

Optimising sensory and nutritional quality of processed meats

**FUNDING: DEPARTMENT OF AGRICULTURE, FOOD AND THE MARINE
FIRM-Food Institutional Research Measure**

Development of consumer accepted low salt and low fat Irish traditional processed meats; PROSSLOW
(FIRM Ref: 11/F/026)

Partners: Teagasc Food Research Centres, Ashtown and Moorepark



Co-ordinator:

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- Government & consumer pressure stimulating product reformulation

Overconsumption of:

- Fat & sugar - associated with obesity, type 2 diabetes, high cholesterol and coronary heart diseases
- Sodium - associated with high blood pressure ($\geq 140/90$ mm Hg) = Major risk factor for strokes, heart attacks, heart failure

Overview – Health concerns?

- Meat and fish (30%), 18% cured/processed meats, main contributors to Irish salt intakes, followed by bread (22%) (FSAI, 2013)
- Animal fats relatively high in saturated fat and cholesterol



??? Health concerns???

Food Safety Authority of Ireland (FSAI)

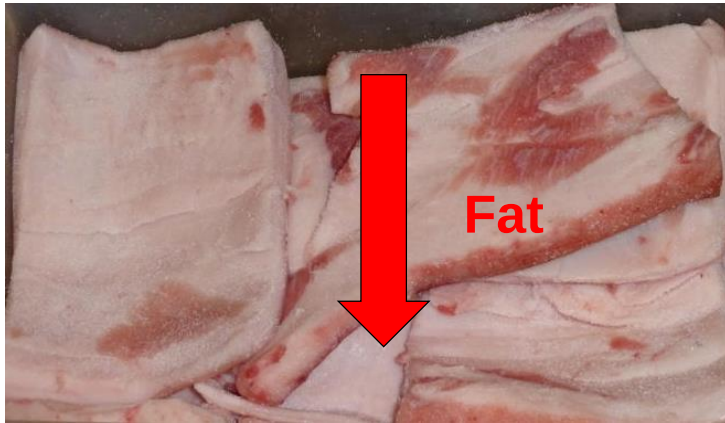
- Agreed national guideline (2011) for meat (and bread) industry to decrease sodium content
- Following sodium levels for processed meat were set:
 - 600mg Na per/100g for uncured cooked meat products,
 - 1300mg Na per/100g for cured uncooked meat products,
 - 600mg Na per/100g for black & white puddings,
 - 550mg Na per/100g for sausages
 - 400mg Na per/100g for burgers
 - no guideline: cured cooked meat products (e.g. cooked ham and corned beef)

Food Standards Agency UK

- 650 mg Na/100g for ham & other cured cooked meat products (2014)

Overview – Salt- and fat-reduction in processed meat

- Salt and fat have key role in processed meat products
 - Reduction is challenging



!! Challenge !!

Overview – Role of salt in processed meat

Salt

- Salt (NaCl) reduces water activity of foods
 - Past: mainly to preserve meat from microbial growth
 - Increasing products shelf-life

$$\text{Salt} \uparrow = a_w \downarrow = \text{Shelf-life} \uparrow$$

- Salt added impacts flavour significantly
 - Perceived saltiness (sodium-related transduction mechanism)
 - Acts as flavour enhancer
 - Reduces sensation of bitterness



Overview – Role of salt in processed meat

- Major role in developing meat texture
- Adding of salt & water technologically necessary - swelling & dissolving myofibrillar proteins (Hamm, 1972)
 - Impact on water & fat binding
 - Processing yields (Barat & Toldrá, 2011)
 - Alteration of sensory properties (e.g. tenderness)

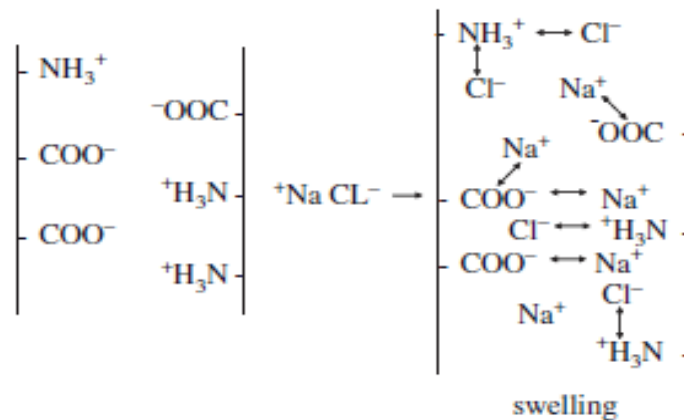


Figure: Swelling of myofibers through diffusion of water surrounded Na^+ and Cl^- ions (Hamm, 1972)

Overview – Role of fat in processed meat

Fat

- Most volatile compounds responsible for flavour in meat found in fat
- Fats are extremely satiating macronutrients (1 g fat = 9.3 kcal)



