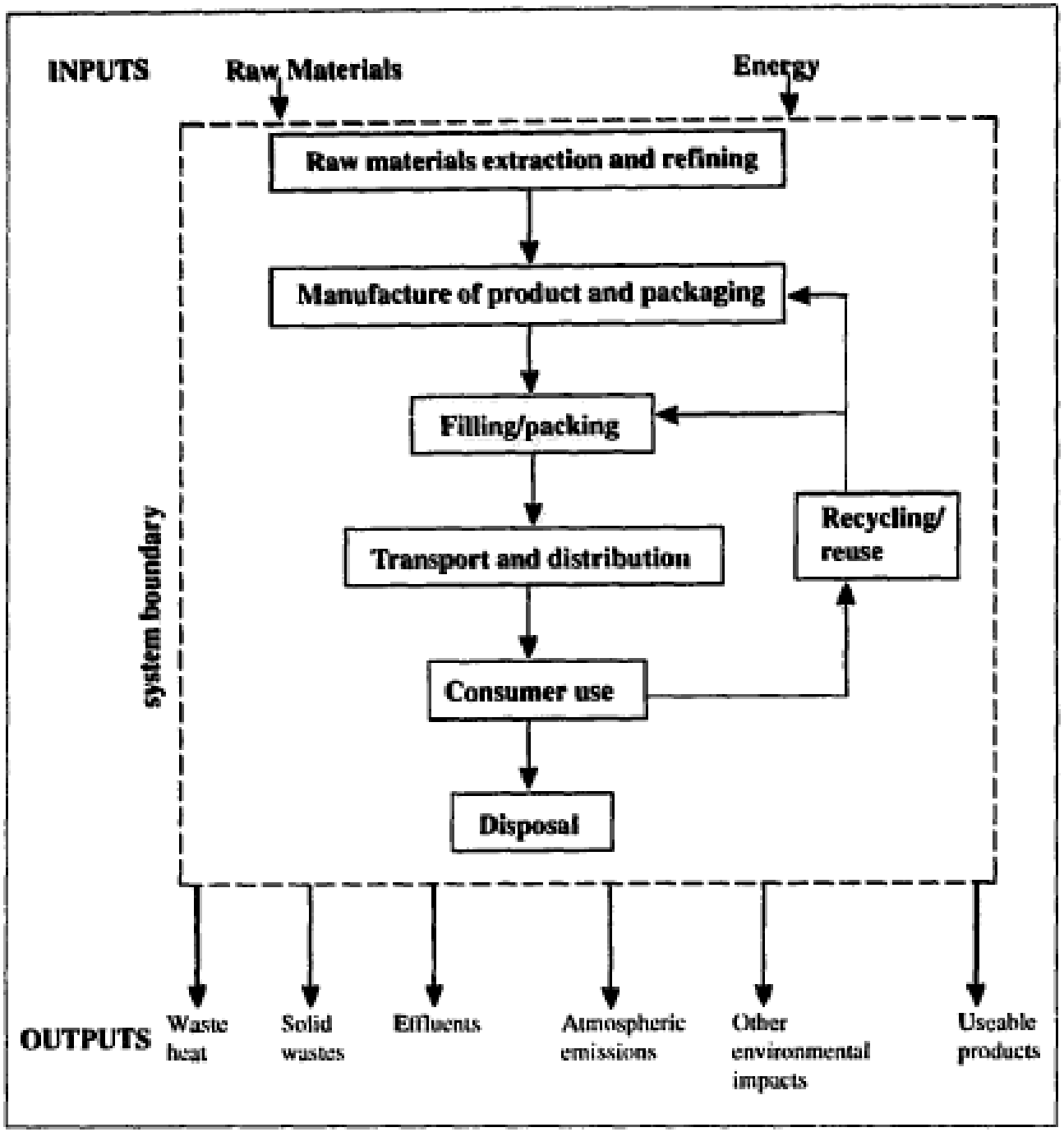


Fig. 1

The three 'P's of packaging: presentation, protection and preservation.

Factors for evolution to current state

- Health consciousness (nutrient and additive contents)
- Family size/singles (different portions)
- Economy (various sizes, quality levels)
- Mobility (convenience items)
- Labeling requirements (contents and directions)
- Available equipment (products for the freezer or microwave)
- Time and convenience to purchase and use
- Consumerism (consumer complaints have the highest influence on pharmaceutical and health-related products)
- Customs and social habits (beverage packaging)
- Environmental concerns (reduced, reusable, recyclable packaging and recovery as energy)



The packaging chain

Packaging and production process

- **Water use – extensive**

  10% reduction in the use of water by the food industry across the UK would save 43 mega litres of water a day, or 1% of all industrial use.
- **Energy use - extensive**

  about 14% of energy consumption by UK businesses and 7 million tonnes of carbon emissions per year.

- **Degradation of biodiversity.**

- **Contamination of soil and water**

  Children, pregnant women and the unborn are thought to be most susceptible to these negative health effects

  A study of almost 2,000 wells across the country showed that 9 percent of domestic wells and 2 percent of public-supply wells had nitrate concentrations in excess of the EPA's maximum contaminant level.

