Willingness to Pay for Food Produced with re-cirulated nutrients
- A choice Experiment

IFRO ordinary lunch seminars
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RECONCILE

- **RE**cycling, **CON**sumer **C**redib**IL**ity and **E**cosystem integrity
- Organic RDD-project,
- Collaboration between Department of Agroecology, (*Århus Universitet*), Department of Food and Resource Economics and Department of Plant and Environmental Science (*Københavns Universitet*), Department of Science and Environment (*RUC*) and The Danish Agriculture and Food Council.

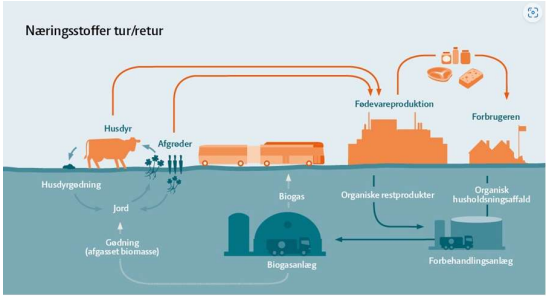
- Natural science: Maps the extent of harmful effects on the earth's ecosystem by recirculating e.g. biosolids from wastewater, composted household waste

- Social science: Analyse consumers' understanding and possible concerns in relation to recycling (Qualitative focus groups interviews, surveys and Choice Experiments)

ICROFS Organic RDD

Why is recirculation a good idea?

- Nitrogen and phosphorous are essential for food production, but phosphorous reserves are declining, nitrogen production has huge environmental and climatic consequences
- In the organic agricultural production the problem is even more salient since artificial fertilizer are not allowed and farmers must rely on manure from live-stock production.
- Re-cycling of nutrients from urban-areas could solve some of these problems
- Gasified biological household waste, gasified biological waste from the food industry and sewage bio-solids are good candidates
- No proven risks to humans involved with the use of these



Source: School material from Landbrug&Fødevarer Recirkulering af næringsstoffer i økologisk produktion (lf.dk)

What about the consumer?

- Consumers are found :
  - to have low awareness and knowledge about current fertilizer practices and methods in agriculture, and generally have low knowledge about hazards
  - to have strong opinions on the matter,
- Consumer acceptance of re-circulation is not necessarily based on real risks and benefits associated with the use of these
- Knowledge about consumers attitudes towards re-circulation of nutrients and how to communicate with the consumers is important

Aim of study

- Do consumers have positive Willingness to Pay (WTP) for foods grown with recirculated fertilizers?
- How can we communicate with the consumer in order to facilitate his or her accept of recirculation to organic agriculture?
- How does attitudes, as e.g. perceived risks and perceived benefits associated with recirculation affect this WTP

Consumer analysis - overview

Qualitative analysis (Spring 2021)
Preus, N, Mortensen F., and Vesterbæk P. (2022): Organic consumers' opinions about new types of re-circulation in organic production

$n = 1374$

Choice Experiment and survey
(Dec. 2021 – Jan. 2022)
WTP and attitudes towards organic, recirculation and sustainability

Household
$n \approx 2000$

Consumption
(2022)

- All staples
- All foods is registered as organic or conventional

Socio - demographics

- Age, education, place of living, family type etc.
- Attitude to food, sustainability and health in general
- Attitude to organic

Setup Choice Experiment and Questionnaire

Question battery	
1 and 2	Warm up questions
	Choice Experiments (16 choices)
3, 4 and 5	Validation questions in relation to Choice Experiments
6	Questions concerning the consumers attitudes to the specific fertilizer types that are applied in this project
7	Questions concerning attitude to organic
8	Questions concerning attitude to sustainability
9	Questions concerning attitude to re-circulation
10	The 10 item Food Disgust Scale (Hartmann and Siegrist, 2018)
11	The 15 item New Ecologial Pardigm scale (Dunlap et al., 2000)
12	Questions concerning trust in authorities, the food industry and in other humans.
13	Questions concerning social acceptance and how important this is for own behaviour