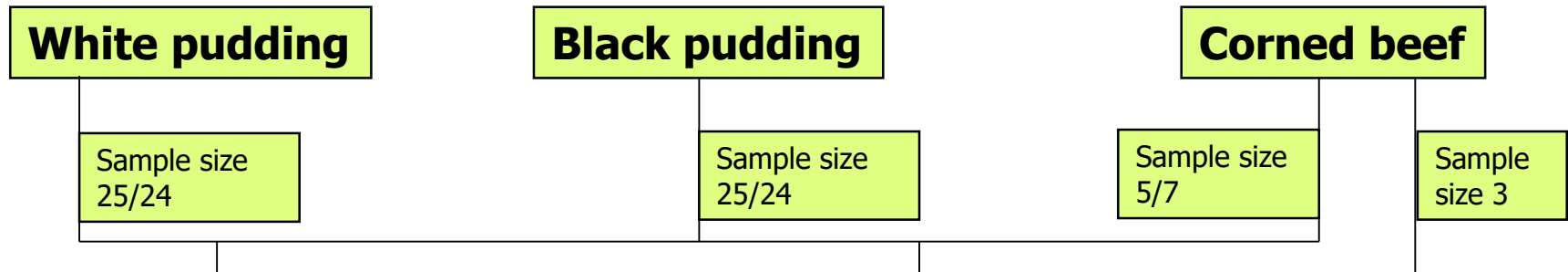
Product development



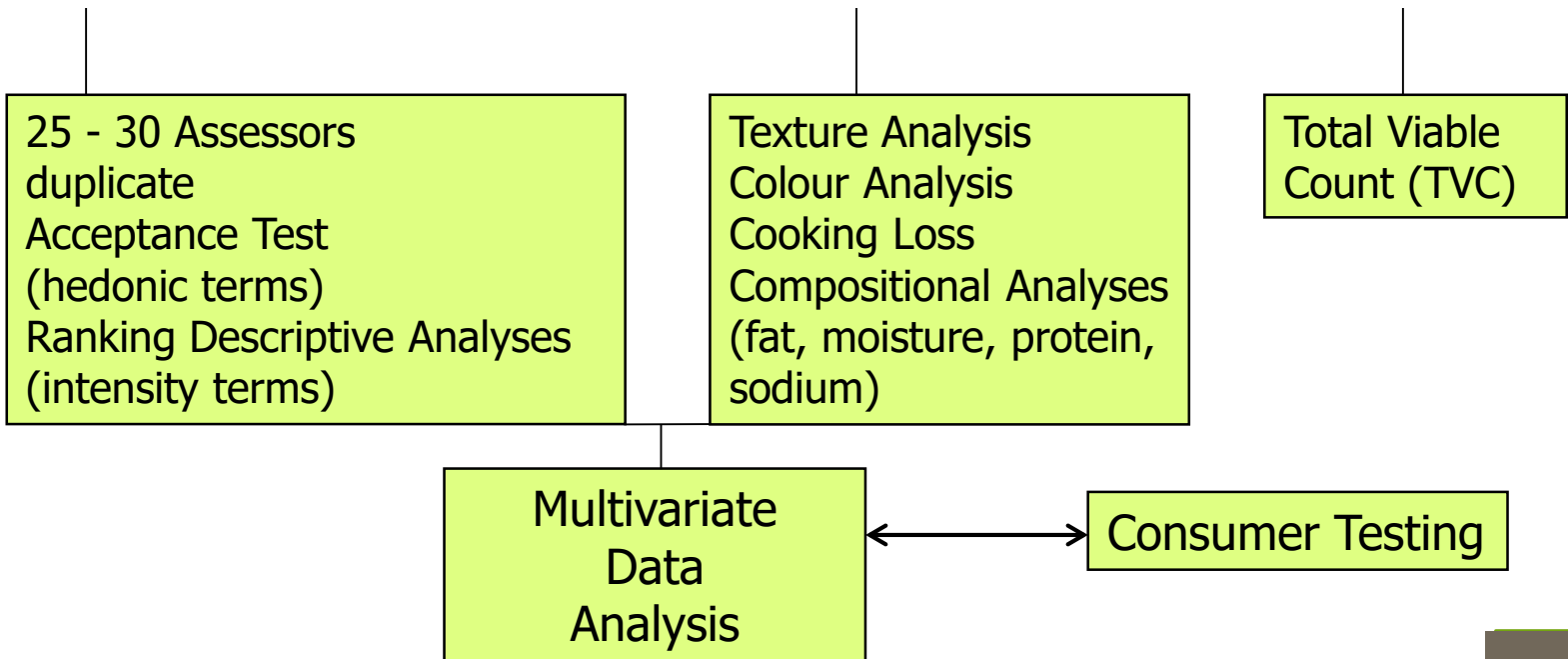
Challenges

- Some producers - scattergun approach taken
 - Start with current recipe & modify ingredient of interest (sugar, fructose, fat, salt, etc.)
 - Reflect current industry & competitor levels
 - Current stipulations & predicted regulatory guidelines
 - Levels above and below ranges - fully explore modification limits in full factorial design.