  Nitrate poisoning can cause dangerously low blood-oxygen levels in babies (or blue-baby syndrome), spontaneous abortions, and possibly cancer

Table 3. Equivalent Carbon emissions based on energy source and amount

Raw materials preparation					PJ	Carbon emissions coeff ktC	tC
debarking	8.5	kWh	elec		2.36E-09	1.15E-07	1.15E-04
conveyor	30.3	kWh	elec		8.42E-09	4.08E-07	4.08E-04
Pulping							
mechanical	1650	kWh	elec		assume chemical pulping only		
chemical	4.4	GJ/t steam			0.0000044	0	0
	406	elec			1.13E-07	5.47E-06	5.47E-03
recovery boiler	1.1	GJ/t	-10	GJ/t reusable heat	0.0000011	5.34E-05	5.34E-02
	58	elec	-17	GJ/t reusable heat	1.61E-08	7.81E-07	7.81E-04
lime kiln	2.3	GJ/t	oil/gas		0.0000023	0.00004692	0.04692
	15	kWh/t	elec		4.17E-09	2.02E-07	2.02E-04
bleaching	4.3	GJ/t	steam		0.0000043	0	0
	159	kWh/t	elec		4.42E-08	2.14E-06	2.14E-03
Papermaking							
stock prep	274	kwh/t	elec		7.61E-08	3.69E-06	3.69E-03
	0.7	GJ/t	steam		0.0000007	0	0
press	238	kwh/t	elec		6.61E-08	3.21E-06	3.21E-03

Table 1. Summary of energy usage for paper production process

Raw materials preparation				
debarking	8.5	kWh/t	elec	
conveyor	30.3	kWh/t	elec	
Pulping				
mechanical	1650	kWh/t	elec	
chemical	4.4	GJ/t	steam	
	406	kWh/t	Elec	
recovery boiler	1.1	GJ/t	-10	GJ/t reusable heat
	58	Elec	-17	GJ/t reusable heat
lime kiln	2.3	GJ/t	oil/gas	
	15	kWh/t	Elec	
bleaching	4.3	GJ/t	steam	
	159	kWh/t	elec	
Papermaking				
stock prep	274	kwh/t	elec	
	0.7	GJ/t	steam	
Pressing	238	kwh/t	elec	
drying	10	GJ/t	steam	
	21	kwh/t	elec	

Effects of dioxines

- Dioxin is almost insoluble in water.
- Instead, it has a high affinity for lipids.
- Dioxin tends to stick to organic matter, such as ash, leaves, and soil.
- Since dioxin binds strongly to soil, it does not easily contaminate the water supply.
- When dioxin is in water, it sticks to organic matter or even plankton.

Source

- Waste incineration
- Leaching from packaging material
- Paper bleaching

Effects –

- Cancerous
- Non cancerous
- Indicated by serum levels in body

- *concept of toxic equivalency factors (TEFs) has been developed and introduced to facilitate risk assessment and regulatory control of exposure to these mixtures.*
- *toxic equivalents concentration (TEQs) contributed by all dioxin-like congeners in the mixture using the following equation which assumes dose additivity:*

$$TEQ = \sum (PCDD_i \times TEF_i) + \sum (PCDF_i \times TEF_i) + \sum (PCB_i \times TEF_i) + ..$$

Supply chain

Outreach

- Variety of food available throughout the globe
- The 2006 E coli outbreak is a good example of this, as contaminated spinach from a single region in California managed to sicken people in 26 states.