Measurement of risk and benefits

Question battery	
1	Warm up questions
	Choice Experiments (16 choices)
3	Validation questions in relation to Choice Experiments
6	Questions concernin… type that are applied…
7	Questions concernin…
8	Questions concerning attitude to sustainability
9	Questions concernin…
10	The 10 item Food Di…
11	The 15 item New Ec…
12	Questions concernin… humans.
13	Questions concernin… own behaviour

Specific risk

Disgust

Benefit

General risk

6. To which extend do you agree with?

	Totally disagree	Disagree	Neither/nor	Agree	Totally agree
I believe that this type of fertilizer poses a health risk when used for food production	❑	❑	❑	❑	❑
It is disgusting to use this type of fertilizer for food production	❑	❑	❑	❑	❑
This type of fertiliser contains to many residuals to be used on agricultural land	❑	❑	❑	❑	❑
I do not mind eating food produced with this fertilizer	❑	❑	❑	❑	❑

9 To which extend do you agree with?

	Totally disagree	Disagree	Neither/nor	Agree	Totally agree
Re-circulation of nutrients is sustainable	❑	❑	❑	❑	❑
Re-circulation of nutrients is an important element in the green transition	❑	❑	❑	❑	❑
It is a waste of resources not to recirculate nutrients	❑	❑	❑	❑	❑
There is too many risks involved in recirculation of nutrients	❑	❑	❑	❑	❑

Choice Experiment

Kelvin Lancaster, 1966

"The total utility gained form a product or service is the sum of the individual utilitites provided by the attributes of that good"

- The consumers do not get utility from the product them selves, but from the attributes inherent in a product
- By varying the price and the level of different attributes we can derive the consumers preferences for the attributes
- Advantage leave us the possibility to derive the consumers preferences (and WTP) for products that do not exist at the market (yet!)

Choice Experiment

Carrots and bread

Attributes and levels

Mode of production:	Organic Conventional
Type of fertilizer:	Manure Sewage sludge Biological waste from food industry Biosolids
Origin of fertilizer	Organic Conventional
Price:	Various price levels (8 – 10 levels)

Choice Experiment

Carrots and bread

Attributes and level

Mode of productior

Type of fertilizer:

Origin of fertilizer

Price:

Manure: Manure is a mixture of livestock urine and excrement. The manure is stored in manure tanks until it is ready to be brought out onto the farmland. Livestock manure must be brought onto the field just before or at the start of the growing season

Biological household waste: Source-sorted biological waste from households (the green bio bin) and commercial kitchens. The waste is composted or has been through biogas production (gasification) before being used on agricultural land

Biological waste products from the food industry: The food industry has many residuals from the production of food. This can, for example, be fish waste, or peels and residues from vegetables. The residual products are composted or have been through a biogas production (gasified) before use
on the agricultural land.

Bio-solids from waste water: Bio-solids is purified biological material from waste water treat-ment, which is both mechanically, biologically and chemically treated, and has been through biogas production (gasified). Food crops must not be grown until at least one year after the fields have been fertilized

Choice cards

Imagine that you are in the supermarket and have to choose between 3 bundles of carrots that are equal in terms of apperance and taste. The only difference is mode of production, what fertilizers has been used and the price

We ask you to choose the product you would have chosen given this was a real choice

	Gulerodstype 1	Gulerodstype 2	Gulerodstype 3
Produktionsform	Økologisk	Økologisk	Konventionel
Gødningstype	Husdyrgylle	Organiske restprodukter fra fødevareindustrien	Organiske restprodukter fra fødevareindustrien
Gødningsoprindelse	Økologisk	Økologisk	Blandet
Pris	18 kr. per kg.	15 kr. per kg.	9 kr. per kg.
Vælg et produkt	☐	☒	☐

