Evaluating the life cycle benefits of nanoenabled polymers through food waste avoided

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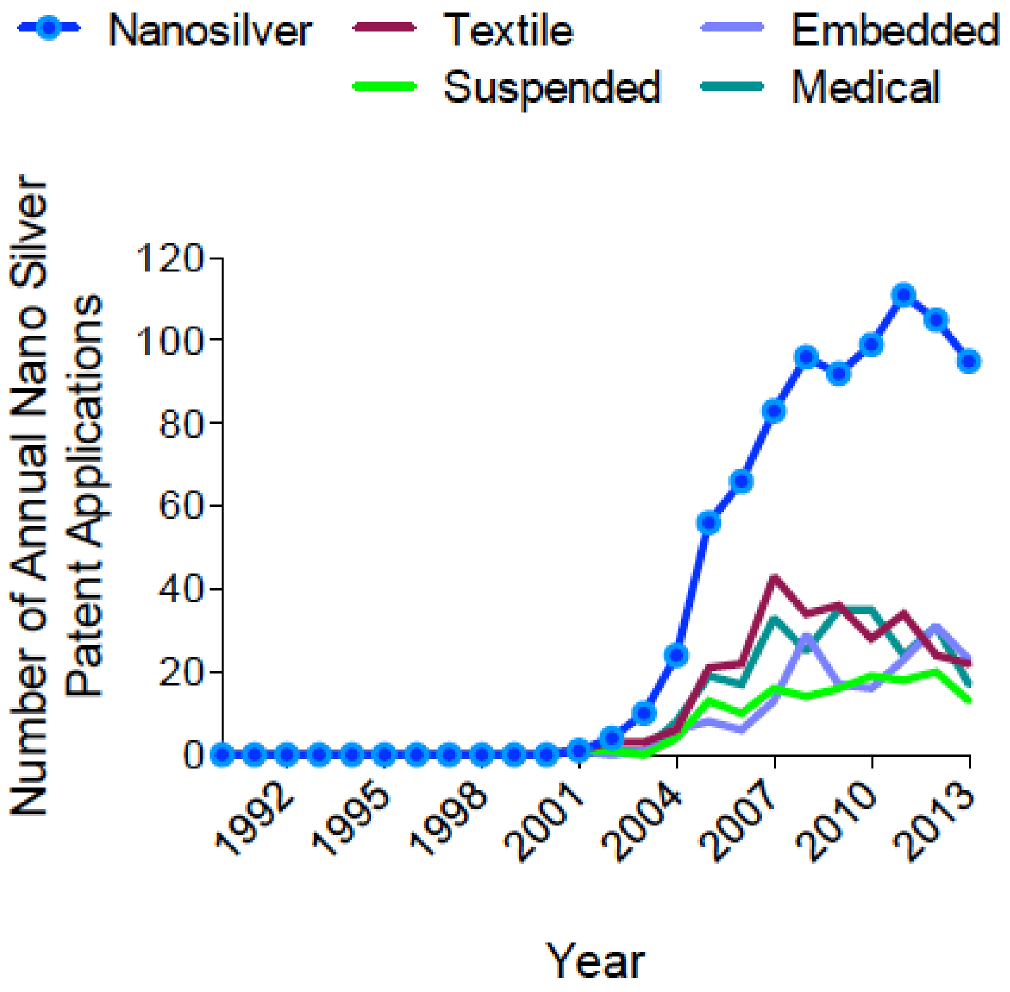
Silver Keeps Food Fresh Longer!
oso*fresh
Everyday
Silver Keeps Food Fresh Longer!
oso*fresh
Everyday
SAVE FOOD! SAVE MONEY!


AIR KEEPER 2qt.

