The variability of European beef can be reduced by predicting consumer satisfaction

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Outline

- Consumers want quality beef but can't identify it
- Consumers have a consistent appreciation of beef value and quality
- Predicting eating quality

Which is better?

And why?

Which is better?

And why?

- Colour
- Knowledge of cut/muscle
- Marbling
- Feel?

Which is better?

And why?

- Colour
- Knowledge of cut/muscle
- Marbling
- Feel?

Which is better?

And why?

- Branded products?
  - Small market share
  - Refer to extrinsic quality

Which is better?

And why?

Consumers want a reliable eating quality guarantee

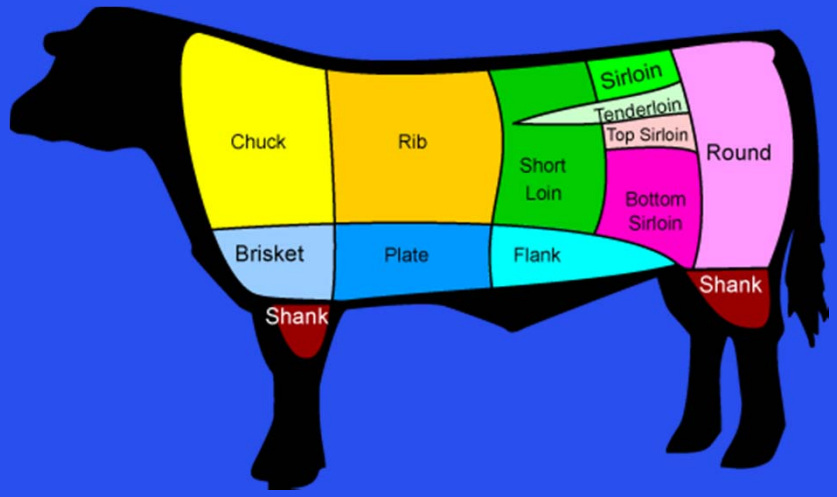
Verbeke *et al* 2010

Can we grade beef for eating quality?

Beef Quality Prediction

Consumers

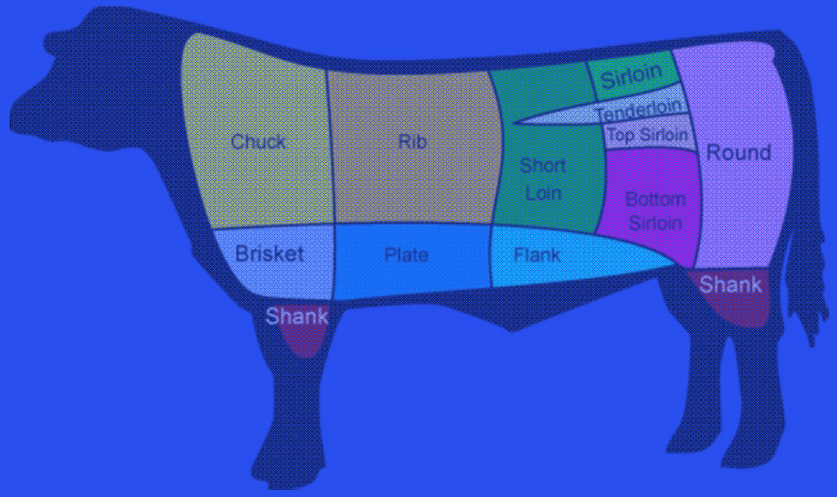
Cattle



Beef Quality Prediction

Consumers

Cattle



Are consumers predictable?

1. Sensory scores 70% accurate in predicting quality grades for beef
    1. Australia
    2. Japan
    3. Korea
    4. South Africa
2. Minimal effect of demographics
    1. Age
    2. Importance of beef in the diet

3. Consumers willing to pay twice as much for Premium quality

£ $ zł €

Hypotheses - For European Consumers

1. Sensory scores will accurately categorise beef into quality groups

2. Demographics will only have small effects on sensory scores

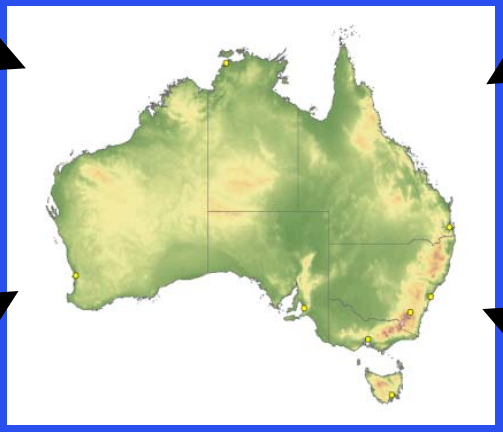
3. Consumers will pay more for better quality beef

Collaborative partners

Poland

France

Australia



Nth Ireland

Ireland

Consumer testing

19,492 Consumers

Consumer testing

Untrained

19,492 Consumers

Consumer testing

Untrained

19,492 Consumers

Demographic questionnaire

- Age
- Gender
- Income
- Occupation
- Children/adults in the household
- Frequency of eating beef
- Importance of beef
- Preferred cooking doneness

Consumer testing

Untrained

19,492 Consumers

X 7 samples

- 1 medium quality ‘link’ sample
- 6 experimental samples
  - ranging in quality
- *Latin* square design

Consumer testing

Untrained

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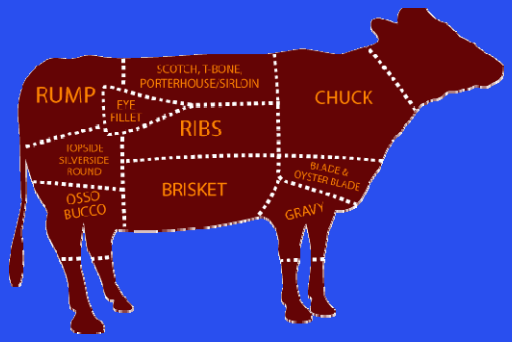
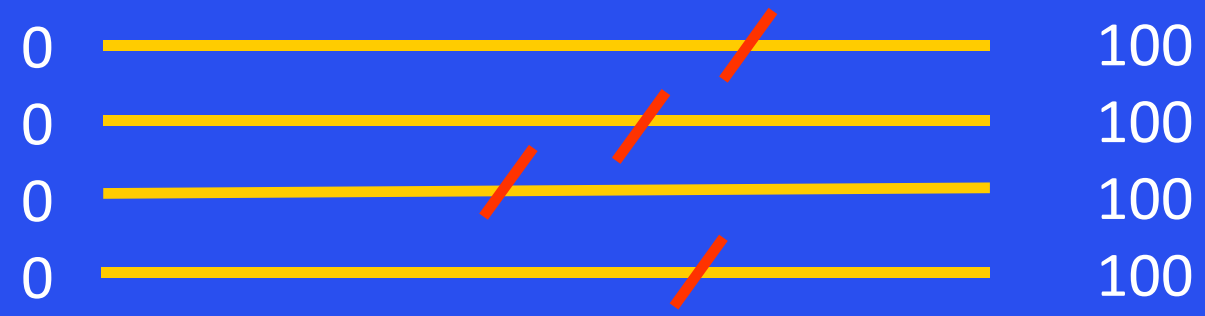