Materials and Methods



Black Pudding Case study presented
The other studies followed a similar protocol



Effect of different salt and fat levels on the physicochemical properties and sensory quality of black pudding.

Submitted: Food Science & Nutrition



Impact of ingredient replacers on the physicochemical properties and sensory quality of reduced salt and fat black puddings.

Published: Meat Science, 2016, Volume 113, Pages 17-25



Black Pudding Case study presented

Black pudding



Commercial black puddings

- Fat content ranges from 6.0% to 22%, though the majority puddings contain between 13% and 16% fat
- Level of sodium ranges from 520 mg/100 g to 1190 mg/100 g, with an average content of 867 mg/100 g (FSAI, 2013)

Target

- Objective was to investigate the effects of varying the fat and salt levels on the physicochemical and sensory properties of black pudding products, with the target to achieve a highly sensory accepted end product
 - Without the use of replacers
 - With the use of ingredient replacers



Black pudding production

Twenty-five black pudding formulations were produced with varying fat contents (20%, 15%, 10%, 5%, 2,5%) and varying sodium contents (1.0%, 0.8%, 0.6%, 0.4%, 0.2%)

Table 1
Black pudding formulations

Sample ^a	Formulation [%]									
	Meat	Fat	Salt	Water	Blood powder	Seasoning	Oatmeal	Onion	Boiled barley	Rusk
F 20 Na 1.0	12.76	36.70	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.8	13.27	36.70	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.6	13.78	36.70	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.4	14.28	36.70	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.2	14.79	36.70	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 1.0	21.94	27.52	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.8	22.45	27.52	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.6	22.96	27.52	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.4	23.46	27.52	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.2	23.97	27.52	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 1.0	31.11	18.35	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.8	31.62	18.35	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.6	32.13	18.35	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.4	32.64	18.35	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.2	33.14	18.35	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 1.0	40.29	9.17	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.8	40.80	9.17	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.6	41.31	9.17	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.4	41.81	9.17	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.2	42.32	9.17	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 1.0	44.87	4.59	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.8	45.38	4.59	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.6	45.89	4.59	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.4	46.40	4.59	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.2	46.90	4.59	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85

^a Sample code: F = fat, Na = sodium.

Recipe black pudding and white pudding

Black pudding

Blood powder: yes
Cereals: 14.40%
Spiciness: less spicy

	Meat	Fat	Salt	Water	Blood powder	Seasoning	Oatmeal	Onion	Boiled barley	Rusk
F 20 Na 1.0	12.76	36.70	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.8	13.27	36.70	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.6	13.78	36.70	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.4	14.28	36.70	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 20 Na 0.2	14.79	36.70	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 1.0	21.94	27.52	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.8	22.45	27.52	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.6	22.96	27.52	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.4	23.46	27.52	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 15 Na 0.2	23.97	27.52	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 1.0	31.11	18.35	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.8	31.62	18.35	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.6	32.13	18.35	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.4	32.64	18.35	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 10 Na 0.2	33.14	18.35	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 1.0	40.29	9.17	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.8	40.80	9.17	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.6	41.31	9.17	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.4	41.81	9.17	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 5 Na 0.2	42.32	9.17	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 1.0	44.87	4.59	2.54	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.8	45.38	4.59	2.03	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.6	45.89	4.59	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.4	46.40	4.59	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85
F 2.5 Na 0.2	46.90	4.59	0.51	27.00	3.00	1.10	6.55	2.50	3.00	4.85

^a Sample code: F = fat, Na = sodium.