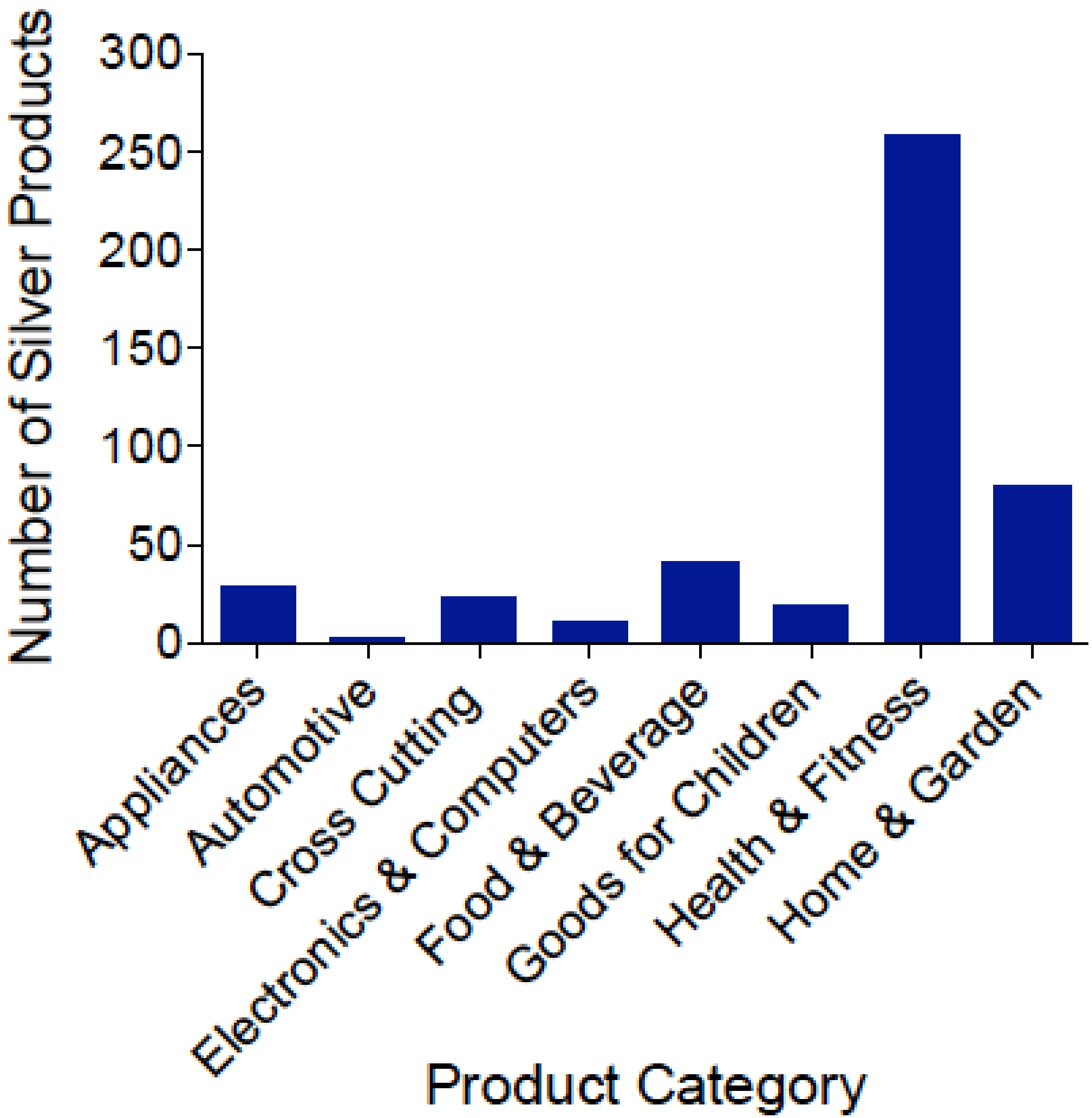

NANO SILVER
NANO SILVER


AIR KEEPER 2qt.
Ag+

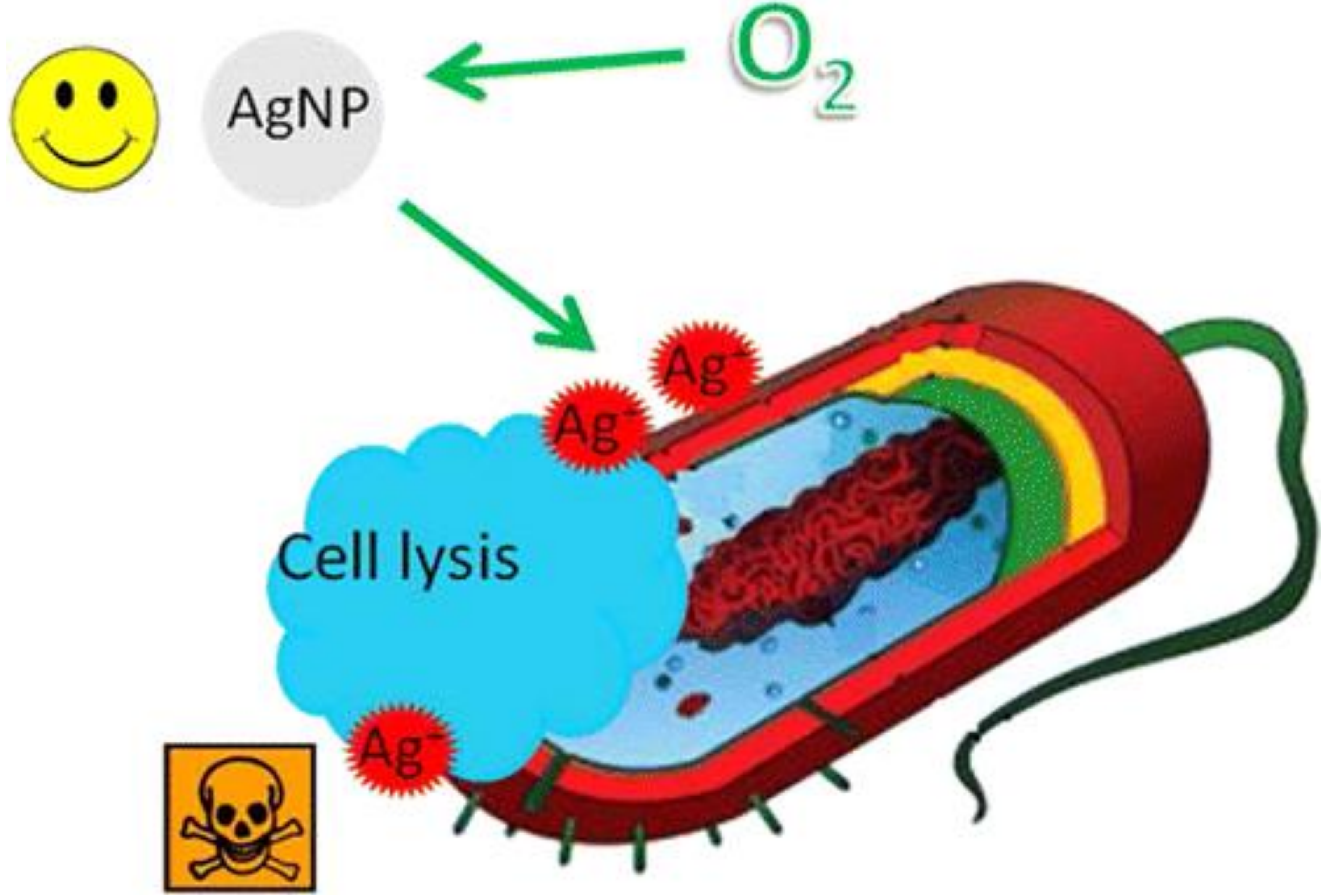
What does the future look like?