Choice card

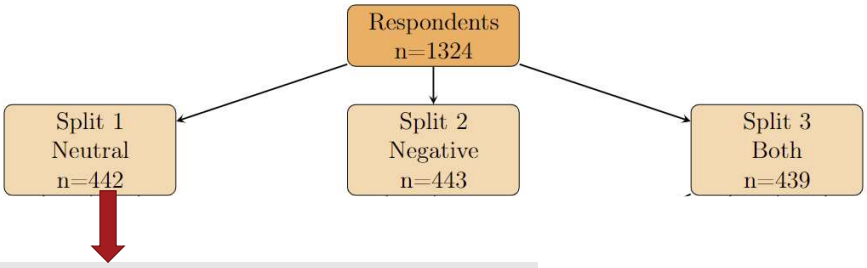
Imagine that you are in the supermarket and have to choose between 3 types of bread that are equal in terms of apperance and taste. The only difference is mode of production, what fertilizers has been used and the price

We ask you to choose the product you would have chosen given this was a real choice

	Brødtype 1	Brødtype 2	Brødtype 3
Produktionsform	Konventionel	Økologisk	Konventionel
Gødningstype	Husdyrgylle	Organisk materiale fra spildevand	Organisk husholdningsaffald
Gødningsoprindelse	Blandet	Blandet	Blandet
Pris	21 kr. per brød	27 kr. per brød	18 kr. per brød
Vælg et produkt	☒	☐	☐

Information provision, split 1 neutral

Figure 1: **Overview over number of respondents to survey**



There is a need to develop and increase the supply of nutrients for agriculture in general, and for organic agriculture in particular. One obvious sources is to recycle nutrients from the surrounding community to a much larger extent than now. Examples of this could be recycling of biological household waste, biological waste from the food industry and purified biological material from waste water. Fertilizers, regardless of the type used, must always be spread according to the rules so that threshold values are not exceeded.

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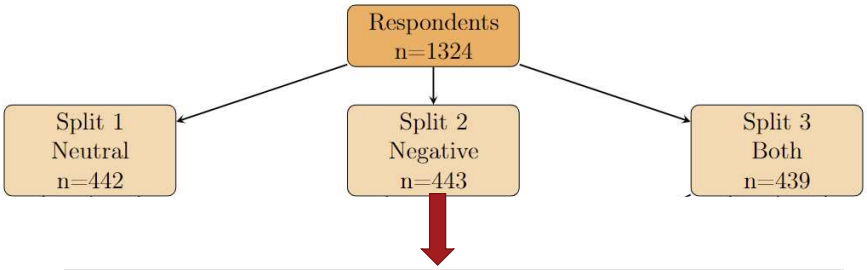
Information provision, split 2 negative

Figure 1: **Overview over number of respondents to survey**



Same information as in split 1 but additional also……..Manure can contain infectious substances such as bacteria, and to a limited extent heavy metals and drug residues. However, the processes in the soil convert infectious substances and medicinal residues, so that these do not harm humans, and only to a very small extent harm the environment, as long as the fertilizer is applied according to the rules and the threshold values are not exceeded.

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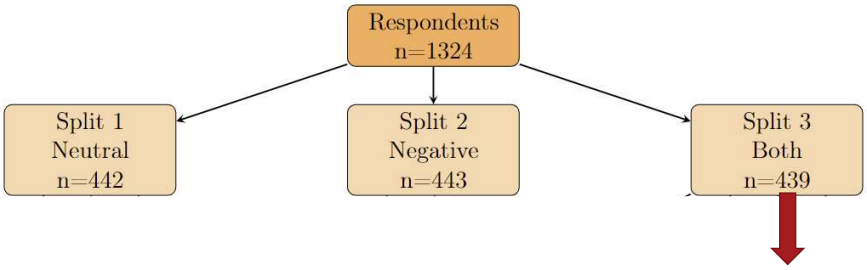
Information provision, split 3, neutral and positive

Figure 1: **Overview over number of respondents to survey**



Same information as split 1 and 2, but additional…….. A sustainable use of natural resources is in accordance with one of the basic ideas behind ecology. It is also a very important element in the green transition. The re-circulated fertilizers do not contain more adverse substances than the conventional manure used today.