774 Carcasses

The Meat Standards Australia System

- Scored for
  - Tenderness
  - Juiciness
  - Flavour
  - Overall Liking



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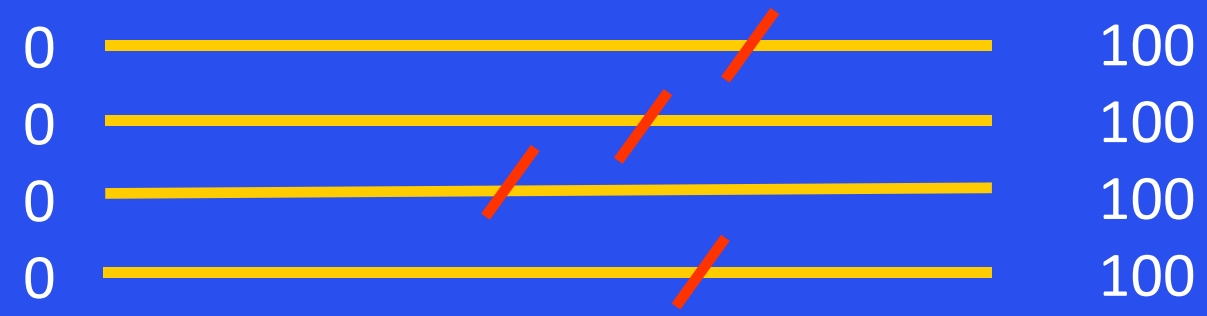


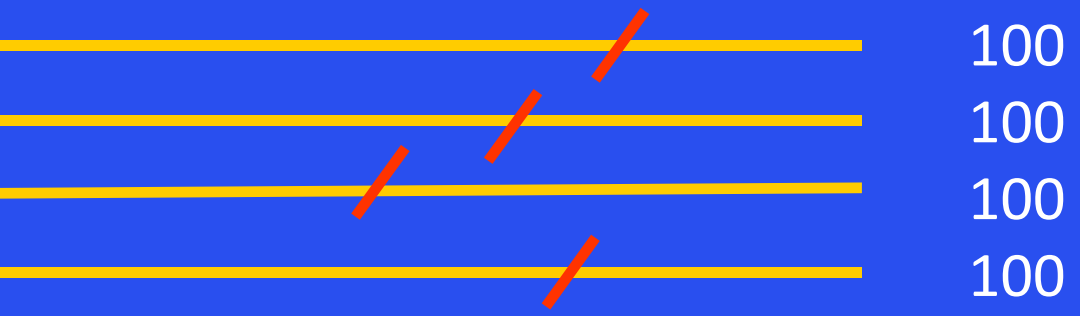
- Scores then weighted and combined into a single MQ4 value

Tenderness x 0.3
+
Juiciness x 0.1
+
Flavour x 0.3
+
Overall Liking x 0.3

MQ4

The Meat Standards Australia System

- Scored for
  - Tenderness 0 — 100
  - Juiciness 0 — 100
  - Flavour 0 — 100
  - Overall Liking 0 — 100



- Categorised as:
  - ❑ Unsatisfactory
  - ❑ Good every day
  - ☑ Better than every day
  - ❑ Premium

- Value € $ £ zł:
  - ❑ Unsatisfactory
  - ❑ Good every day
  - ❑ Better than every day
  - ❑ Premium

Statistical analysis

- Discriminant analysis
  - Accuracy of using the sensory scores to categorise beef samples into quality grades
- Linear mixed effects model
  - Demographic effects on sensory scores
  - Willingness to pay by country

Discriminant Analysis

	Australia	France	Ireland	Northern Ireland	Poland
Accuracy (average)	72.1%	75%	59.6%	66.1%	67.3%

- Scored for
  - Tenderness
  - Juiciness
  - Flavour
  - Overall Liking

Discriminant

- Categorised as:
  - ❑ Unsatisfactory
  - ❑ Good every day
  - ❑ Better than every day
  - ❑ Premium