(Hicks et al., 2015, ES&T)

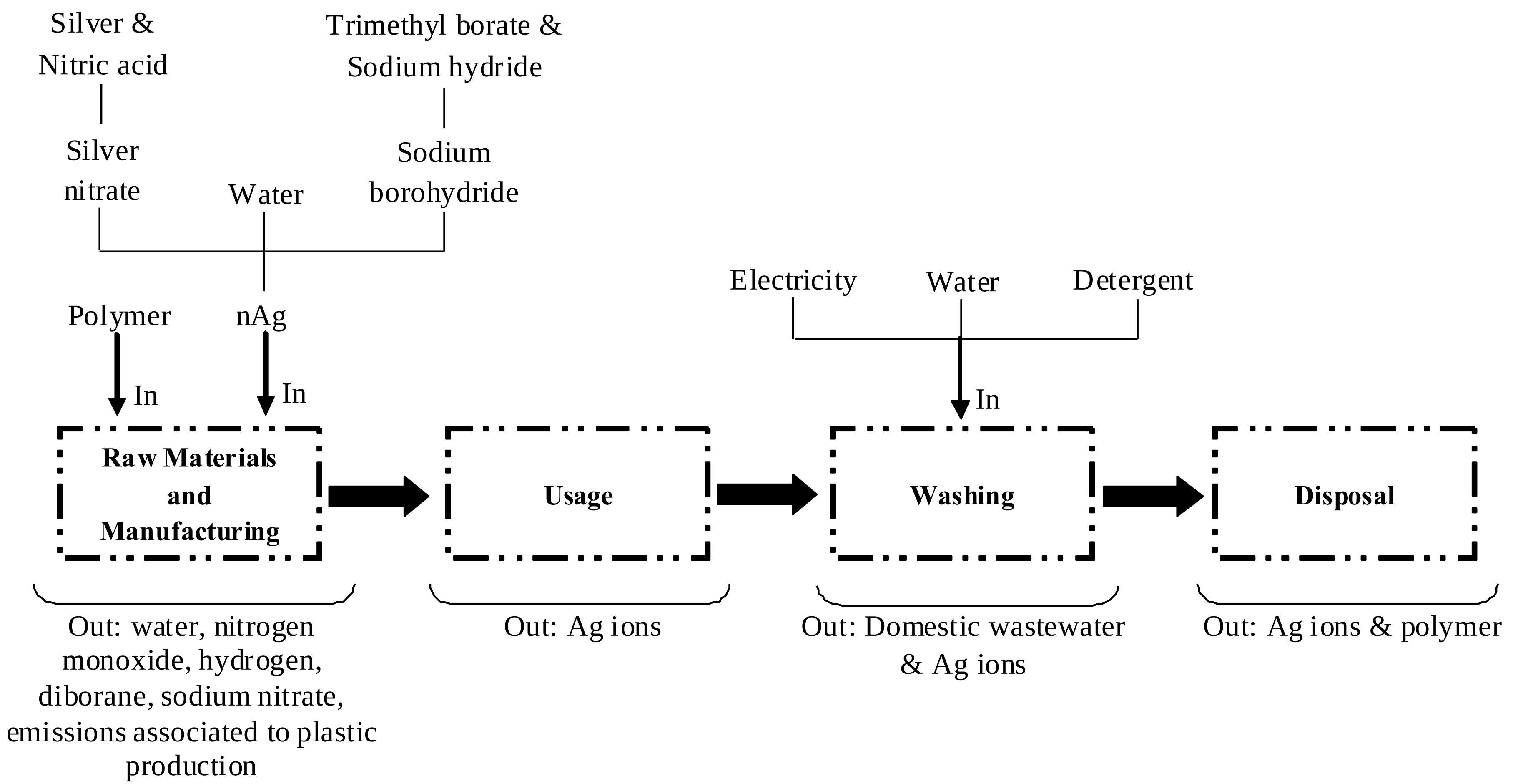


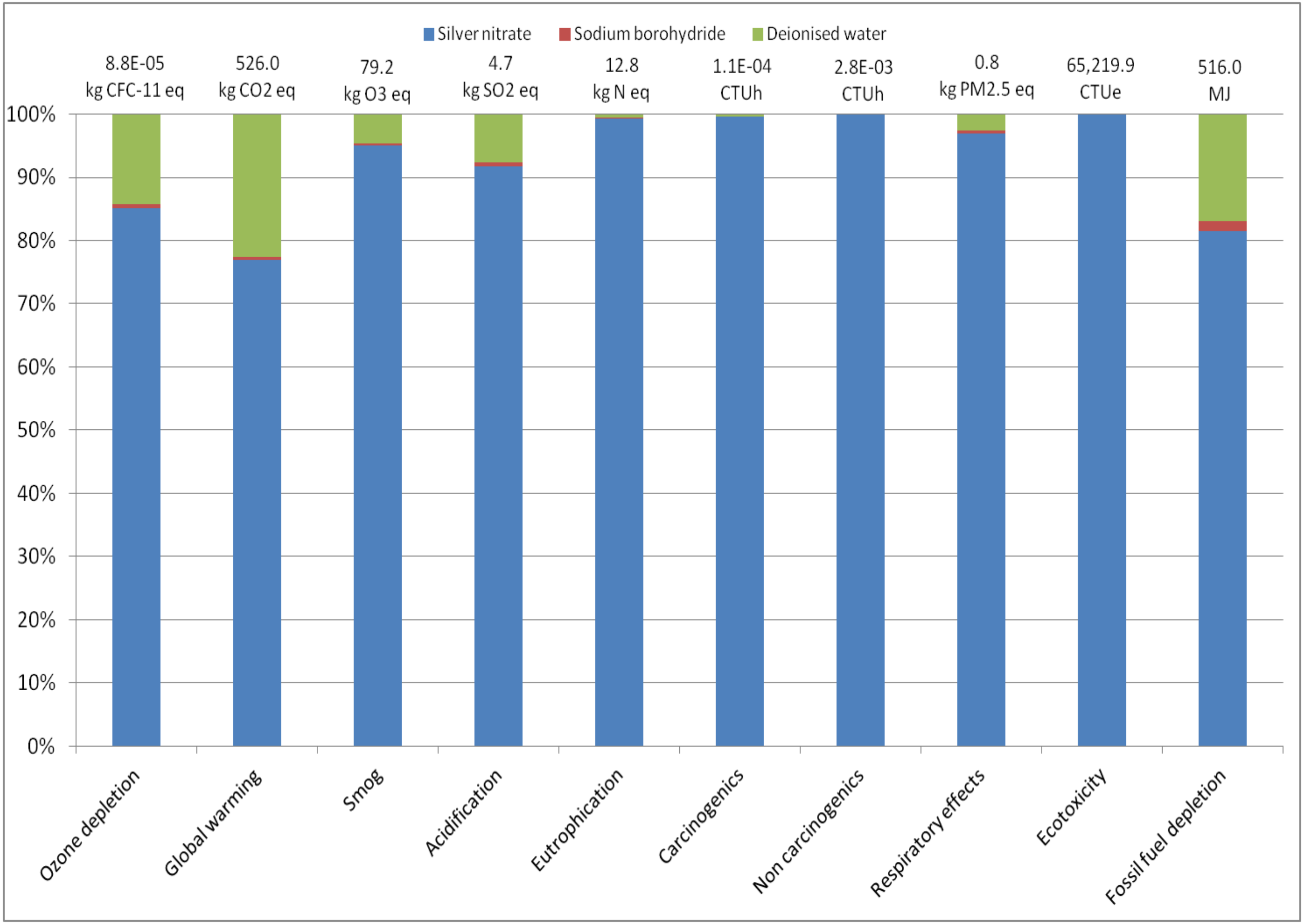
(Hicks et al., 2015, ES&T)