Description of the respondents

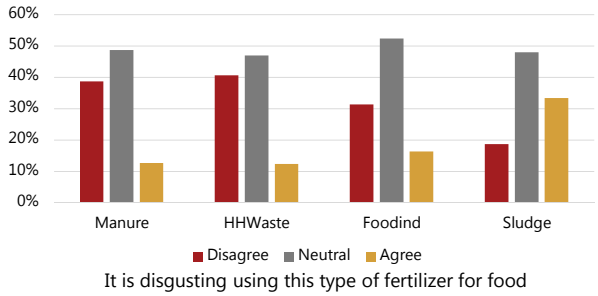
split		Mean						
				Education				
	n	Age (Year)	Female Shopper (share)	No further (share)	Vocat. (share)	Short (share)	Medium (share)	Long (share)
Neutral	*442*	58	0.78	0.17	0.24	0.16	0.25	0.07
Negative	*443*	59	0.81	0.19	0.23	0.14	0.25	0.08
Both	*439*	58	0.80	0.19	0.21	0.12	0.26	0.08
Total	*1324*	58	0.80	0.18	0.22	0.14	0.25	0.07

Notes: The main shopper is the main respondent to GfK about food purchases

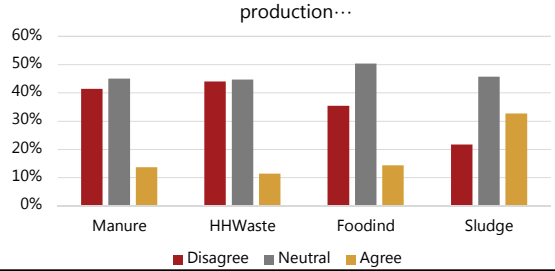
split	Mean							
	hhsize (numb.)	child06 (numb.)	child714 (numb.)	child1520 (numb.)	Capital (share)	Urban (share)	Rural (share)	Income (DKK/year)
Neutral	1.9	0.06	0.15	0.13	0.17	0.44	0.28	307,748
Negative	1.9	0.07	0.13	0.14	0.19	0.42	0.29	329,239
Both	2.0	0.08	0.15	0.14	0.18	0.43	0.27	314,719
Total	1.9	0.07	0.15	0.14	0.18	0.43	0.28	317,295

Some statistics

I think there is health risks associated with the use of this fertilizer

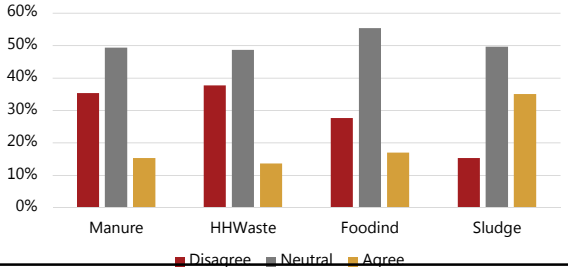


It is disgusting using this type of fertilizer for food production…



- Bio-solids from wastewater plants are found to pose larger health risks, be more disgusting and to contain more residuals than the other fertilizers
- Household waste is found to be safer and less disgusting than waste from the food industry
- Surprisingly many are neutral

There is too many residuals in this type of fertilizer



Modelling approach

- We apply the random utility model developed by McFadden et al. (1973).
- The utility that respondent i derives from choosing alternative j in choice situation k, can be specified as:

$$U_{ijk} = -\alpha p_{ijk} + \beta Z_{ijk} + \epsilon_{ijk}$$

- As we include the cost attribute in 1, the respondents WTP can be calculated as the ratio of the coefficients on the non-cost attributes (β) to the cost coefficient (α), i.e. WTP= β/α.

$$U_{ijk} = -\alpha p_{ijk} + (\alpha WTP) Z_{ijk} + \epsilon_{ijk}$$

- Using this idea we can estimate a Random Parameter Logit estimating the probability of respondent i's sequence of choices

$$\Pr(y_i|p_i,\Omega) = \int \prod_{k=1}^{K} \frac{exp(-\alpha p_{ijk} + (\alpha WTP) Z_{ijk})}{\sum_{n=1}^{N} exp(-\alpha p_{ijk} + (\alpha WTP) Z_{ijk})} f(\theta_n, \Omega) d(\theta_n)$$