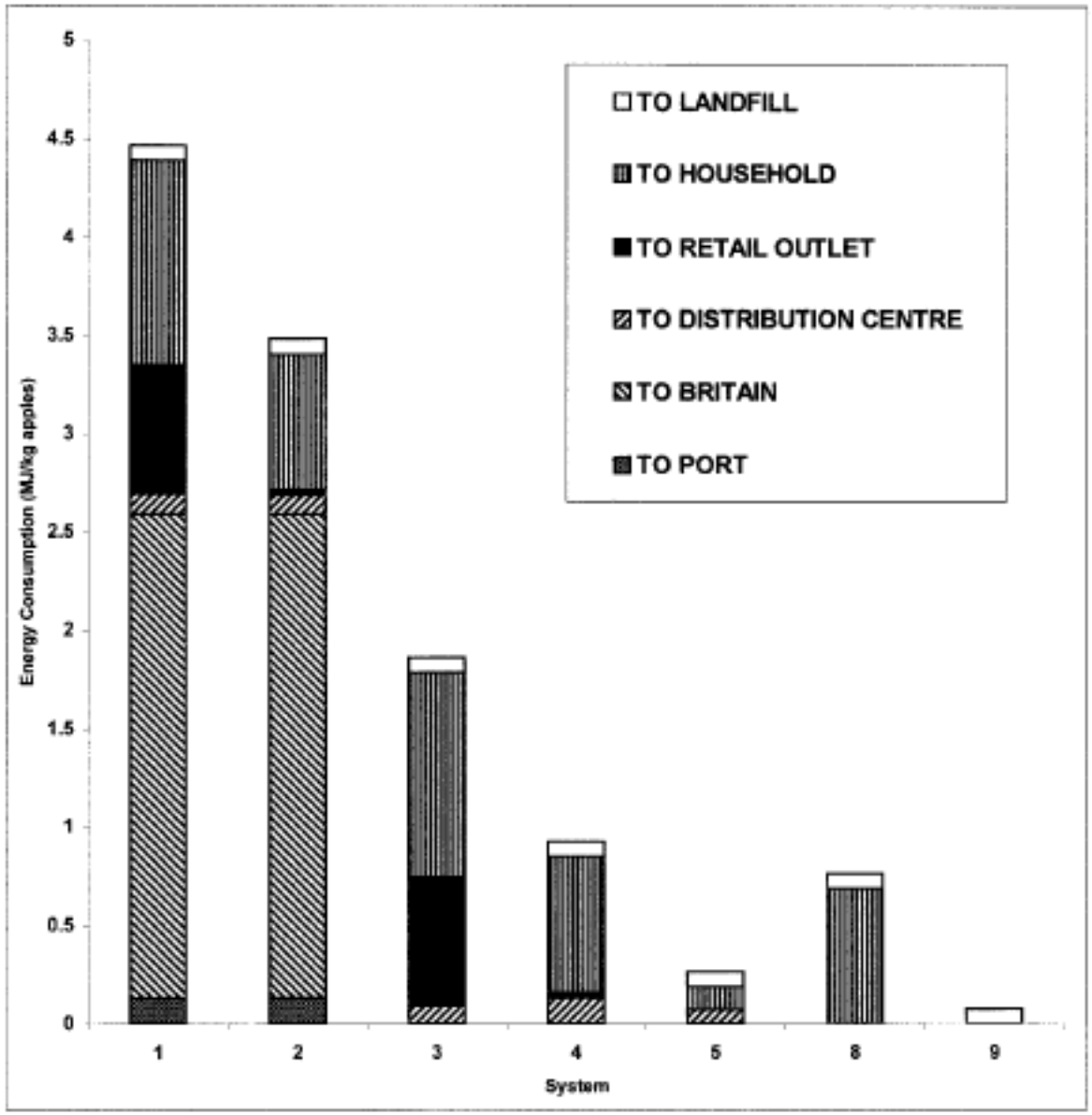
Monetary Benefits

- Multiple links increase the cost to end user and reduce the share of initial point

Distance travelled

- In England, where over 80% of food is now purchased in Supermarkets, the contents of a typical supermarket trolley of food has traveled more than 3,000 kilometers before it reaches the display shelves. This contributes greatly to planetary pollution and depleted food quality.

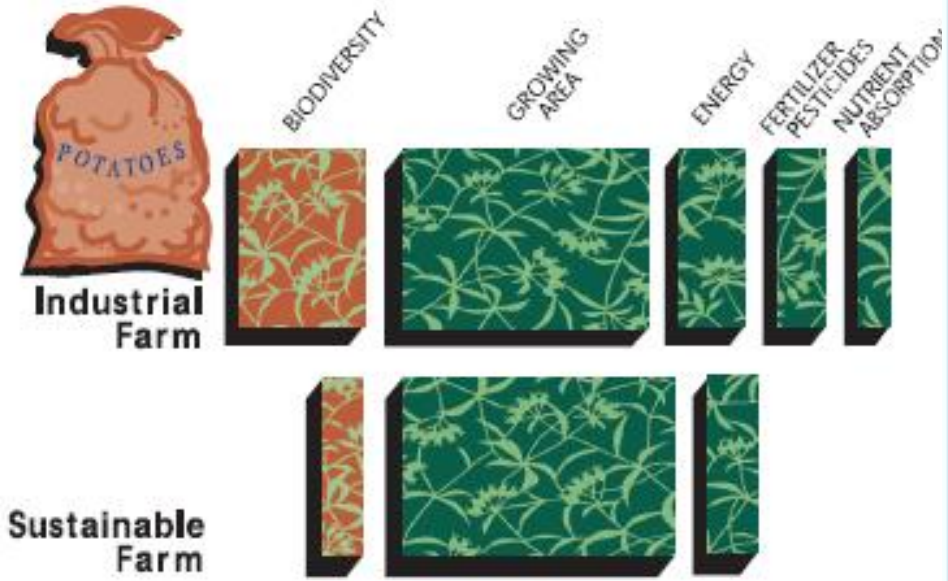
- In 2001, food typically traveled 1,500 – 3,000 miles from farm to plate, an increase of up to 25% since 1980



KEY

System	Description of supply chain
1	Imported from the USA, marketed at a supermarket, shopping trip of 3 km in a medium sized car
2	Imported from the USA, marketed at a street market, shopping trip of 2 km in a medium sized car
3	UK sourced, marketed at a supermarket, shopping trip of 3 km in a medium sized car
4	UK sourced, marketed at a street market, shopping trip of 2 km in a medium sized car
5	Sourced locally, home delivery
8	Sourced locally, picked up in a journey of 2 km in a medium sized car
9	Homegrown

Figure 4. Average transport energy consumption for apple distribution to Brixton. Based upon Jones (2002).