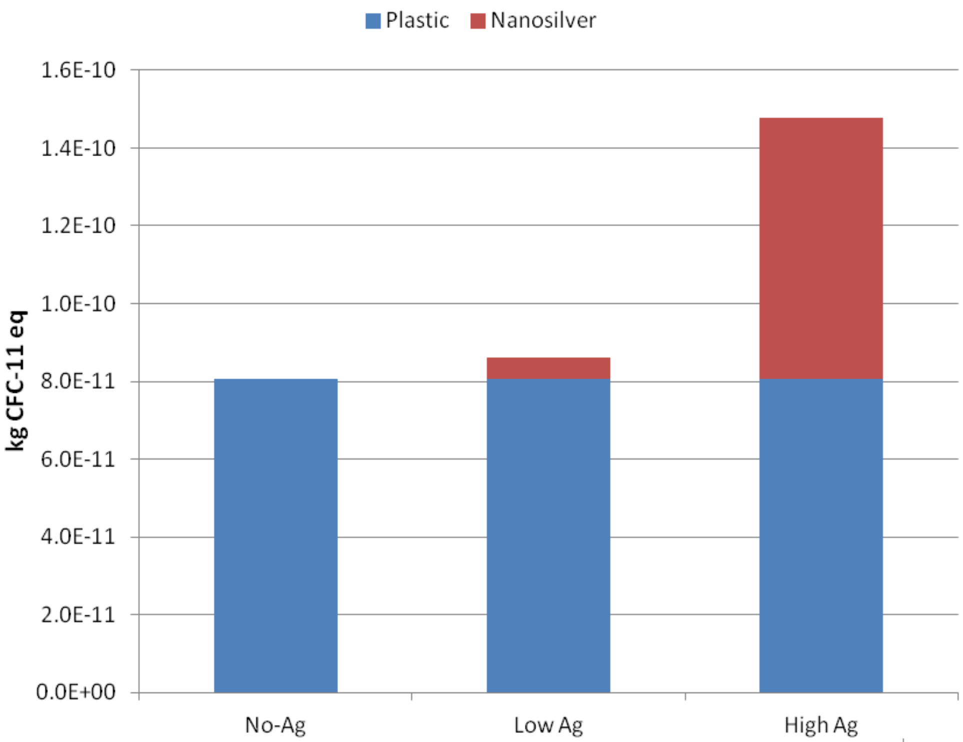


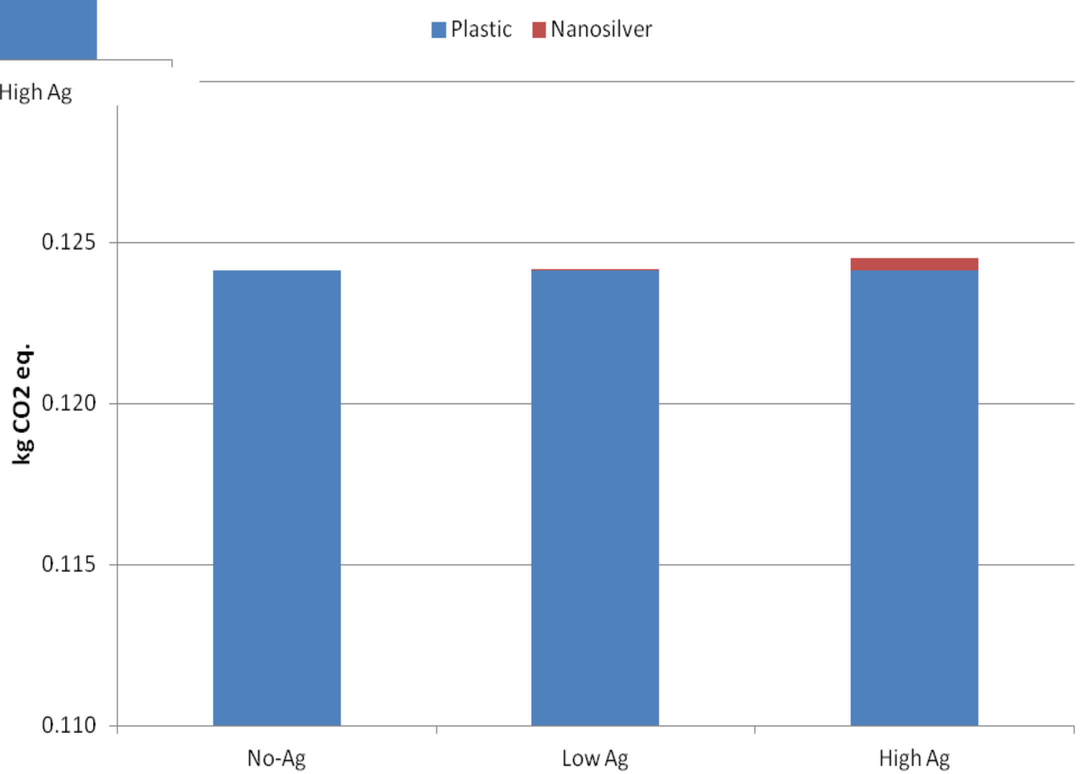
(Xiu et al., 2012, NanoLetters)