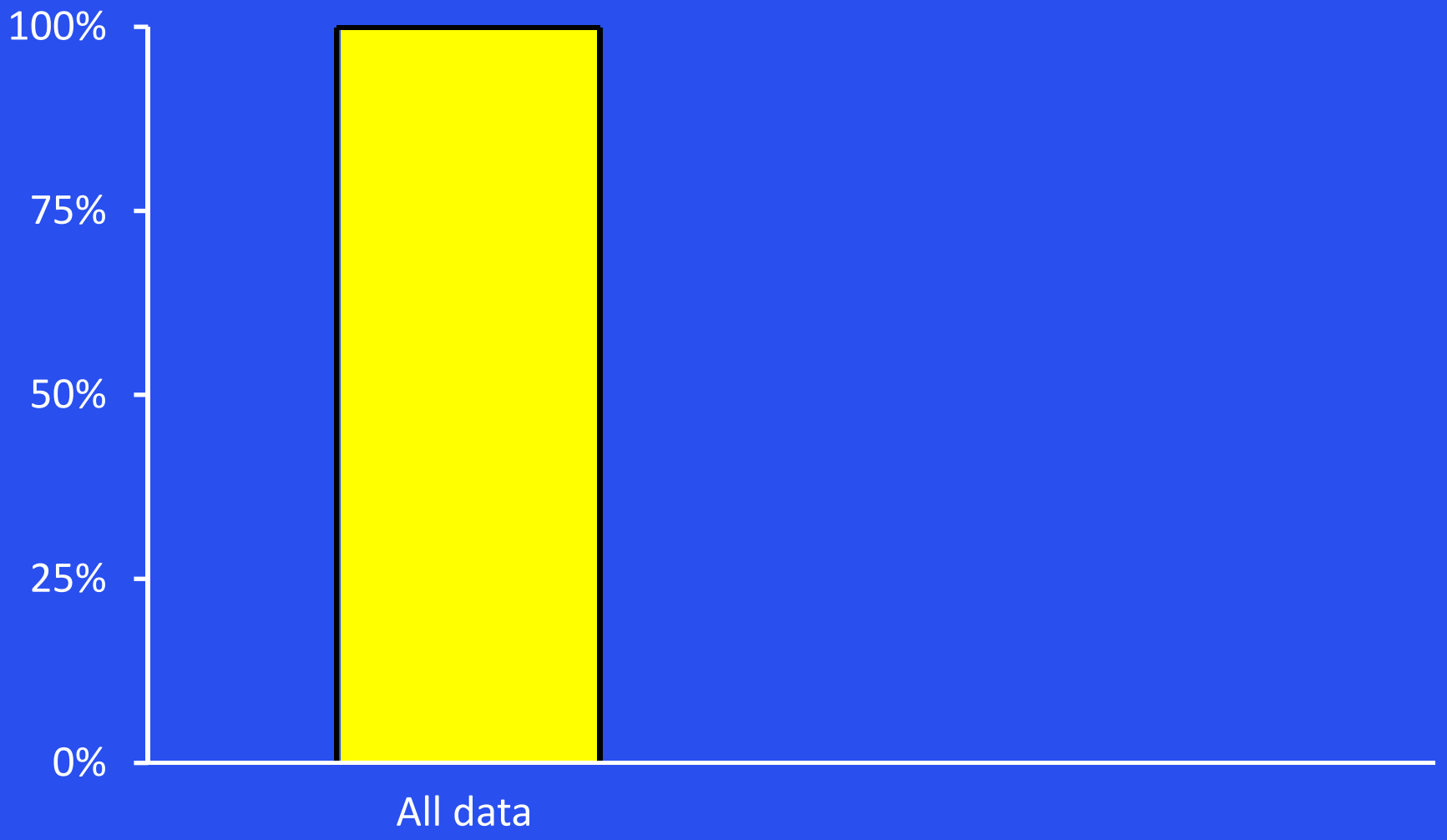
Discriminant Analysis

	Australia	France	Ireland	Northern Ireland	Poland
Accuracy (average)	72.1%	75%	59.6%	66.1%	67.3%
Premium	86.4%	85.3%	67%	77.6%	77.1%
Better-than-every-day	58%	64.5%	44%	49.5%	51.2%
Good-every-day	62.2%	71.7%	46.6%	55.5%	59.7%
Unsatisfactory	81.7%	81.3%	80.6%	81.9%	81%

Discriminant Analysis

	Australia	France	Ireland	Northern Ireland	Poland
Accuracy (average)	72.1%	75%	59.6%	66.1%	67.3%
Premium	**86.4%**	**85.3%**	**67%**	**77.6%**	**77.1%**
Better-than-every-day	58%	64.5%	44%	49.5%	51.2%
Good-every-day	62.2%	71.7%	46.6%	55.5%	59.7%
Unsatisfactory	**81.7%**	**81.3%**	**80.6%**	**81.9%**	**81%**

Percentage samples in each category



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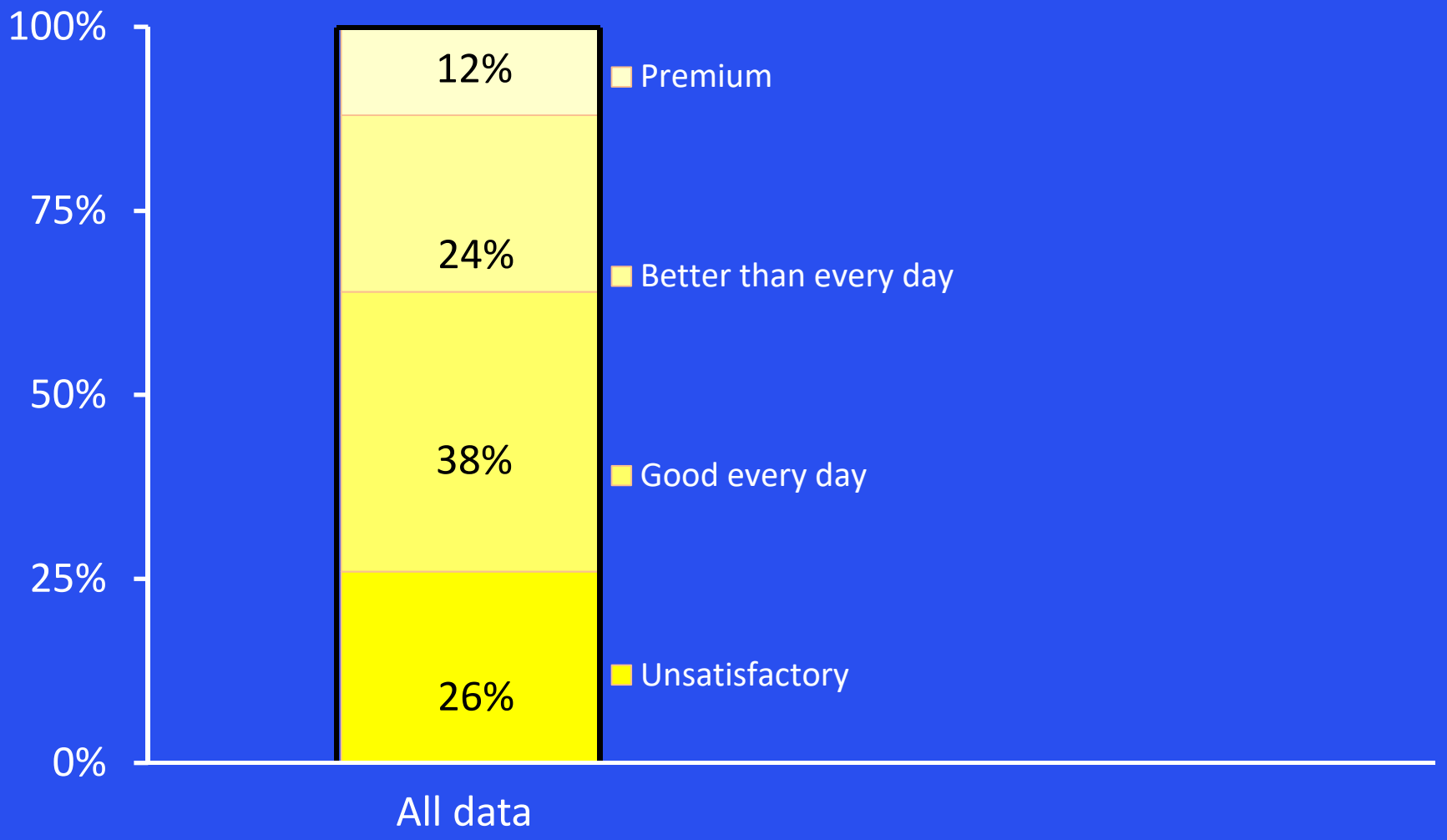