Footprint

	Eating from a supermarket in Chicago (via a major distribution terminal)	Eating locally in San Francisco (bought at the farmers market)
Apples	1,555 miles	105 miles
Tomatoes	1,369 miles	117 miles
Grapes	2,143 miles	151 miles
Beans	766 miles	101 miles
Peaches	1,674 miles	184 miles
Winter Squash	781 miles	98 miles
Greens	889 miles	99 miles
Lettuce	2,055 miles	102 miles

Data from a San Francisco farmers market that calculated the average number of food miles traveled by its produce and compared those distances with produce in a Chicago terminal market, where brokers and wholesalers buy produce that has typically traveled long distances to sell to grocery stores and restaurants.[32]

Consumption practices

- More variety introduced in diet.
- If used properly, a much more balanced diet being offered.
- Diet is a factor in the development of cardiovascular diseases
- Research shows for example, that reducing current average levels of salt, fat and sugar in diets in the UK can make a big impact on the estimated cost to the economy of food related ill health of £2.5 billion.
- Leads to lesser wastage of food

Disposal

ACCELERATED PAPER

BIODEGRADABILITY OF SOME FOOD PACKAGING MATERIALS IN SOIL

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Table 1. Codes, descriptions and compositions of test materials and the summary of degradative changes they underwent during 3 months of aerobic exposure in soil*

Code	Same description	Sample composition (%)	Sample carbon (mg)	Conversion to CO_2 (%)	Weight loss (%)	Loss of elongation (%)
PO	Packaging film†	Irradiated polyolefin, 100	211.2	1.5	NA	−33.0
PP-1	Packaging film†	PP, 100	215.0	ND	ND	ND
PP-2	Packaging film†	PP, 100	214.5	ND	ND	ND
PE	Packaging film†	PE, 100	214.7	ND	ND	ND
PVC-1	Produce/mushroom film‡	PVC, 69.5; DOA 23.6; ESO, 6.9	120.5	27.3	26.8	−94.5
PVC-2	Bakery film‡	PVC, 76.5; DOA, 16.0; ESO, 7.5	116.5	19.4	23.2	−92.6
PVC-3	Meat–poultry film‡	PVC, 70.0; DOA, 19.2; ESO, 10.8	122.7	25.4	38.4	−94.0
PVC-4	Meat–poultry film‡	PVC, 72.0; DOA, 22.0; ESO, 6.0	121.4	25.7	27.2	−94.0
PVC-5	Meat–poultry film‡	PVC, 70.0; DOA, 13.6; ESO, 16.0	123.4	18.8	18.4	−92.0
PVC-6	Shrink film‡	PVC, 84.0; DOA, 2.0; ESO, 14.0	108.3	7.3	14.8	−67.0
PVC-7	Shrink film‡	PVC, 70.5; DOA, 8.6; ESO, 16.0	109.9	5.9	9.6	ND
PVC-8	DOP-plasticized film	PVC, 68.5; DOP, 24.8; ESO, 7.0	123.1	9.7	20.8	−15.0
WP	Wax paper†	Fiber, 75; wax, 25	126.0	78.6	NA	NA
BW	Bread wrap†	Fiber and filler, 68.0; wax, 32.0	126.2	76.2	NA	NA
FC	Food carton†	Cardboard, 96.0; PE, 4.0	104.7	81.9	NA	NA
OC	Frozen juice container†	Cardboard, 95; PE, 5.0	110.2	64.2	NA	NA

*All samples were applied at 250 mg in 25 g soil. Abbreviations: NA: not analyzed; ND: not detectable; PO: polyolefin; PP: polypropylene; PE: polyethylene; PVC: polyvinyl chloride; DOA: dioctyl adipate; DOP: dioctyl phthalate.
†Manufacturer not known to us.

Alarming !!

- Packaging represents roughly one-third of municipal waste in the United States.
- 150 billion beverage containers are sold annually in the U.S.
- People in the US throw away 2.5 million plastic bottles every hour and less than 3% are recycled
- In the last decade, Americans wasted 7.1 million tons of cans: enough to manufacture 316,000 Boeing 737 airplanes.
- Had the 50.7 billion cans wasted in 2001been recycled, they could have saved the energy equivalent of 16 million barrels of crude oil--enough energy to generate electricity for 2.7 million U.S. homes for a year.

Morphology

Preservatives
- to prevent bacterial or fungal growth in foods,
- prevent oxidation
- inhibit natural ripening processes

Primary material
- Physical barrier
- Marketing objectives

Additives
- Color and Flavor Additives (Enhancers)
- Color and Flavor preservatives
- Nutritional Additives
- Texture-Improving Additives

Internal Layers

Morphology – primary material

Packaging Material	Advantages	Disadvantages
PAPER AND BOARD	Low cost for a given level of rigidity, and their excellent printability and promotional potential Good environmental image	No barrier to gasses and lose their strength and rigidity when wet Have to be coated and/or laminated with impermeable materials
GLASS	Made from silica	Colour variation and contamination with ceramic particles can cause difficulties during recycling Weight and fragility, and its vulnerability to abrupt temperature fluctuations Requires high initial energy inputs.
STEEL	Readily and cheaply separated	Heavy material with low intrinsic value `
ALUMINIUM	Ideal material for recycling High intrinsic worth, and hence scrap value Recycling does not degrade aluminium Creation of practically closed loop system	Limited
PLASTICS	Economic to recycle Well-developed markets for the products of its recycling such as carpet fibres and fibrefil	Converting it back to its original components by chemical means using hydrolysis or methanolysis