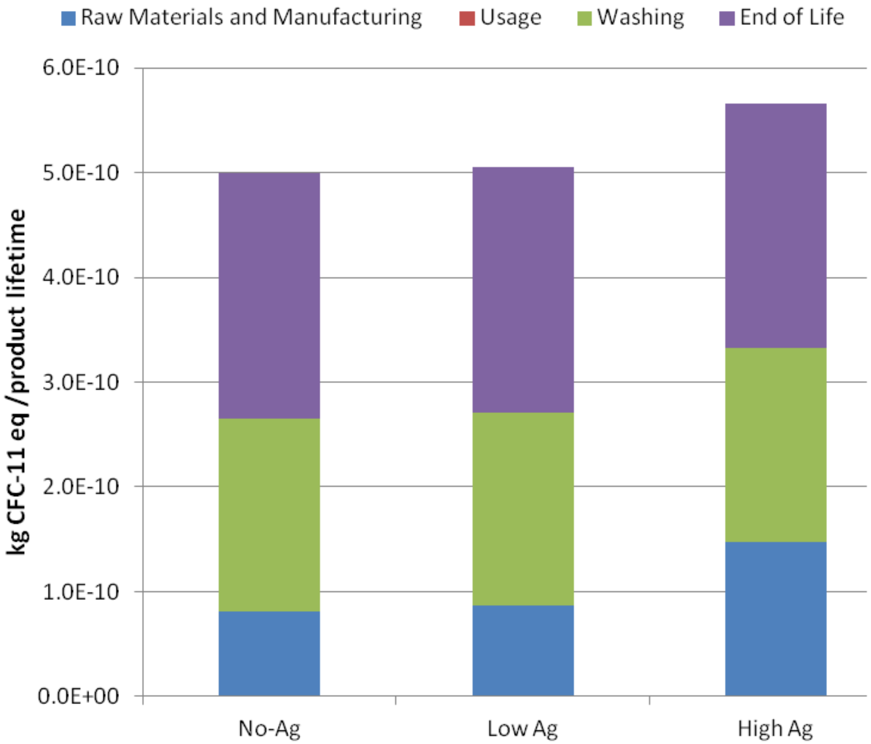
Study	Material	Brand	Product size [cm]	Initial Ag content [µg/g]	Silver migrated range [ng/cm^2]	Silver migrated range [%]
[1]	HDPE (bag)	Fresher Longer	29 x 27	28	0.1	0.06
[5]	PP (container)	Kinetic Go Green	13 x 9 x 7	3,200	31.5	0.01
	PP (container)	Oso Fresh	11 x 8 x 5	3,300	10.2	0.01
	LDPE (bag)	Fresher Longer	20 x 20	3,300	3.8	0.02
[15][a]	PE (bag)	Sunriver Industrial	15 x 15 x 0.007	100	33	*
[17]	PE (container)	Kinetic Go Green	*	1	2.8	1.4
	PE (container)	Original Always	*	11.9	2.7	0.2
	PE (bag)	Fresher Longer	*	22.5	2.0	1
	HDPE (bag)	Special breast milk	*	31.2	3.1	1.6

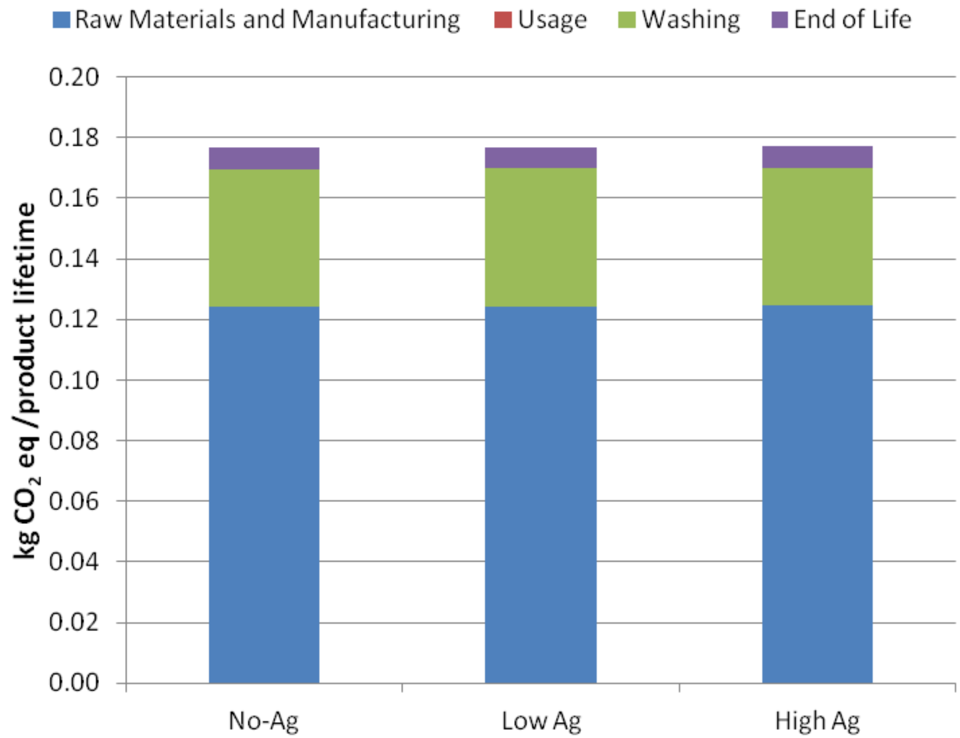

Silver &
Nitric acid
Trimethyl borate &
Sodium hydride
Silver
nitrate
Water
Sodium
borohydride
Polymer
nAg
In
In
Electricity
Water
Detergent
In
Raw Materials and Manufacturing
Usage
Washing
Disposal
Out: water, nitrogen monoxide, hydrogen, diborane, sodium nitrate, emissions associated to plastic production
Out: Ag ions
Out: Domestic wastewater & Ag ions
Out: Ag ions & polymer