Modelling approach

- Advantage of RPL
  - We can model the distribution of the WTP for the various attribute not only the mean
  - We can allow for correlation in the WTP between the attributes
  - We can derive individual WTP for the respondents (conditionals)

$$U_{ijk} = -\alpha p_{ijk} + (\alpha WTP) Z_{ijk} + \epsilon_{ijk}$$

- Attributes

$$\begin{aligned} Z_{ijk} = & prod\_org_{ijk} + fert\_org_{ijk} + hhwaste_{ijk} + hhwaste_{ijk} * neg\_info_i + hhwaste_{ijk} * pos\_info_i \\ & + hhwaste_{ijk} * risk_i + hhwaste_{ijk} * benefit_i + iwaste_{ijk} + iwaste_{ijk} * neg\_info_i \\ & + iwaste_{ijk} * pos\_info_i + iwaste_{ijk} * risk_i + iwaste_{ijk} * benefit_i \\ & + wwaste_{ijk} + wwaste_{ijk} * neg\_info_i + wwaste_{ijk} * pos\_info_i + wwaste_{ijk} * risk_i \\ & + wwaste_{ijk} * benefit_i \end{aligned}$$

Test of interactions

Models to be tested	Hypothesis	Result
M1 >< Inf. treatment interact with fertilizer of organic origin	H_0: Inf. has no influence on WTP on fertilizer of organic origin	Cannot reject
M1 >< Inf. treatment interact with organic production	H_0: Inf. has no influence on WTP on organic origin	Cannot reject
M1 >< No inf. treatment	H_0: Inf. has no influence on WTP for foods grown with recirc. fertilizers	Cannot reject
M1 >< No neg. inf. treatment	H_0: Neg. inf. no influence on WTP for foods grown with recirc. fertilizers	Cannot reject
M1 >< No pos. inf. treatment	H_0: Pos. inf. has no influence on WTP for foods grown with recirc. fertilizers	Cannot reject
M2 >< No interaction between fertilizer type and benefits	H_0: Benefits no influence on WTP for foods grown with recirc. fertilizers	Reject
M2 >< No interaction between fertilizer type and risks	H_0: Risks no influence on WTP for foods grown with recirc. fertilizers	Reject

Model 1:

$$Z_{ijk} = prod\_org_{ijk} + fert\_org_{ijk} + hhwaste_{ijk} + hhwaste_{ijk} * neg\_info_i + hhwaste_{ijk} * pos\_info_i + hhwaste_{ijk} * risk_i + hhwaste_{ijk} * benefit_i + iwaste_{ijk} + iwaste_{ijk} * neg\_info_i + iwaste_{ijk} * pos\_info_i + iwaste_{ijk} * risk_i + iwaste_{ijk} * benefit_i + wwaste_{ijk} + wwaste_{ijk} * neg\_info_i + wwaste_{ijk} * pos\_info_i + wwaste_{ijk} * risk_i + wwaste_{ijk} * benefit_i$$

Model 2:

$$Z_{ijk} = prod\_org_{ijk} + fert\_org_{ijk} + hhwaste_{ijk} + hhwaste_{ijk} * risk_i + hhwaste_{ijk} * benefit_i + iwaste_{ijk} + iwaste_{ijk} * risk_i + iwaste_{ijk} * benefit_i + wwaste_{ijk} + wwaste_{ijk} * risk_i + wwaste_{ijk} * benefit_i$$

- Model is run with various measures of risks (General, specific and disgust)

Conclusions based on testing

- Information do not affect the WTP for foods grown with re-circulated fertilizers
- Information do not affect the WTP for organic production or fertilizers of organic origin
- Perceived risk and perceived benefits has a significant influence on the WTP for food grown with re-circulated fertilizers
- General risk has smaller influence than specific risk
- Risk measured as disgust has the same effect as specific risk