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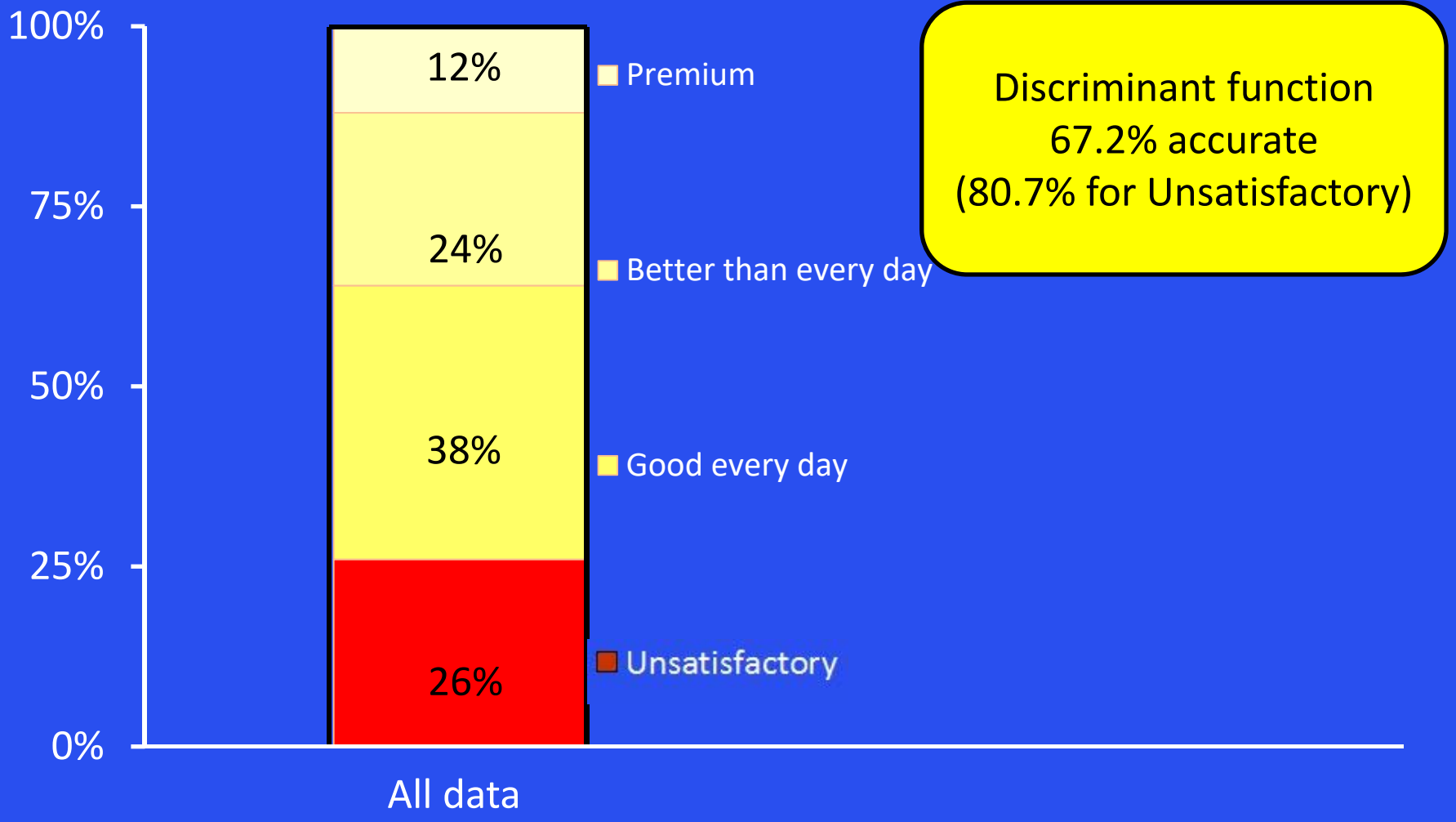
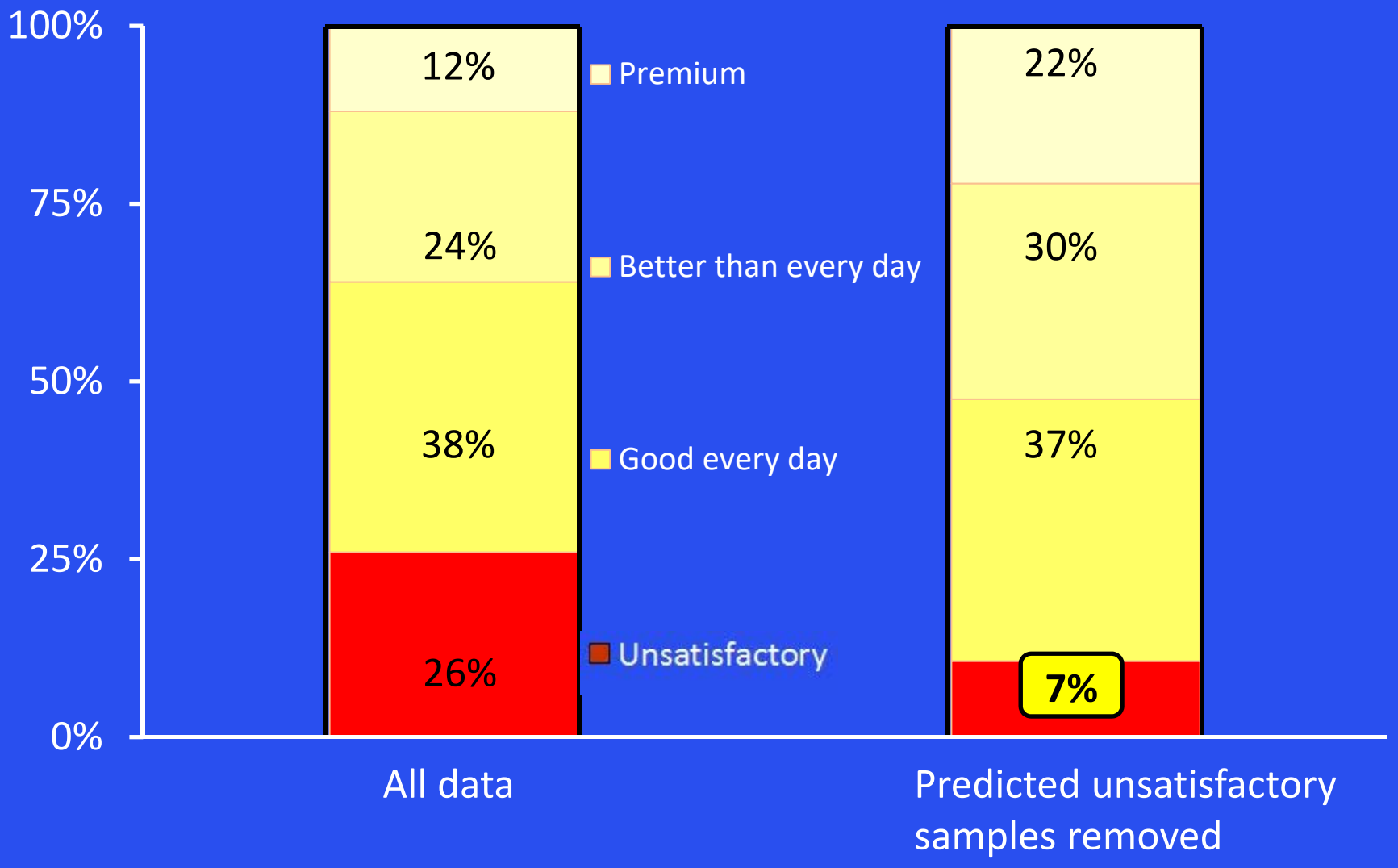
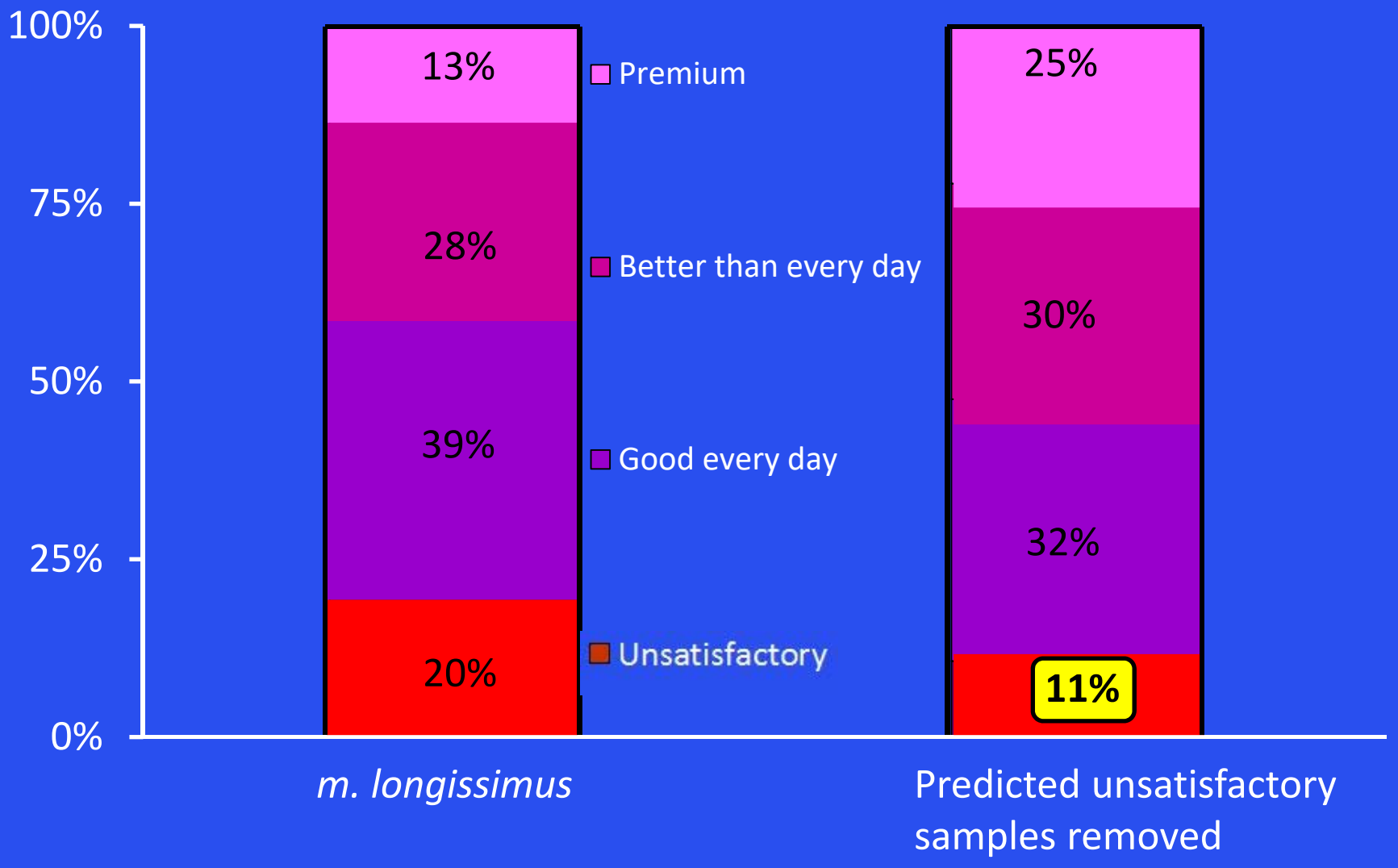