White pudding

no
17.75%
more spicy

Sample ^a	Formulation [%]								
	Meat	Fat	Salt	Water	Seasoning	Oatmeal	Onion	Boiled barley	Rusk
F 20 Na 1.0	18.44	30.77	2.54	27.00	1.00	11.00	2.50	4.35	2.40
F 20 Na 0.8	18.95	30.77	2.03	27.00	1.00	11.00	2.50	4.35	2.40
F 20 Na 0.6	19.46	30.77	1.52	27.00	1.00	11.00	2.50	4.35	2.40
F 20 Na 0.4	19.96	30.77	1.02	27.00	1.00	11.00	2.50	4.35	2.40
F20 Na 0.2	20.47	30.77	0.51	27.00	1.00	11.00	2.50	4.35	2.40
F 15 Na 1.0	26.13	23.08	2.54	27.00	1.00	11.00	2.50	4.35	2.40
F15 Na 0.8	26.64	23.08	2.03	27.00	1.00	11.00	2.50	4.35	2.40
F15 Na 0.6	27.15	23.08	1.52	27.00	1.00	11.00	2.50	4.35	2.40
F 15 Na 0.4	27.66	23.08	1.02	27.00	1.00	11.00	2.50	4.35	2.40
F 15 Na 0.2	28.17	23.08	0.51	27.00	1.00	11.00	2.50	4.35	2.40
F 10 Na 1.0	33.83	15.38	2.54	27.00	1.00	11.00	2.50	4.35	2.40
F 10 Na 0.8	34.33	15.38	2.03	27.00	1.00	11.00	2.50	4.35	2.40
F 10 Na 0.6	34.84	15.38	1.52	27.00	1.00	11.00	2.50	4.35	2.40
F10 Na 0.4	35.35	15.38	1.02	27.00	1.00	11.00	2.50	4.35	2.40
F 10 Na 0.2	35.86	15.38	0.51	27.00	1.00	11.00	2.50	4.35	2.40
F 5 Na 1.0	41.52	7.69	2.54	27.00	1.00	11.00	2.50	4.35	2.40
F 5 Na 0.8	42.03	7.69	2.03	27.00	1.00	11.00	2.50	4.35	2.40
F 5 Na 0.6	42.53	7.69	1.52	27.00	1.00	11.00	2.50	4.35	2.40
F 5 Na 0.4	43.04	7.69	1.02	27.00	1.00	11.00	2.50	4.35	2.40
F 5 Na 0.2	43.55	7.69	0.51	27.00	1.00	11.00	2.50	4.35	2.40
F2.5 Na 1.0	45.36	3.85	2.54	27.00	1.00	11.00	2.50	4.35	2.40
F 2.5 Na 0.8	45.87	3.85	2.03	27.00	1.00	11.00	2.50	4.35	2.40
F 2.5 Na 0.6	46.38	3.85	1.52	27.00	1.00	11.00	2.50	4.35	2.40
F 2.5 Na 0.4	46.89	3.85	1.02	27.00	1.00	11.00	2.50	4.35	2.40
F 2.5 Na 0.2	47.40	3.85	0.51	27.00	1.00	11.00	2.50	4.35	2.40

^a Sample code: F = fat, Na = sodium

Black pudding production



1- Mincer: mince fresh meat to 10mm and fat to 5mm

2- Freezer: store meat and fat

3- Defrost meat and fat at RT 1 day before production

4- Scale: weigh in all ingredients, boil the pearl barley for 40 min

5- Bowl chopper:

(I) add fat and meat, seasonings, salt, blood powder and $\frac{3}{4}$ amount of water

→ chop at high speed for 45 sec

(II) add the rest of water

→ chop at high speed for 30 sec

(III) add oatmeal and onions

→ chop at slow speed for 15 sec

(IV) add boiled pearl barley and rusk

→ chop at slow speed for 30 sec

6- Piston filler: fill the pudding mix into casings and close it with metal clips