Morphology – additives

Type	Classification	Example / Explaination
Color and Flavor Additives (Enhancers)		extract of the annatto seed, which gives cheese and butter a yellowish color The most commonly used flavor additives are sugars (including dextrose and corn syrups), salt, and spices
Color and Flavor preservatives	Antioxidants Chelating agents. Fat Substitutes Antimicrobials	 Low calories ! Mold inhibitors, such as sodium and calcium propionate, are commonly used in breads and cakes
Nutritional Additives	Fortified foods contain added vitamins and minerals that are not naturally present in the food or that are found only in low levels.	
Texture-Improving Additives	Anticaking agents. Emulsifiers Thickeners Meat tenderizers Dough conditioners	Two common anticaking agents are silicates (used in table salt) and cornstarch (added to sugar). prevent the separation of the oil and water portions of a food product and help maintain a uniform consistency Certain gums also have humectant properties when used in candies.

Health effects of additives

Saccharin

- Discovered in 1879 at Johns Hopkins University, it is a petroleum-based product that has no calories and is 300 times sweeter than sugar.
- In 1977, FDA proposed banning saccharin

Nitrites in meat

- The function of nitrite is threefold: it provides the desirable pink color in these products, adds flavor, and inhibits the bacterium that causes botulism.
- converted in the stomach into nitrites. Nitrites, in turn, react with chemicals called amines to form nitrosamines, which are carcinogens associated with liver cancer in some animals.

Health effects of additives

Plastic	*Common Uses*	*Adverse Health Effects*
Polyvinyl chloride (#3PVC)	Food packaging, plastic wrap, containers for toiletries, cosmetics, crib bumpers, floor tiles, pacifiers, shower curtains, toys, water pipes, garden hoses, auto upholstery, inflatable swimming pools	Can cause cancer, birth defects, genetic changes, chronic bronchitis, ulcers, skin diseases, deafness, vision failure, indigestion, and liver dysfunction
Phthalates (DEHP, DINP, and others)	Softened vinyl products manufactured with phthalates include vinyl clothing, emulsion paint, footwear, printing inks, non-mouthing toys and children's products, product packaging and food wrap, vinyl flooring, blood bags and tubing, IV containers and components, surgical gloves, breathing tubes, general purpose labware, inhalation masks, many other medical devices	Endocrine disruption, linked to asthma, developmental and reporoductive effects. Medical waste with PVC and pthalates is regularly incinerated causing public health effects from the relese of dioxins and mercury, including cancer, birth defects, hormonal changes, declining sperm counts, infertility, endometriosis, and immune system impairment.
Polycarbonate, with Bisphenol A (#7)	Water bottles	Scientists have linked very low doses of bisphenol A exposure to cancers, impaired immune function, early onset of puberty, obesity, diabetes, and hyperactivity, among other problems (Environment California)
Polystyrene	Many food containers for meats, fish, cheeses, yogurt, foam and clear clamshell containers, foam and rigid	Can irritate eyes, nose and throat and can cause dizziness and unconsciousness. Migrates into food and stores in body fat.

Morphology

Volume of storage	Individual consumption	Family consumption			
Dimension	variable				
Usage information	printed on packaging	inside			
Branding and marketing Information dissemination	on packaging	inside			
Brand communication	Shape	Colour	Print		
Dispensing mechanism	Can - open lid n	Hole for straw	Cap	tear	
Sealing mechanism	One time	Multiple use			
Sealing	Seperable and inseperable				
Dispensing	One time	Multiple use			
Mode of display	Flexible	Stiff	Self standing	Lying down	
Grouping	Sachets	independent			
Sealing method	Individual	In group			
Internal coating for contamination prevention					
Material	Glass	Plastic	Paper	Aluminium	Steel
Type of paints and chemicals used	petroleum based	Non petroleum based			
Type of print					
Carrying	Shape	Handle			
Protection from duplicacy	physical	non physical			
leakage proofing(esp incase of beverage)	material	coating			
weight	variable				
Waterproofing	coating	material			
material seperation possible /not	Yes	No			
Additives					
Color and Flavor Additives	Yes	No			
Color and Flavor preservatives	Yes	No			
Nutritional Additives	Yes	No			
Texture-Improving Additives	Yes	No			
Transport packaging	shape	size			
condition control	External required	Internal			
No of layers between food and environment	single	mulitple			
Storage medium	Permanent	Temporary			
		In consumption	Storage		
Biodegradable	Yes	No			
Recyclability	Yes	No			

Food and beverage Packging

Raw material

Manufacturing

Delivery

Consumption

Disposal

Environmental frendliness
Processes and materials involved
Impact on ecology
Water bodies, soil and air

Optimality of content
Quantity
Quality
Toxicity

Quantity of litter
Type pf packaging-
One time /reusable

Agricultural practices-
Produce
Import
Export

Economics
Per unit cost and variation with scale

Effectiveness of packaging
Microbial contamination
Permeation of microorganism
Moisture sensitivity

Packaging material
Organic /synthetic

Time period of usage

Contamination
Soil
Air
Water

Consistency of contents

Health of individuals

Consumption pattern
Life of food required

Sustainability -context

Sustainable packaging:

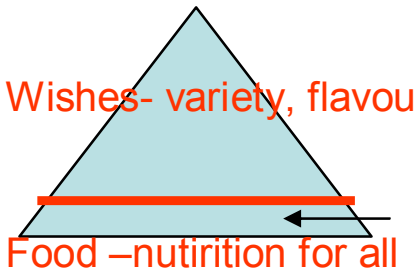
- Is beneficial, safe and healthy for individuals and communities throughout its life cycle;
- Meets market criteria for performance and cost;
- Is sourced, manufactured, transported and recycled using renewable energy;
- Maximizes the use of renewable or recycled source materials;
- Is manufactured using clean production technologies and best practices;
- Is made from materials healthy in all probable end-of-life scenarios;
- Is physically designed to optimize materials and energy; and
- Is effectively recovered and utilized in biological and/or industrial cradle-to-cradle cycles

Sustainable Packaging Coalition (http://www.sustainablepackaging.org/).

More holistic

carrying capacity of
•community's natural resources
•ecosystem services
•aesthetic qualities
•community's human capital

Should not be drastically affected



Society

Consumers	Health state	
	number of working women	
	Income	
practices	ratio pf packaged to normal food consumed per capita	
	MSW generated per capita	
	wastage of food	
	Variety of food stuff consumed	
	percentage of waste as litter	
Food	nutritional Value of food	
	freshness of food	
	Quanitity of packaged food	
	Shelf life	
	Hygiene of food (preventing contamination)	
	distance travelled between point of produce and consumption	
Employees	Processing industry	Health hazards
	Transportation industry	dioxine exposure
	Production of food	
	Preservation	Quanitity of preservatives used
people around the industry	Health state	
	food consumed by them because of ecological conditions around the industry	
	Prosperity and standard of living	
animals surrounding disposal area	Health state	
	toxic contents inside body	
Packaging industry		
	petroleum products consumed per unit	
	energy consumed	

Resources

TEQ

bioderadability of packaging material (life of packaging material)