Discriminant function
67.2% accurate
(80.7% for Unsatisfactory)

Percentage samples in each category



Percentage samples in each category



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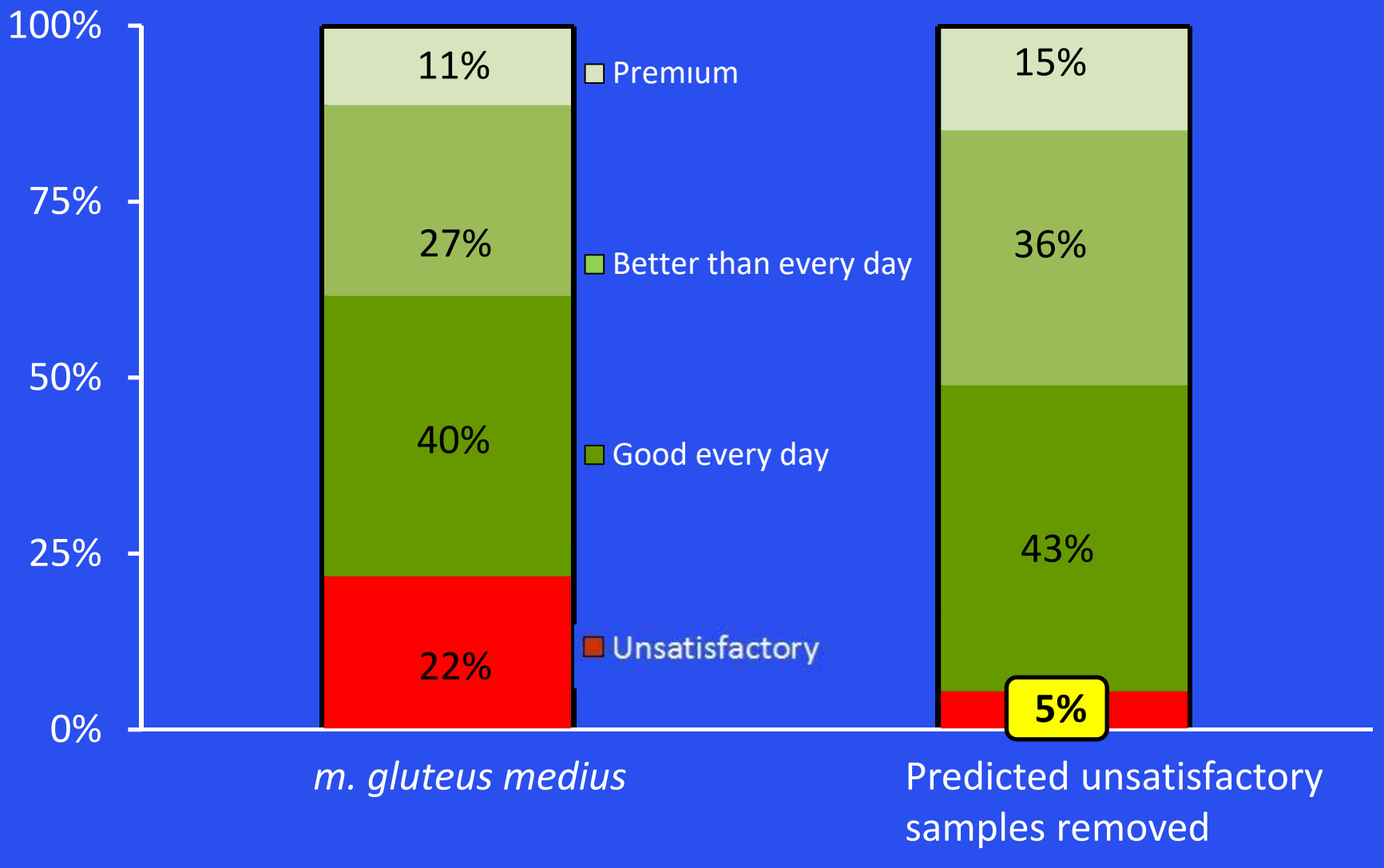