WTP for carrots

	MNL		RPL		RPL w. corr.		Cond.
	Parm	Rob.s.e.	Parm	Rob.s.e.	Parm	Rob.s.e.	Parm
asc	0.12 ***	0.05	0.30	0.25	-0.46	0.22	
Org	2.76 ***	0.28	3.49 ***	0.43	4.26 ***	0.35	4.33
Std.err.			12.15 ***	0.52	5.12 ***	0.45	
Hhwaste	0.64	0.44	0.41	0.43	0.29	0.39	0.35
Std.err.			6.28 ***	0.34	1.52	0.69	
Iwaste	-0.20	0.47	-0.37	0.45	-1.56 ***	0.42	-1.47
Std.err.			5.62 ***	0.81	3.92 ***	0.52	
Wwast	1.02 ***	0.43	-0.57	0.41	-1.99 ***	0.39	-1.91
Std.err.			4.41 ***	0.70	4.33 ***	0.58	
Hhw*risk	-1.04	0.78	-2.17	1.13	-1.08	0.75	-1.10
Std.err.			6.86 ***	1.24	3.61 ***	0.95	
Hhw*bene	0.59	0.52	0.81	0.51	0.07	0.45	0.07
Std.err.			0.42	2.12	0.11	0.66	
Iw*risk	-2.97 ***	0.77	-3.42 ***	0.84	-3.16 ***	0.72	-3.15
Std.err.			4.97	4.32	4.68 ***	1.22	
Iw*bene	0.08	0.54	0.07	0.54	0.01	0.51	0.01
Std.err.			1.58	0.95	0.28	0.78	
Ww*risk	-6.45 ***	0.56	-7.52 ***	0.75	-6.08 ***	0.61	-6.09
Std.err.			6.37 ***	1.06	4.56 ***	0.83	
Ww*bene	-0.83	0.47	-0.57	0.49	0.19	0.46	0.20
Std.err.			2.50	1.90	2.48 ***	0.90	
Fert. Org	1.77 ***	0.22	1.68 ***	0.21	0.40	0.20	0.42
Std.err.			3.43 ***	0.33	2.86 ***	0.26	
Log-Lik		-10347.41		-8317.24		-7958.05	
Rho sqr.		0.11		0.29		0.32	
Adj. Rho sqr.		0.11		0.28		0.31	
AIC		20720.81		16682.47		15984.11	
BIC		20815.29		16856.90		16231.21	

- There is a positive WTP for organic
- Insignificant average WTP for fertilizer of organic origin, significant variation
- No significant WTP for household waste, negative for food industry waste and bio-solids
- Risk perception large and negative impact
- Benefits has no significant average effect, but the variation is significant for bio-solids
- Positive towards organic implies positive towards household waste

	Carrots	
	Estimate	Rob.s.e.
Org - Fert.org	9.83 ***	0.43
Hhwaste - Iwaste	-1.57 ***	0.65
Hhwaste - Wwaste	1.65	1.08
Hhwaste - Org	3.24 ***	0.52
Hhwaste - Fert. Org	5.70 ***	0.32
Iwaste Wwaste	4.48 ***	0.60
Iwaste - Org	1.25	0.86
Iwaste - Fert. Org	1.29	0.47
Wwaste - Org	2.99	0.73
Wwaste - Fert. Org	-1.54	0.42