7- Zanussi convection oven: puddings are placed in the chamber

phase 1: water steam 100%, heat up at $T = 85^{\circ}\text{C}$

until the internal sausages is $T = 75^{\circ}\text{C}$

phase 2: water steam 100%, hold at $T = 85^{\circ}\text{C}$ for 15 min

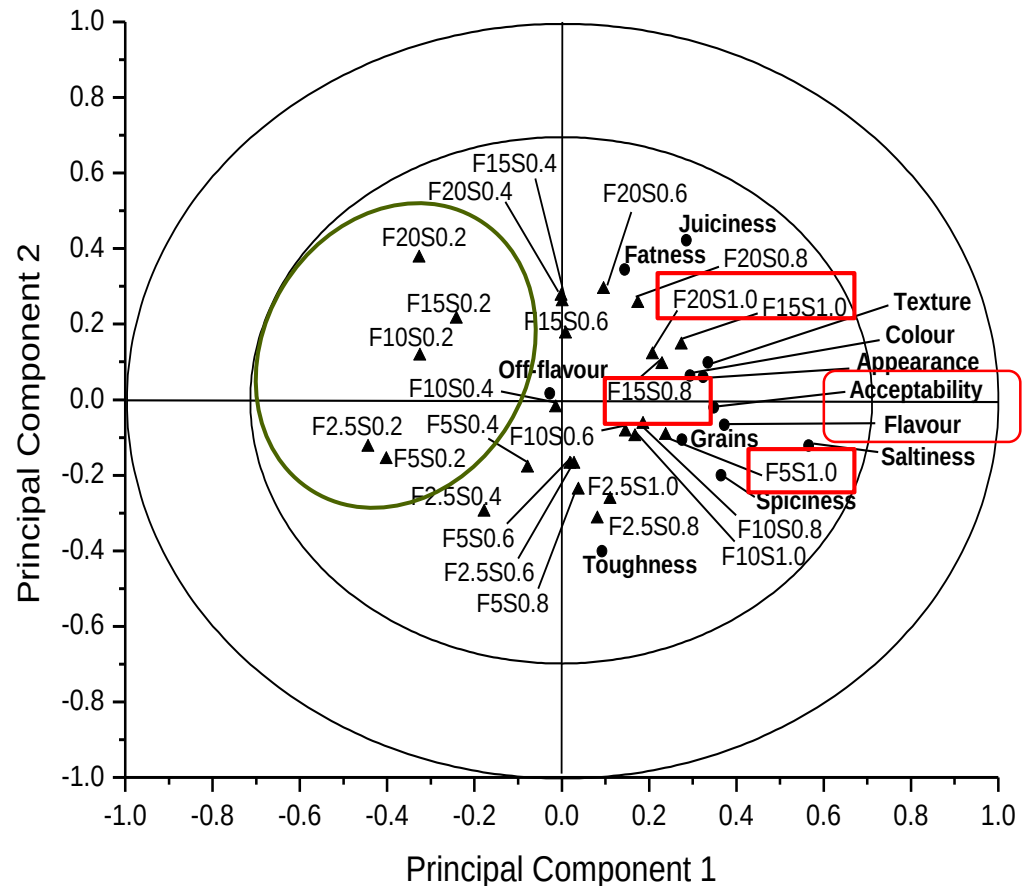
8- Chiller: cool down fast

9- Analysing: compositional and technological analyses, sensory test



Salt- and fat-reduction of black pudding without using replacers

- Samples high in sodium (1.0% - 0.6%) were scored higher in liking of flavour and overall acceptability
- Samples with 0.2% sodium were scored lower in liking of flavour and overall acceptability
- No correlations were observed between different fat levels for liking of flavour
- Salt seemingly plays a key role in consumers' acceptance



Salt- and fat-reduction of black pudding without using replacers

- Samples with 0.6% sodium and 10% fat displayed a positive ($P < 0.05$) correlation to liking of flavour and overall acceptability**
 - Meets the sodium target level (0.6%) set FSAI, and shows additionally a fat reduction

P-values of regression coefficients from ANOVA values of regression coefficients from APLSR for the hedonic and intensity sensory terms of reheated black pudding, including significance and correlation