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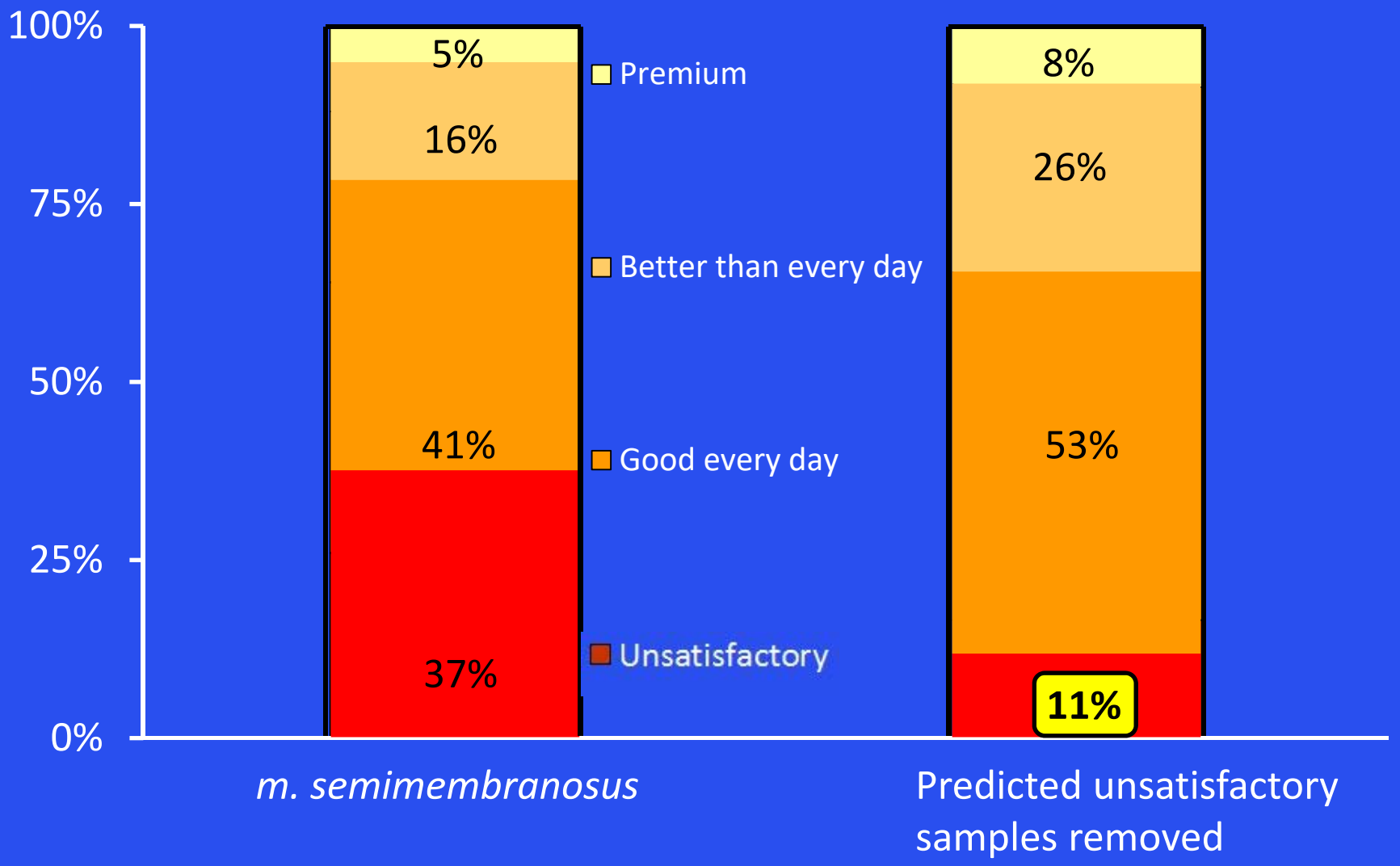

Demographics

	France	Ireland	Northern Ireland	Poland
Age				
Gender				
Income				
Occupation				
Children in the household				
Adults in the household				
Frequency of eating beef				
Importance of beef				
Preferred cooking doneness				

Demographics

	France	Ireland	Northern Ireland	Poland
Age				
Gender	✓	✓	✓	✓
Income				
Occupation				
Children in the household				
Adults in the household				
Frequency of eating beef				
Importance of beef	✓	✓	✓	✓
Preferred cooking doneness		✓	✓	✓

Demographics

	France	Ireland	Northern Ireland	Poland
Age				
Gender → Men > Women	1 point	1-2 points	1 point	1 point
Income				
Occupation				
Children in the household				
Adults in the household				
Frequency of eating beef				
Importance of beef	✓	✓	✓	✓
Preferred cooking doneness		✓	✓	✓

Demographics

	France	Ireland	Northern Ireland	Poland
Age				
Gender → Men > Women	1 point	1-2 points	1 point	1 point
Income				
Occupation				
Children in the household				
Adults in the household				
Frequency of eating beef				
Importance of beef → Positive	6-18 points	3 points (overall)	2.5 points	1-2 points
Preferred cooking doneness		✓	✓	✓

Demographics

	France	Ireland	Northern Ireland	Poland
Age				
Gender → Men > Women	1 point	1-2 points	1 point	1 point
Income				
Occupation				
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Adults in the househ				
Frequency of eating b				
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Preferred cooking doneness		✓	✓	✓