WTP for bread

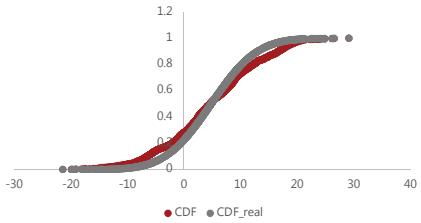
	MNL		RPL		RPL w. corr.		Cond.
	Parm	Rob.s.e.	Parm	Rob.s.e.	Parm	Rob.s.e.	Parm
asc	0.00	0.03	-0.27	0.23	-0.52	0.25	
Org	2.67 ***	0.30	2.74 ***	0.38	2.75 **	1.99	2.78
Std.err.			12.35 ***	0.58	3.39	8.52	
Hhwaste	3.38 ***	0.66	3.55 ***	0.72	4.78 ***	2.04	4.79
Std.err.			10.19 ***	0.70	6.38 ***	0.95	
Iwaste	-1.35 ***	0.46	-0.84	0.47	-0.55	0.56	-0.53
Std.err.			6.65 ***	0.50	3.37	16.88	
Wwaste	0.69	0.56	-0.41	0.61	-0.84	1.11	-0.80
Std.err.			9.47 ***	0.85	9.45	7.64	
Hhwaste*risk	-3.91 ***	1.23	-4.98 ***	1.59	-5.68 ***	2.16	-5.69
Std.err.			9.48 ***	2.47	11.23	5.56	
Hhwaste*bene	1.62	0.80	0.07	0.87	0.04	2.61	0.04
Std.err.			0.89	1.16	1.08	4.84	
Iwaste*risk	-4.97 ***	0.92	-5.66 ***	1.45	-5.70 ***	2.70	-5.69
Std.err.			10.67 ***	1.98	10.07 ***	4.74	
Iwaste*bene	1.36	0.59	0.57	0.60	1.01	0.73	1.01
Std.err.			2.62	1.17	1.56	1.65	
Wwaste*risk	-8.07 ***	0.83	-10.28 ***	1.09	-9.08 ***	1.09	-8.95
Std.err.			7.25 ***	2.53	8.44 ***	2.19	
Wwaste*bene	-0.80	0.74	-0.80	0.82	0.17	0.83	0.17
Std.err.			3.70	2.16	1.28	12.13	
Fert. Org	1.51 ***	0.25	1.22 ***	0.24	0.35	1.12	0.37
Std.err.			5.82 ***	0.36	5.97 ***	0.90	
LogLik	-10347.41		-8317.24		-7958.05		
Rho-sqr.	0.11		0.29		0.32		
Adj.Rho-sqr.	0.11		0.28		0.31		
AIC	20720.81		16682.47		15984.11		
BIC	20815.29		16856.90		16231.21		

- Positive WTP for organic
- Insignificant average WTP for fertilizer of organic origin, sig. variation
- Significant WTP for household waste, insignificant for food industry waste and bio-solids
- Risk perception large and negative impact
- Benefits no significant effectz
- Positive towards organic implies positive towards household waste

How large are the shares?

	Bread		Carrot	
	WTP < 0	WTP > 0	WTP < 0	WTP > 0
Organic production	0.21	0.79	0.20	0.80
Household waste	0.23	0.77	0.43	0.57
Food industry waste	0.56	0.44	0.66	0.34
Wastewater waste	0.54	0.46	0.68	0.32
Risk (hhw)	0.69	0.31	0.62	0.38
Benefit (hhw)	0.49	0.51	0.24	0.76
Risk (Iw)	0.71	0.29	0.75	0.25
Benefit (Iw)	0.26	0.74	0.48	0.52
Risk (Ww)	0.86	0.14	0.91	0.09
Benefit (Ww)	0.45	0.55	0.47	0.53
Organic fertilizer	0.48	0.52	0.44	0.56

Average price paid in sample 8 DKK for a kg of carrots, 14 DKK for a bread



	WTP		%	
	Bread	Carrot	Bread	Carrot
Organic	2.75	4.26	20%	53%
Org fertilizer	0.35	0.40	3%	5%
Hhwaste	4.78	0.29	34%	4%
Iwaste	-0.55	-1.56	-4%	-20%
Wwaste	-0.84	-1.99	-6%	-25%
Risk				
Hhwaste	-0.91	-0.79	-6%	-10%
Iwaste	-6.24	-4.72	-45%	-59%
Wwaste	-9.92	-8.07	-71%	-101%
Benefits				
Hhwaste	4.81	0.36	34%	4%
Iwaste	0.46	-1.55	3%	-19%
Wwaste	-0.67	-1.80	-5%	-22%

Summary of results

- Information do not affect the WTP for foods grown with re-circulated fertilizers or the WTP for organic production or fertilizers of organic origin
- When asked very few are critical towards the use of re-circulated fertilizers
- Average WTP for food produced with household waste as a fertilizer is positive, especially for bread
- Average WTP for food produced with Industry waste or bio-solids from wastewater plants is negative, especially for carrots
- Perceived risk has a significant influence on the WTP for food grown with re-circulated fertilizers, this is larger for food produced with food industry waste and bio-solids than for household waste
- General perceived benefits has a positive effect for food produced with household waste (larger for bread), but negative when it comes to bio-solids from waste water
- Further work on the relationship between WTP and attitudes towards organic, sustainability and re-circulation