Sample ^a	Hedonic term ^b					Intensity term						
	Appearance	Flavour	Texture	Colour	Acceptability	Grains	Fatness	Spiciness	Saltiness	Juiciness	Toughness	Off-flavour
F 20 Na 1.0	0.0014 **	0.0052 **	0.0012 **	0.0022 **	0.0025 **	0.0304 *	0.0081 **	0.0498 *	0.0106 *	0.0021 **	0.2418 ns	-0.7242 ns
F 20 Na 0.8	0.0151 *	0.0957 ns	0.0082 **	0.0145 *	0.0454 *	0.3326 ns	0.0007 ***	0.6170 ns	0.1228 ns	0.0011 **	0.0044 **	-0.9711 ns
F 20 Na 0.6	0.0542 ns	0.5087 ns	0.0225 *	0.0492 *	0.2457 ns	0.8110 ns	0.0008 ***	0.2938 ns	0.5694 ns	0.0008 ***	0.0002 ***	-0.8757 ns
F 20 Na 0.4	-0.4589 ns	-0.3928 ns	-0.2496 ns	-0.4144 ns	-0.7689 ns	-0.1145 ns	-0.0008 ***	-0.0227 *	-0.2899 ns	-0.0020 **	-0.0005 ***	0.7165 ns
F 20 Na 0.2	-0.0041 **	-0.0004 ***	-0.0200 *	-0.0041 **	-0.0015 **	-0.0001 ***	-0.0378 *	-0.0001 ***	-0.0001 ***	-0.0483 *	-0.0001 ***	0.5253 ns
F 15 Na 1.0	0.0001 ***	0.0001 ***	0.0002 ***	0.0001 ***	0.0001 ***	0.0017 **	0.0047 **	0.0012 **	0.0003 ***	0.0011 **	0.2170 ns	-0.7066 ns
F 15 Na 0.8	0.0003 ***	0.0010 ***	0.0003 ***	0.0006 ***	0.0004 ***	0.0030 **	0.0089 **	0.0036 **	0.0003 ***	0.0015 **	0.4736 ns	-0.6651 ns
F 15 Na 0.6	0.4595 ns	0.6617 ns	0.3025 ns	0.4186 ns	0.9821 ns	0.2760 ns	0.0093 **	0.0935 ns	0.5622 ns	0.0116 *	0.0010 ***	-0.7559 ns
F 15 Na 0.4	0.5053 ns	0.4722 ns	0.2987 ns	0.4687 ns	0.8221 ns	0.1779 ns	0.0021 **	0.0553 ns	0.3742 ns	-0.0052 **	0.0016 **	0.7231 ns
F 15 Na 0.2	-0.0260 *	-0.0029 **	-0.0533 ns	-0.0323 *	-0.0055 **	-0.0015 **	-0.1499 ns	-0.0002 ***	-0.0017 **	-0.5646 ns	-0.0003 ***	0.4886 ns
F 10 Na 1.0	0.0263 *	0.0077 **	0.0456 *	0.0304 *	0.0182 *	0.0042 **	0.6154 ns	0.0025 **	0.0051 **	0.8051 ns	0.0056 **	-0.4731 ns
F 10 Na 0.8	0.0029 **	0.0003 ***	0.0048 **	0.0038 **	0.0007 ***	0.0010 **	0.8392 ns	0.0002 ***	0.0003 ***	0.3407 ns	0.0304 *	-0.4727 ns
F 10 Na 0.6	0.0264 *	0.0101 *	0.0422 *	0.0358 *	0.0134 *	0.0078 **	0.6586 ns	0.0041 **	0.0034 **	0.8169 ns	0.0310 *	-0.4968 ns
F 10 Na 0.4	-0.7403 ns	-0.8510 ns	-0.7157 ns	-0.7320 ns	-0.8109 ns	-0.9219 ns	-0.6268 ns	-0.9756 ns	-0.8649 ns	-0.6292 ns	-0.7184 ns	0.9969 ns
F 10 Na 0.2	-0.0013 **	-0.0001 ***	-0.0024 **	-0.0022 **	-0.0002 ***	-0.0003 ***	-0.7793 ns	-0.0001 ***	-0.0001 ***	-0.2123 ns	-0.0092 **	0.4753 ns
F 5 Na 1.0	0.0030 **	0.0004 ***	0.0033 **	0.0048 **	0.0006 ***	0.0001 ***	0.9412 ns	0.0001 ***	0.0004 ***	0.3286 ns	0.0166 *	-0.4901 ns
F 5 Na 0.8	0.9129 ns	0.1708 ns	0.5954 ns	0.8232 ns	0.3506 ns	0.0615 ns	0.0015 **	0.0170 *	0.1231 ns	0.0053 **	0.0022 **	-0.6523 ns
F 5 Na 0.6	0.8134 ns	0.3378 ns	0.5960 ns	0.7501 ns	0.5785 ns	0.1125 ns	0.0301 *	0.0385 *	0.2556 ns	0.0458 *	0.0063 **	-0.6912 ns
F 5 Na 0.4	-0.1441 ns	-0.4879 ns	-0.0789 ns	-0.1278 ns	-0.3185 ns	-0.8955 ns	-0.0069 **	-0.7390 ns	-0.5449 ns	-0.0077 **	-0.0025 **	0.9230 ns
F 5 Na 0.2	-0.0003 ***	-0.0005 ***	-0.0001 ***	-0.0018 **	-0.0005 ***	-0.0014 **	-0.0009 ***	-0.0004 ***	-0.0001 ***	-0.0001 ***	-0.2470 ns	0.6564 ns
F 2.5 Na 1.0	0.3853 ns	0.0136 *	0.6522 ns	0.4670 ns	0.0517 ns	0.0062 **	0.0199 *	0.0020 **	0.0205 *	0.0417 *	0.0006 ***	-0.5883 ns
F 2.5 Na 0.8	0.7642 ns	0.0769 ns	0.8855 ns	0.8625 ns	0.1926 ns	0.0319 *	0.0006 ***	0.0037 **	0.0355 *	0.0013 **	0.0001 ***	-0.6302 ns
F 2.5 Na 0.6	0.9538 ns	0.3701 ns	0.7213 ns	0.8870 ns	0.5369 ns	0.1876 ns	0.0602 ns	0.0961 ns	0.2861 ns	0.0755 ns	0.0260 *	-0.6834 ns
F 2.5 Na 0.4	-0.0063 **	-0.0873 ns	-0.0018 **	-0.0072 **	-0.0269 *	-0.3848 ns	-0.0001 ***	-0.8200 ns	-0.0904 ns	-0.0001 ***	-0.0007 ***	0.9943 ns
F 2.5 Na 0.2	-0.0002 ***	-0.0001 ***	-0.0001 ***	-0.0002 ***	-0.0001 ***	-0.0005 ***	-0.0074 **	-0.0001 ***	-0.0001 ***	-0.0002 ***	-0.7429 ns	0.6169 ns

^a Sample code: F = fat, Na = sodium.

Salt- and fat-reduction of black pudding containing different replacers

Impact of 11 different ingredient replacer combinations were investigated for black puddings containing either 10% fat and 0.4% sodium or 5% fat and 0.6% sodium with the focus of producing a more highly accepted end product with further reductions in fat and salt levels

Black pudding formulations with different replacers

Sample ^c	Formulation [%]										Replacer(s)
	Meat	Fat	Salt	Water	Blood powder	Seasoning	Oatmeal	Onion	Boiled barley	Rusk	
Control 1	35.60	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	-
Control 2	42.79	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	-
Wheat bran 1	34.60	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	1.00
Wheat bran 2	41.79	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	1.00
Sodium citrate 1	35.15	15.38	0.97	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.50
Sodium citrate 2	42.34	7.69	1.47	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.50
Carrageen 1	35.10	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.50
Carrageen 2	42.29	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.50
Pectin 1	35.20	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.40
Pectin 2	42.39	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.40
KCl 1	34.58	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	1.02
KCl 2	42.11	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.68
KClG 1	34.08	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.91/0.61 ^a
KClG 2	41.77	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.61/0.41 ^a
CMC 1	35.10	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.50
CMC 2	42.29	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.50
Seaweed 1	32.30	15.38	0.72	27.00	3.00	1.10	6.55	2.50	3.00	4.85	3.30
Seaweed 2	39.49	7.69	1.22	27.00	3.00	1.10	6.55	2.50	3.00	4.85	3.30
PuraQ 1	32.60	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	3.00
PuraQ 2	39.79	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	3.00
KCPCI 1	34.10	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.5/0.5/0.5 ^b
KCPCI 2	41.29	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	0.5/0.5/0.5 ^b
WMS 1	32.60	15.38	1.02	27.00	3.00	1.10	6.55	2.50	3.00	4.85	3.00
WMS 2	39.79	7.69	1.52	27.00	3.00	1.10	6.55	2.50	3.00	4.85	3.00