Poor spread of data across the "importance" categories

Demographics

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Gender → Men > Women	1 point	1-2 points	1 point	1 point
Income				
Occupation				
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Frequency of eating beef				
Importance of beef → Positive	6-18 points	3 points (overall)	2.5 points	1-2 points
Preferred cooking doneness		2-3 points ↑	4 points ↑	1-3 points ↓

Demographics

	France	Ireland	Northern Ireland	Poland
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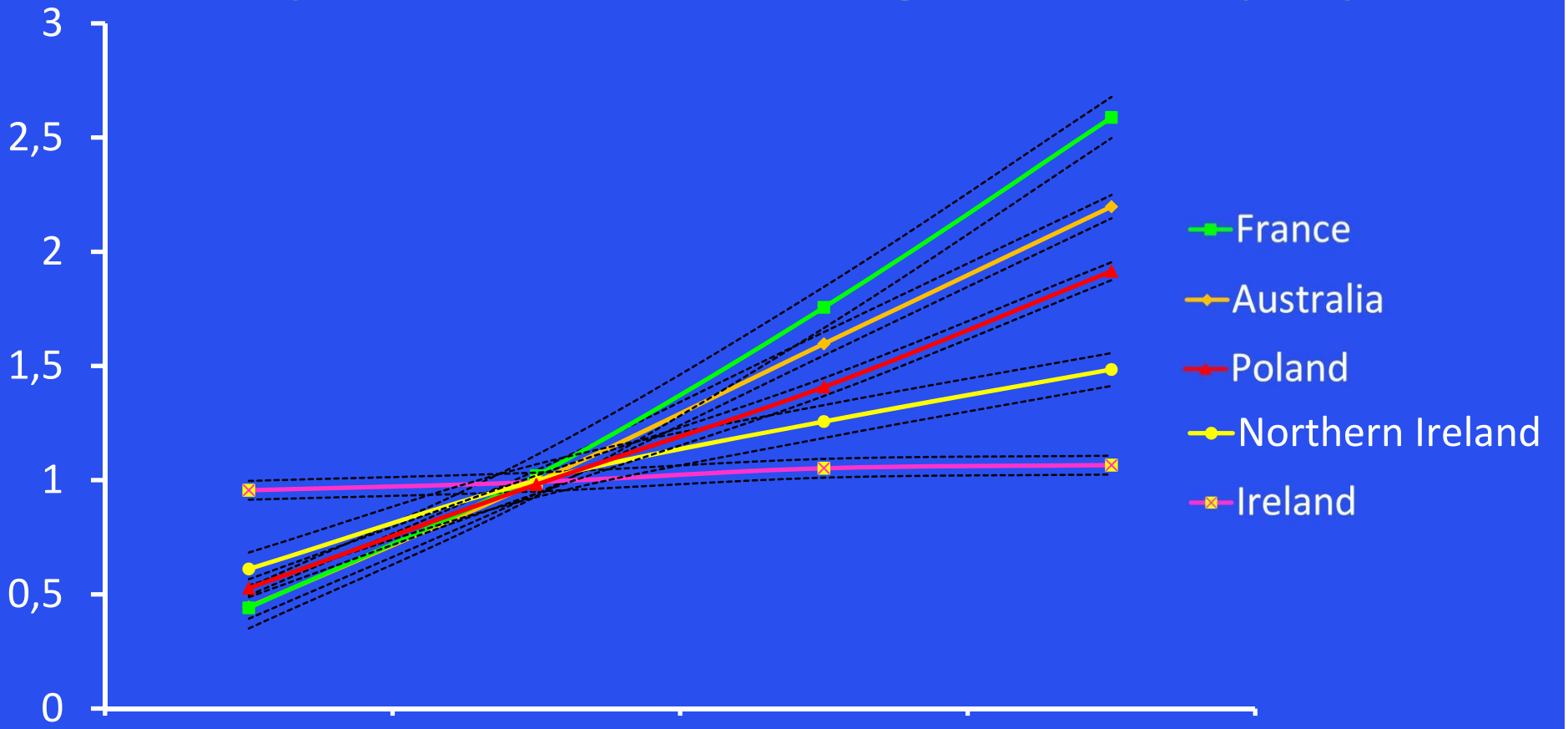
Preferred cooking doneness		2-3 points ↑	4 points ↑	1-3 points ↓

Interaction with cooking doneness in the sensory panel?

Proportional willingness to pay



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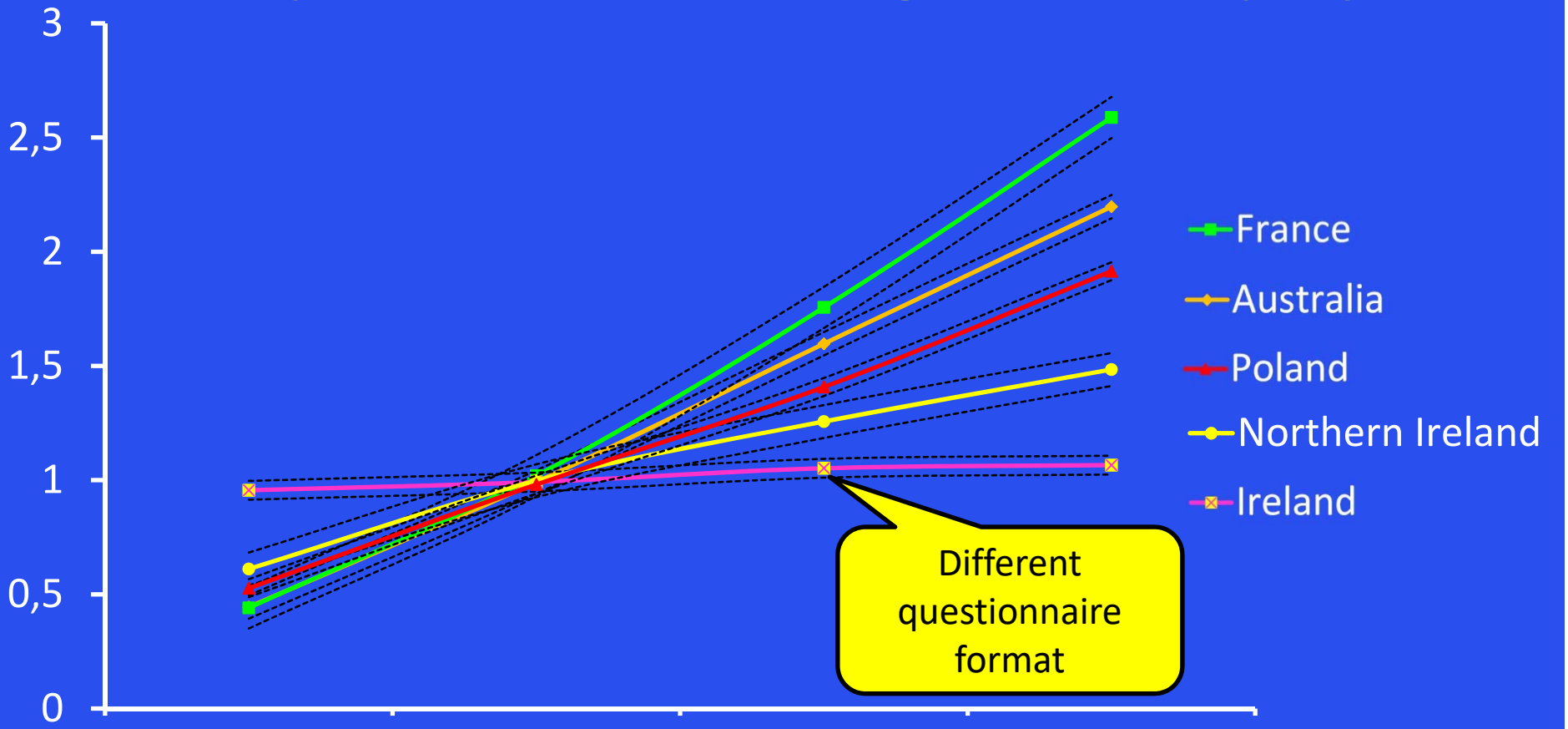