percentage of waste recycled

Soil contamination

Use of paints

Co2 emissions per unit packaging material+entire supply chain

dioxines released into air

discharge of toxic chemicals to water

Biodieversity

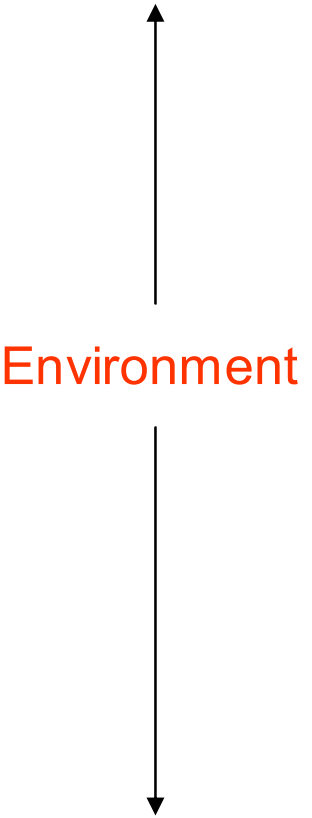
geographic outreach of produced food

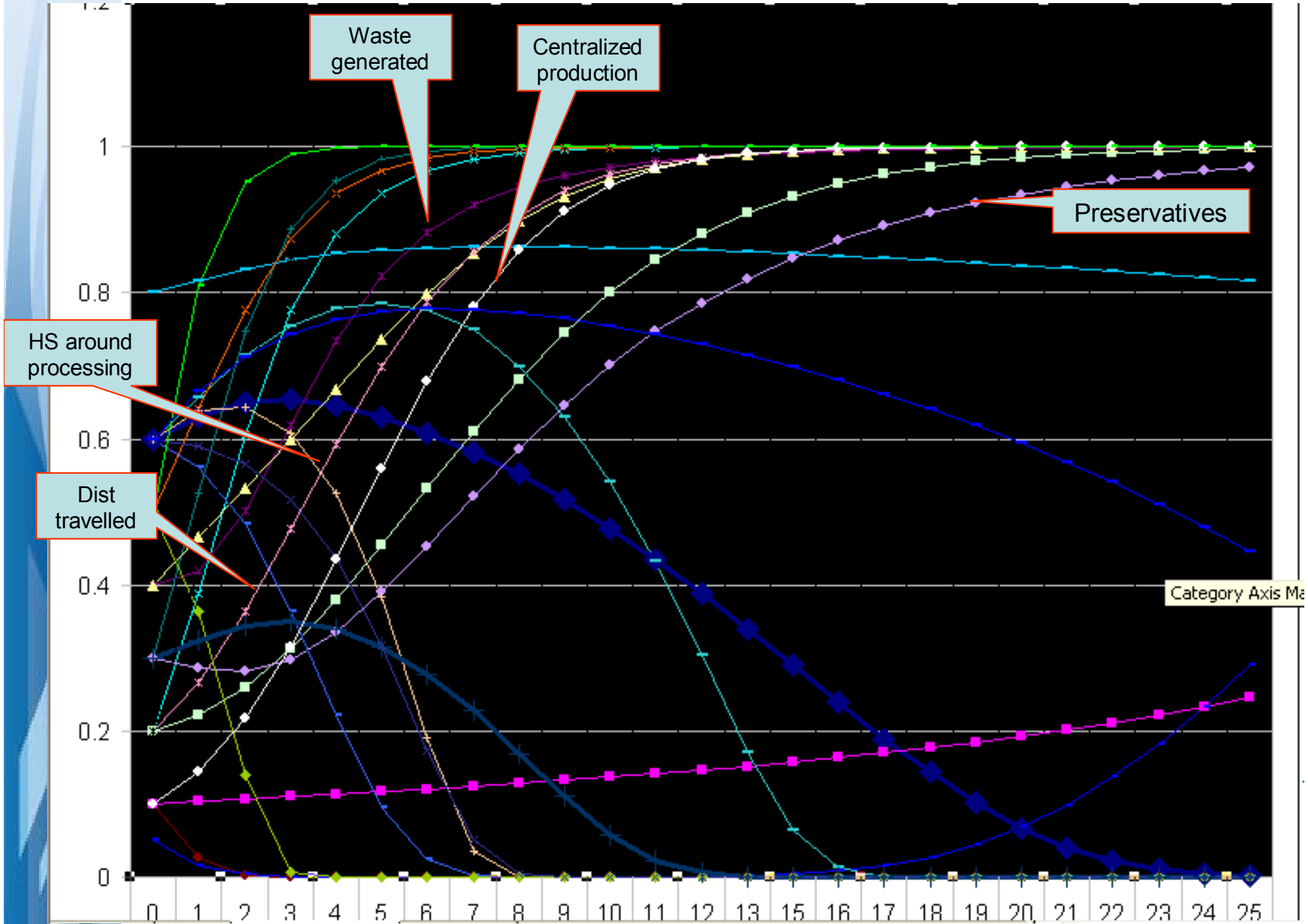
Centralized production

Marketing impetus

Ratio of retail outlets to local sellers

Response to Emergency




Waste generated
Centralized production
Preservatives
HS around processing
Dist travelled
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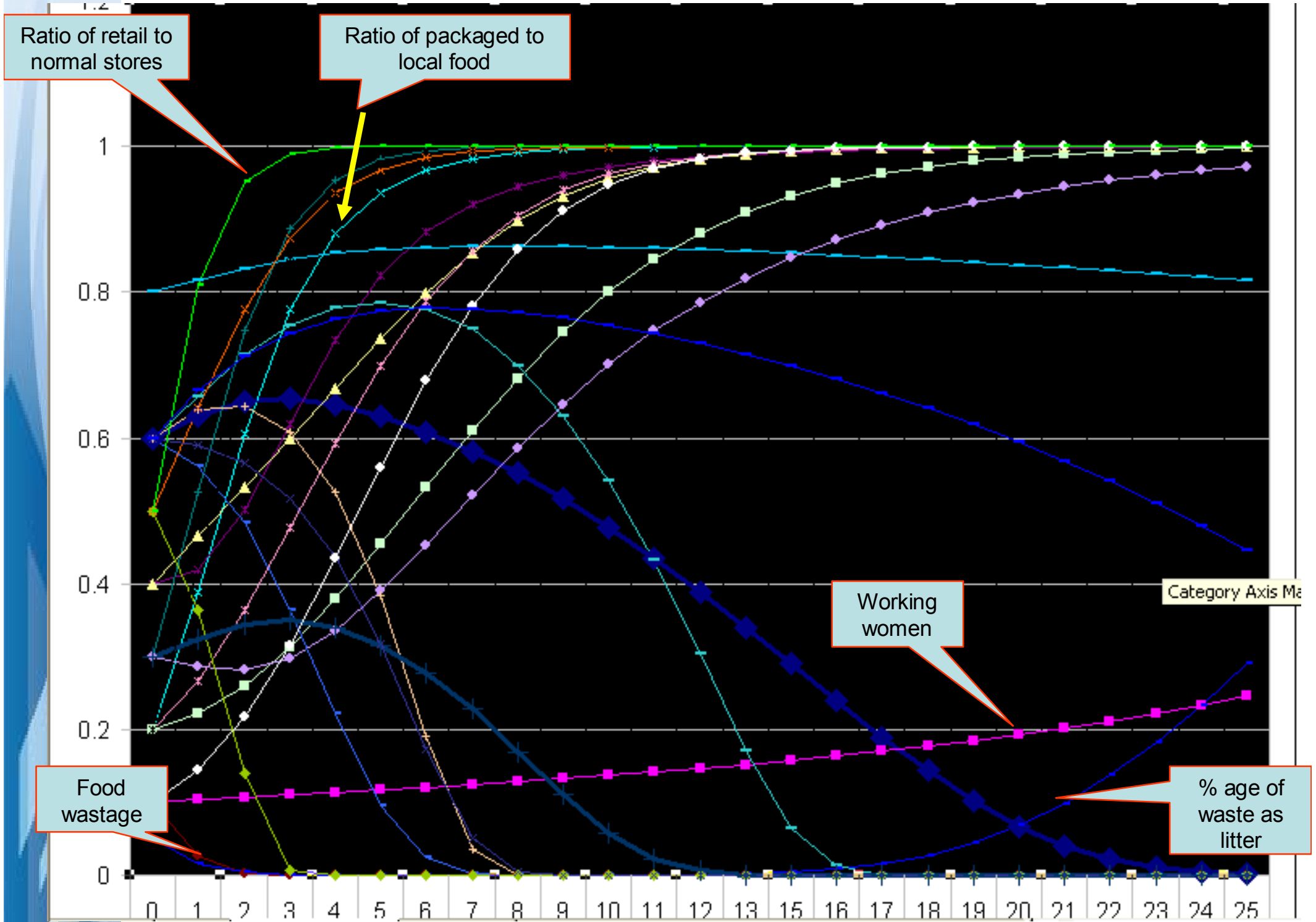
0 1 2 3 4 5 6 7 8 9 10 11 12 13 15 16 17 18 19 20 21 22 23 24 25
Category Axis Ma