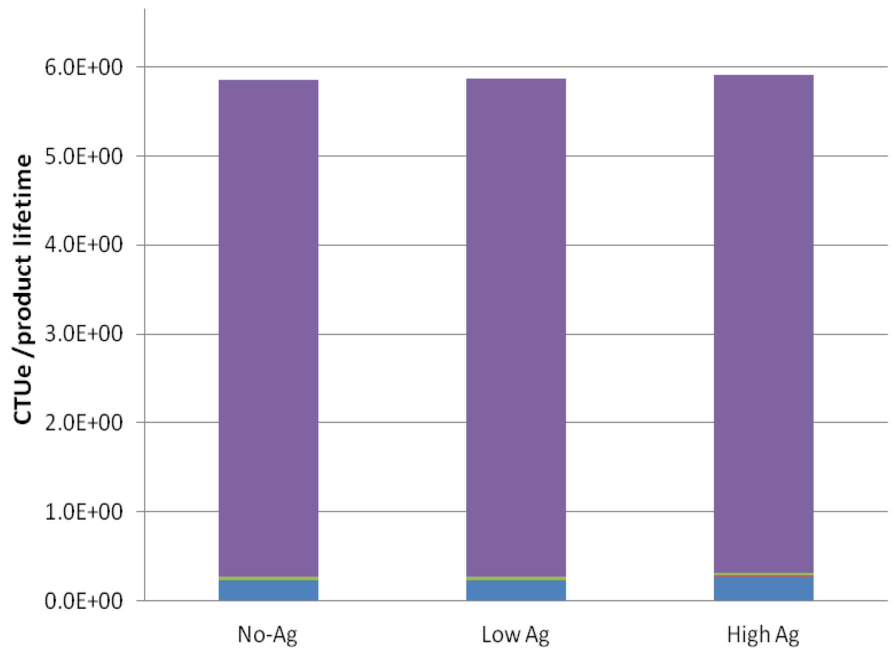

Silver nitrate
Sodium borohydride
Deionised water
8.8E-05 kg CFC-11 eq
526.0 kg CO2 eq
79.2 kg O3 eq
4.7 kg SO2 eq
12.8 kg N eq
1.1E-04 CTUh
2.8E-03 CTUh
0.8 kg PM2.5 eq
65,219.9 CTUe
516.0 MJ
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Ozone depletion
Global warming
Smog
Acidification
Eutrophication
Carcinogenics
Non carcinogenics
Respiratory effects
Ecotoxicity
Fossil fuel depletion

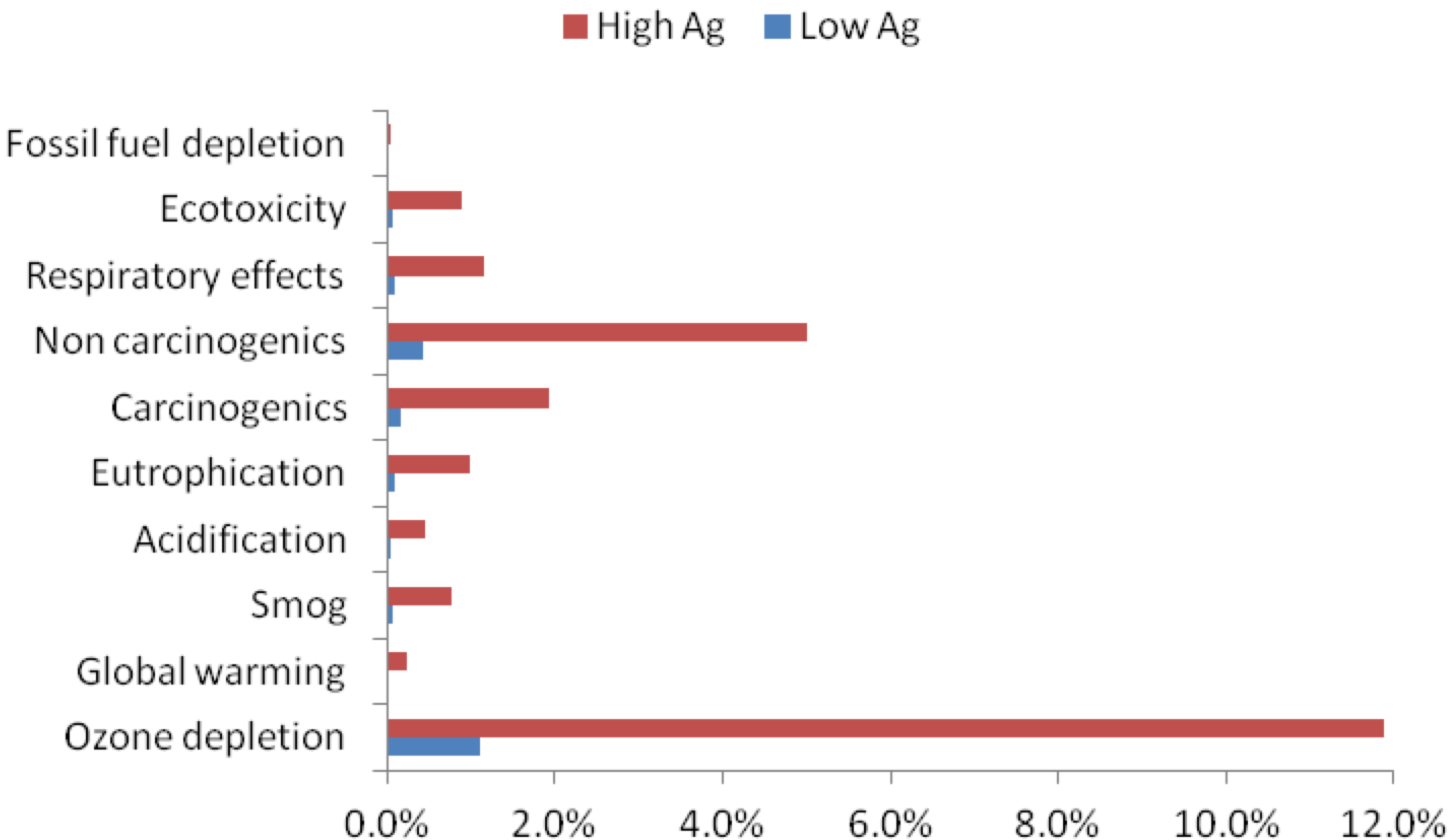

Plastic
Nanosilver
1.6E-10
1.4E-10
1.2E-10
1.0E-10
8.0E-11
6.0E-11
4.0E-11
2.0E-11
0.0E+00
kg CFC-11 eq
No-Ag
Low Ag
High Ag