^c Sample code: 1 = 10% fat and 0.4% sodium, 2 = 5% fat and 0.6% sodium. KCl: potassium chloride, KClG: mixture of potassium chloride and glycine, CMC: carboxymethylcellulose, seaweed: seaweed wakame, PuraQ: PuraQ® Arome NA4, KCPCI: combination of potassium citrate, potassium phosphate and potassium chloride, WMS: waxy maize starch.

Salt- and fat-reduction of black pudding containing different replacers

- Some added replacers showed an increase with respect to spiciness, saltiness or fatness perceptions, but this was not observed consistently with respect to the two salt and fat formulations
- Samples formulated with 5% fat and 0.6% sodium and containing pectin and KCPCl; and sample formulated with 10% fat and 0.4% sodium and containing WMS were liked ($P < 0.05$) in terms of flavour and overall acceptance**
 → Lower sodium level (0.4%) than the recommended sodium level (0.6%) of FSAI

P-values of regression coefficients from ANOVA values of regression coefficients from APLSR for the hedonic and intensity sensory terms of reheated black pudding containing replacers, including significance and correlation

Sample ^a	Hedonic term ^b		Intensity term									
	Appearance	Flavour	Texture	Colour	Acceptability	Grains	Fatness	Spiciness	Saltiness	Juiciness	Toughness	Off-flavour
Control 1	-0.7790 ns	0.7103 ns	0.3218 ns	-0.9829 ns	0.4562 ns	-0.1001 ns	0.7283 ns	-0.0362*	-0.0013**	0.0036**	-0.0030**	-0.4126 ns
Control 2	0.8427 ns	-0.4376 ns	-0.2884 ns	0.6175 ns	-0.3443 ns	0.3137 ns	-0.9614 ns	0.2030 ns	0.0902 ns	-0.1706 ns	0.1433 ns	0.3406 ns
Wheat bran 1	-0.5086 ns	0.4939 ns	0.9683 ns	-0.5142 ns	0.8058 ns	-0.2855 ns	0.5150 ns	-0.0246*	-0.0014**	0.1297 ns	-0.0350*	-0.9746 ns
Wheat bran 2	0.7282 ns	-0.9436 ns	-0.9453 ns	0.8664 ns	-0.9445 ns	0.0607 ns	-0.1608 ns	0.0258*	0.0173*	-0.3589 ns	0.0035**	0.4016 ns
Sodium citrate 1	0.4393 ns	-0.4337 ns	-0.7440 ns	0.6458 ns	-0.5517 ns	0.2724 ns	-0.1095 ns	0.6942 ns	0.2733 ns	-0.8907 ns	0.5067 ns	0.3737 ns
Sodium citrate 2	0.6020 ns	-0.9189 ns	-0.8903 ns	0.7997 ns	-0.9961 ns	0.8939 ns	0.5367 ns	0.2494 ns	0.3670 ns	-0.4095 ns	0.7795 ns	0.3927 ns
Carrageen 1	0.5417 ns	-0.0059**	-0.0335*	0.3436 ns	-0.0206*	0.01330*	-0.0362*	0.0511*	0.0430*	-0.0424*	0.0091**	0.0491*
Carrageen 2	0.9185 ns	-0.0143*	-0.0708 ns	0.3097 ns	-0.0117*	0.4002 ns	-0.6421 ns	0.3741 ns	0.7393 ns	-0.1377 ns	0.0301*	0.1900 ns
Pectin 1	-0.6787 ns	0.2500 ns	0.3638 ns	-0.3281 ns	0.3097 ns	-0.2494 ns	0.9753 ns	-0.1011 ns	-0.0408*	0.4486 ns	-0.1015 ns	-0.6421 ns
Pectin 2	-0.3350 ns	0.0533*	0.0627 ns	-0.1725 ns	0.0526*	-0.3083 ns	0.5580 ns	-0.7973 ns	-0.8164 ns	0.1094 ns	-0.1402 ns	-0.0340*
KCl 1	0.2826 ns	-0.5388 ns	-0.5855 ns	0.3523 ns	-0.5087 ns	0.4029 ns	-0.6609 ns	0.7894 ns	0.8068 ns	-0.3267 ns	0.2553 ns	0.3080 ns
KCl 2	0.7006 ns	-0.7554 ns	-0.1747 ns	0.8929 ns	-0.2689 ns	0.3157 ns	-0.0907 ns	0.0050**	0.0002***	-0.0279*	0.0127*	0.3558 ns
KClG 1	-0.3789 ns	0.8013 ns	0.3331 ns	-0.8250 ns	0.5556 ns	-0.4568 ns	0.03013*	-0.8683 ns	-0.1865 ns	0.0715 ns	-0.0082**	-0.5686 ns
KClG 2	0.5630 ns	-0.5629 ns	-0.9497 ns	0.9520 ns	-0.8780 ns	0.4680 ns	-0.3496 ns	0.0029**	0.0027**	-0.9386 ns	0.3065 ns	0.2711 ns
CMC 1	-0.3839 ns	0.1063 ns	0.0968 ns	-0.1263 ns	0.0837 ns	-0.0005***	0.9801 ns	-0.0686 ns	-0.0037**	0.1048 ns	-0.0001***	-0.1337 ns
CMC 2	-0.5349 ns	0.6673 ns	0.4713 ns	-0.3790 ns	0.4238 ns	-0.0054**	0.3493 ns	-0.4095 ns	-0.7176 ns	0.1253 ns	-0.0001***	-0.3388 ns
Seaweed 1	-0.76265 ns	0.6570 ns	0.6329 ns	-0.5182 ns	0.6294 ns	-0.4106 ns	0.9047 ns	-0.9138 ns	-0.7561 ns	0.6663 ns	-0.3687 ns	-0.6742 ns
Seaweed 2	0.5087 ns	-0.8241 ns	-0.4760 ns	0.6014 ns	-0.5314 ns	0.9891 ns	-0.9504 ns	0.0243*	0.0279*	-0.8094 ns	0.6200 ns	0.2524 ns
PuraQ 1	-0.9632 ns	0.3608 ns	0.0738 ns	-0.4998 ns	0.1559 ns	-0.7595 ns	0.4701 ns	-0.1738 ns	-0.0416*	0.1138 ns	-0.0776 ns	-0.2286 ns
PuraQ 2	0.8001 ns	-0.7377 ns	-0.6005 ns	0.9575 ns	-0.6230 ns	0.0702 ns	-0.5635 ns	0.2271 ns	0.1276 ns	-0.1830 ns	0.0315*	0.3930 ns
KCPCl 1	0.1343 ns	-0.1338 ns	-0.6697 ns	0.2486 ns	-0.2844 ns	0.3586 ns	-0.0040**	0.1078 ns	0.0014**	-0.1004 ns	0.0058**	0.1211 ns
KCPCl 2	-0.0624 ns	0.0243*	0.0342*	-0.0578 ns	0.0183*	-0.9482 ns	0.0982 ns	-0.9236 ns	-0.4330 ns	0.9379 ns	-0.7138 ns	-0.0149*
WMS 1	-0.0915 ns	0.0042**	0.0064**	-0.0600 ns	0.0037**	-0.6648 ns	0.0783 ns	-0.3133 ns	-0.7888 ns	0.6738 ns	-0.8046 ns	-0.0024**
WMS 2	-0.2590 ns	0.3934 ns	0.1520 ns	-0.3029 ns	0.1323 ns	-0.7532 ns	0.3685 ns	-0.0005***	-0.0004***	0.8857 ns	-0.5837 ns	-0.0055**