Ratio of retail to normal stores
Ratio of packaged to local food
Working women
Food wastage
% age of waste as litter
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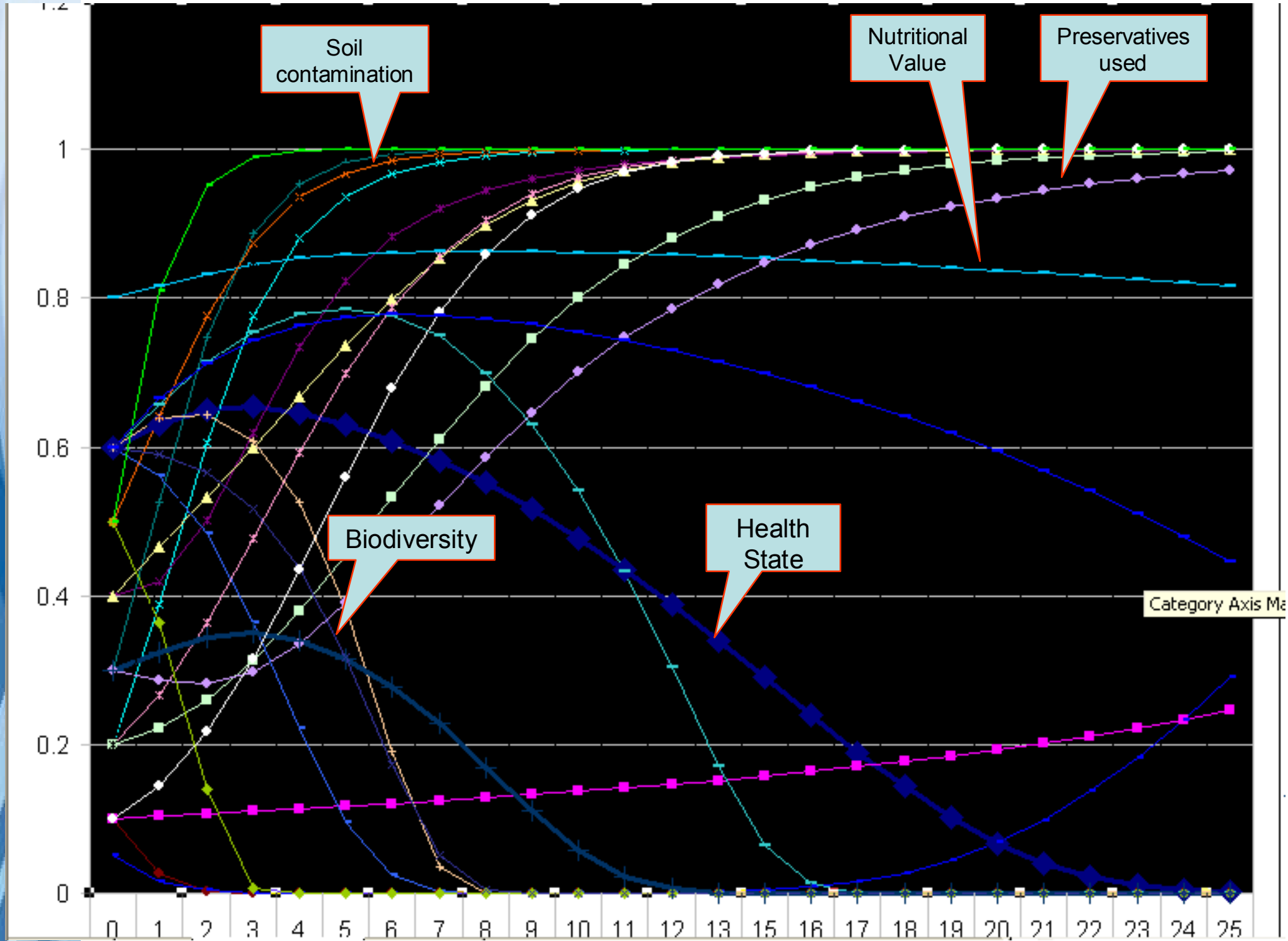
Soil contamination
Nutritional Value
Preservatives used
Biodiversity
Health State
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Recommendations & Conclusion

- The current consumption pattern – which goes beyond serving the needs and is focusing on wishes is unsustainable.
- Market forces have to be controlled.

- Interventions

Products that change the way we consume, buy, dispose.
Reduce unnecessary activities, to as much extent as possible.

- Stimuli

Why take the longer route – home grown or locally grown
Consumption practices need change
Think before you eat !
Vicious circle

OPTIMUM LEVEL can be decided only by the consumer

Think better ,eat healthy