Plastic
Nanosilver
0.125
0.120
0.115
0.110
kg CO2 eq.
No-Ag
Low Ag
High Ag


Raw Materials and Manufacturing
Usage
Washing
End of Life
kg CFC-11 eq /product lifetime
6.0E-10
5.0E-10
4.0E-10
3.0E-10
2.0E-10
1.0E-10
0.0E+00
No-Ag
Low Ag
High Ag


Raw Materials and Manufacturing
Usage
Washing
End of Life
kg CO_2 eq /product lifetime
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
No-Ag
Low Ag
High Ag


CTUe /product lifetime
6.0E+00
5.0E+00
4.0E+00
3.0E+00
2.0E+00
1.0E+00
0.0E+00
No-Ag
Low Ag
High Ag



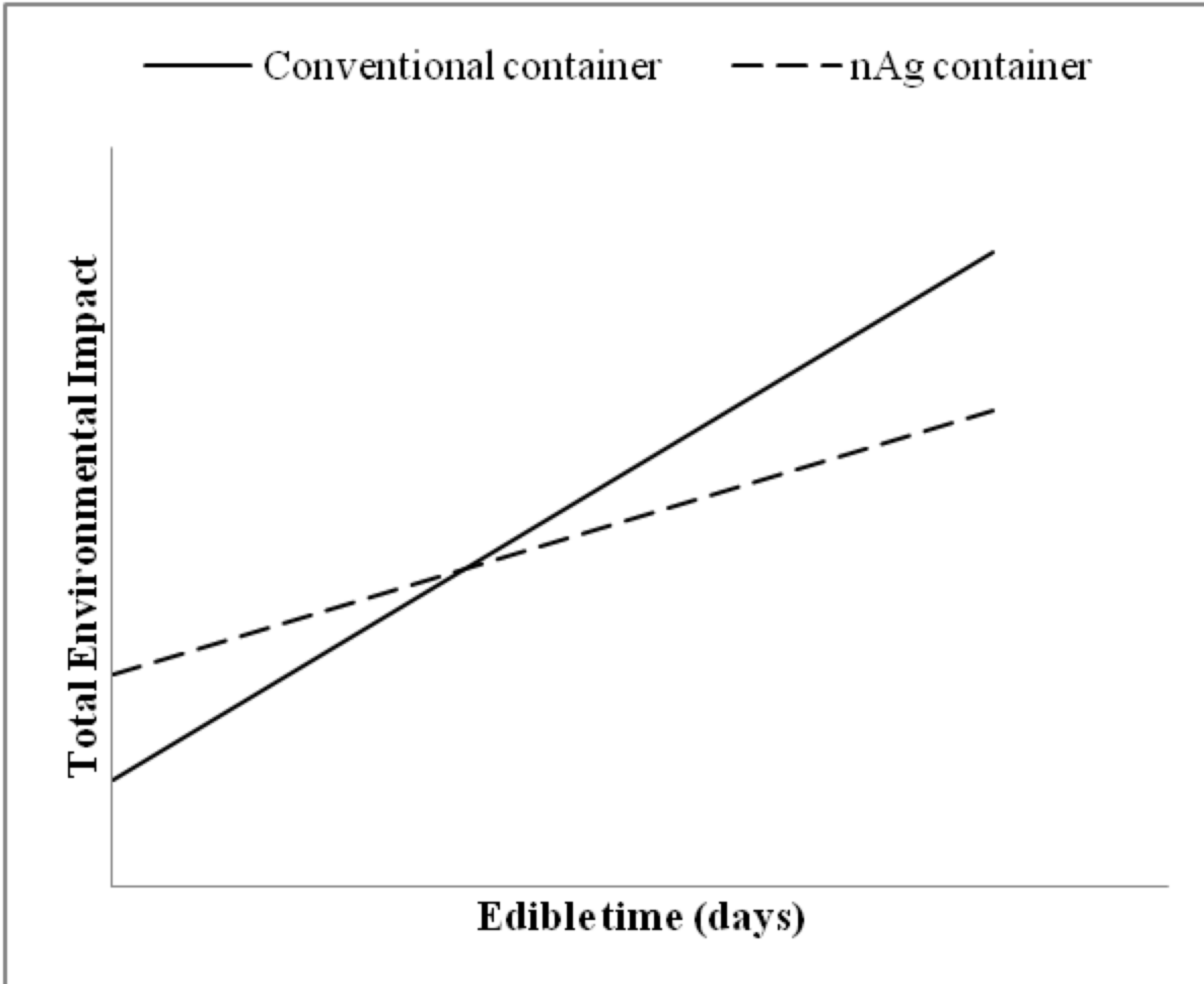
High Ag
Low Ag
Fossil fuel depletion
Ecotoxicity
Respiratory effects
Non carcinogenics
Carcinogenics
Eutrophication
Acidification
Smog
Global warming
Ozone depletion
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
12.0%