^a Sample code: 1 = 10% fat and 0.4% sodium, 2 = 5% fat and 0.6% sodium. KCl: potassium chloride, KClG: mixture of potassium chloride and glycine, CMC: carboxymethylcellulose, PuraQ: PuraQ®Arome NA4, seaweed: seaweed wakame, KCPCl: combination of potassium citrate, potassium phosphate and potassium chloride, WMS: waxy maize starch.

Survey

- Public health campaigns have successfully raised consumers' awareness to the negative health impacts of diets high in salt and fat
- The majority of respondents were well informed, nevertheless, less participants transferred this knowledge into their daily dietary habits
- No conflict can be seen for the concept of traditional food products (white and black puddings) and innovation (salt and fat reduction), as long as the intrinsic sensory character was maintained
- Respondents are looking for more information and a wider range of salt- and fat-reduced foods

Overall conclusion

Studies on product development

- It is possible to reduce salt and saturated fat contents in Irish traditional meat products
 - different products require different modifications
- Salt- and fat-reduction in black pudding is possible by stealth
- Even lower salt and fat contents in black pudding were obtained by using ingredient replacers
- To achieve sensory accepted salt- and fat-reduced white puddings the use of additives was necessary
- The use of additives was necessary to achieve sensory accepted salt-reduced corned beefs

Black pudding

10 % fat and 0.6% sodium

5% fat and 0.6% sodium containing pectin

5% fat and 0.6% sodium containing potassium citrate, phosphate and chloride

10% fat and 0.4% sodium containing waxy maize starch



White pudding

10% fat and 0.6% sodium containing sodium citrate

10% fat and 0.6% sodium containing potassium chloride and glycine



Corned beef

0.4% sodium containing potassium lactate and glycine





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