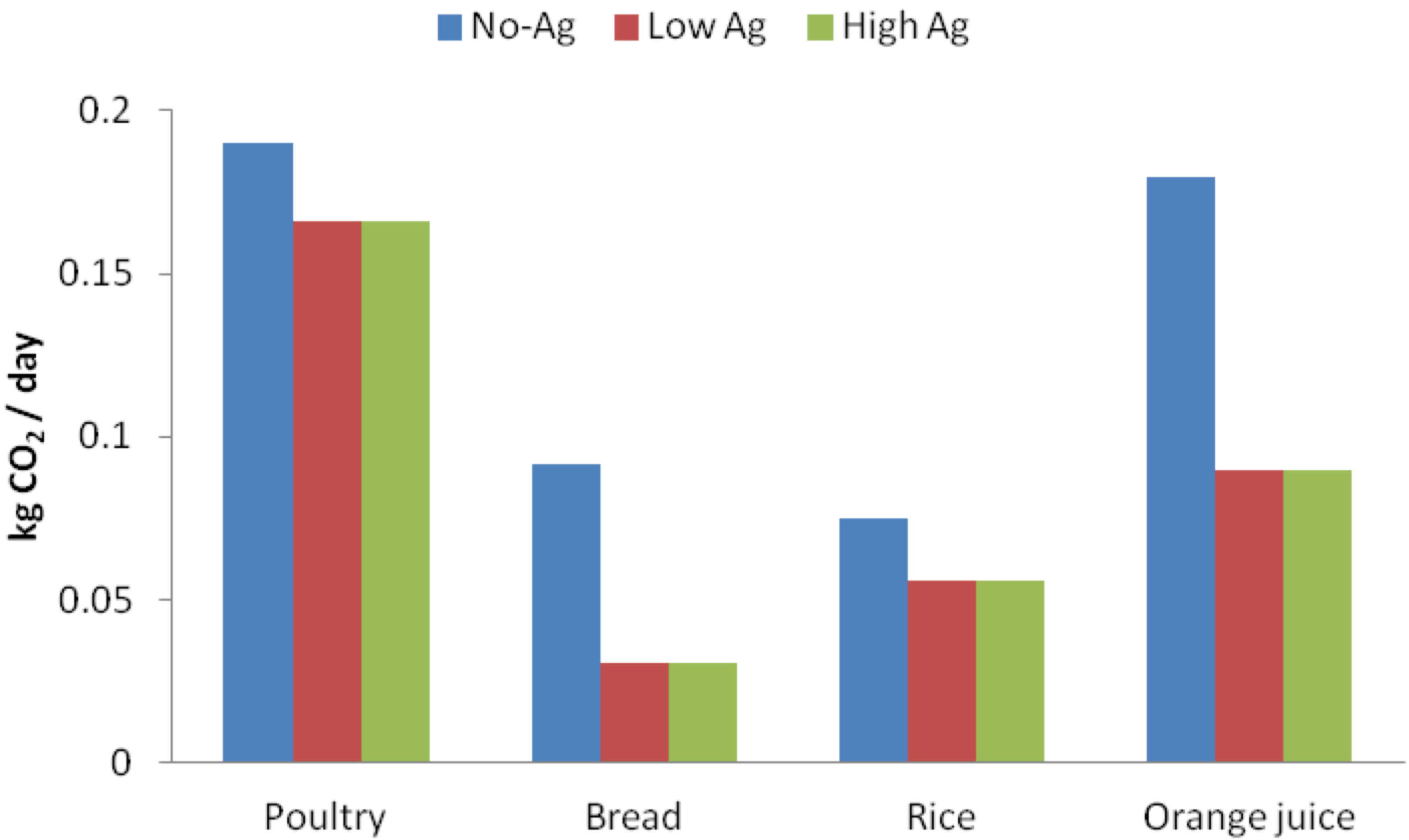
Table 1. Literature review of environmental impacts from producing different types of food

Study	Food type	Functional unit	Global warming (kg CO_2 eq.)	Ozone depletion (kg CFC-11 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg P eq.)
(Pelletier, 2008)	Poultry	1000 kg	1,395	32.2 E-09	15.8	3.9
(da Silva, et al., 2014) [a]	Poultry (France standard)	1000 kg	2,220	-	28.7	13.8
(da Silva, et al., 2014) [a]	Poultry (Brazil small system)	1000 kg	1,450	-	34.5	14.4
(da Silva, et al., 2014) [a]	Poultry (Brazil large system)	1000 kg	2,060	-	31.4	14.0
(Andersson & Ohlsson, 1999) [a]	Tomato ketchup sauce	1000 kg	942	-	-	-
(Tecco, et al., 2016) [a]	Raspberry	1 kg	0.1682	-	-	-
(Foster, et al., 2014) [a]	Raspberry	1 kg	7.3	-	0.01	0.005
(Kulak, et al., 2015) [a]	Bread (France)	1 kg	0.908	9.51 E-08	-	0.0001
(Kulak, et al., 2015) [a]	Bread (Spain)	1 kg	1.429	1.34 E-07	-	0.0003
(Braschkat, et al., 2003) [a]	Bread	1 kg	0.45	-	0.0025	0.004
(Blengini & Busto, 2009) [a]	White rice	1 kg	2.76	0.10 E-06	-	-
(Beccali, et al., 2010) [a]	Orange juice	1 kg	5.7	-	0.039	0.011
(Girgenti, et al., 2013) [a]	Raspberry	125 g	0.053	-	-	-
(Girgenti, et al., 2013) [a]	Blueberry	125 g	0.055	-	-	-
(Hospido, et al., 2003)	Dairy milk	1 L	1.05	5.12 E-08	0.0085	0.00531

[a] *Values were not studied in their respective referenced study*

Study	Product	Nanosilver source	Effectiveness
(Metak & Ajaal, 2013)	Carrots chips	Commercial polymer container	Shelf life extended from 5 days to 10 days.
(An, et al., 2007)	Green asparagus	Coating solution	Shelf life extended from 15 days to 25 days
(Emamifar, et al., 2010)	Orange juice	Commercial polymer packaging	Shelf life extended from 28 days to 56 days
(Cozmuta, et al., 2015)[a]	Wheat bread	Polymer films produced on-site	Shelf life extended from 2 days to more than 6 days
(Li, et al., 2017)[a,b]	Rice	Polymer container produced on-site	Shelf life extended from around 26 days to more than 35 days
(Azlin-Hasim, et al., 2015)	Chicken	Polymer films produced on-site	Shelf life extended from 7 days to 8 days


Conventional container
nAg container
Total Environmental Impact
Edible time (days)



No-Ag
Low Ag
High Ag
0.2
0.15
0.1
0.05
0
kg CO_2 / day
Poultry
Bread
Rice
Orange juice

Conclusions

- nAg enabled food storage containers have the potential to reduce food spoilage
- The added environmental impact of the nAg in the containers is small relative the container
- Small edible lifetime extensions of food by these containers is enough to negate the additional environmental cost of nano-enabling

Acknowledgements

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LC nano

Questions?

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