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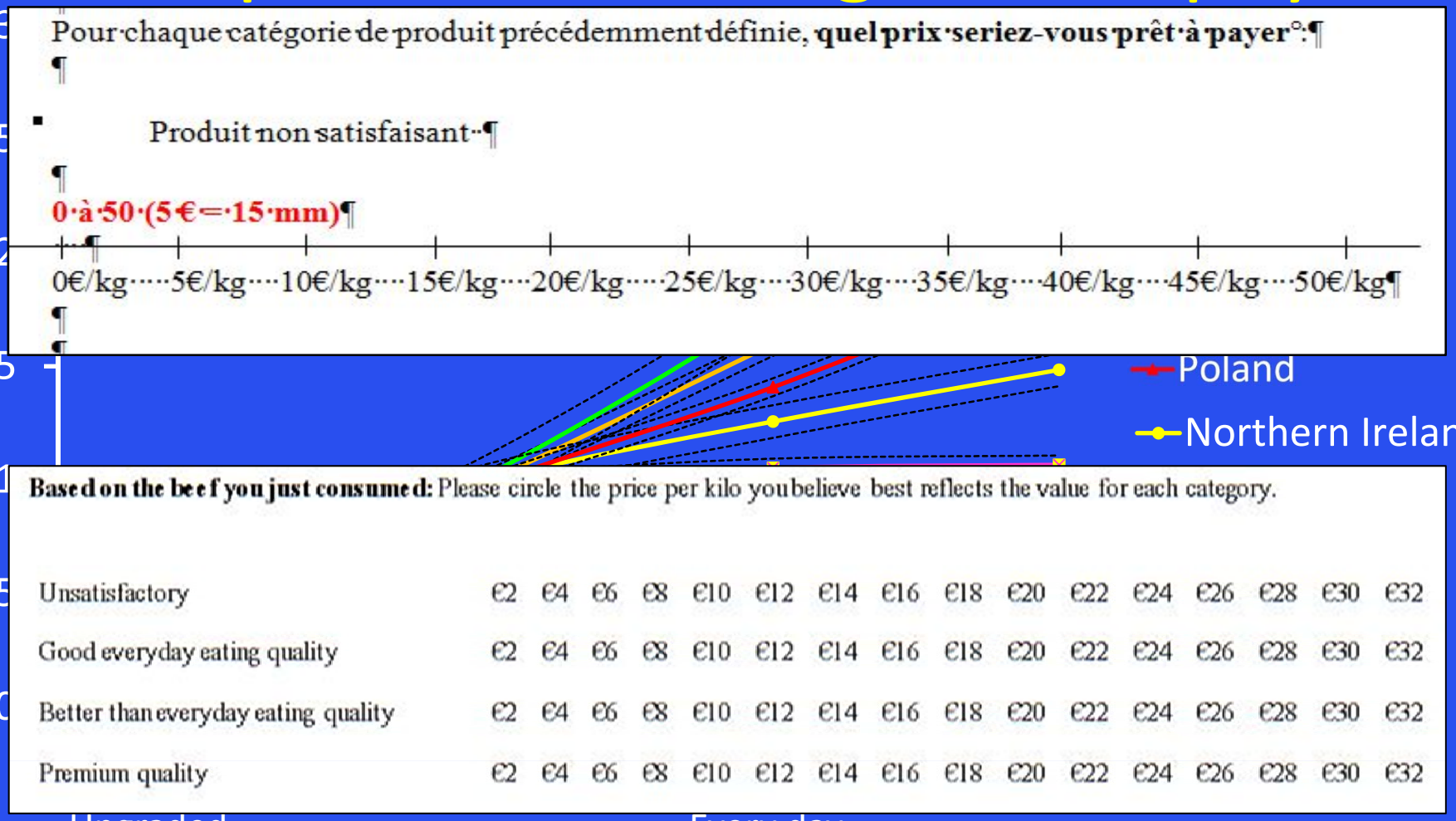

Hypotheses

1. Sensory scores will accurately categorise beef into quality groups

2. Demographics will only have small effects on sensory scores

3. Willingness to pay will be highly transferable between consumer groups

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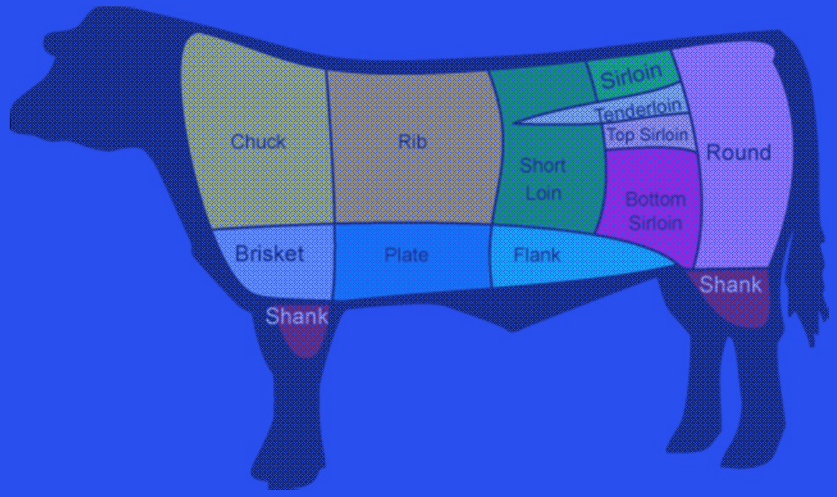
Format is important

Beef Quality Prediction

Consumers

Cattle



Beef Quality Prediction

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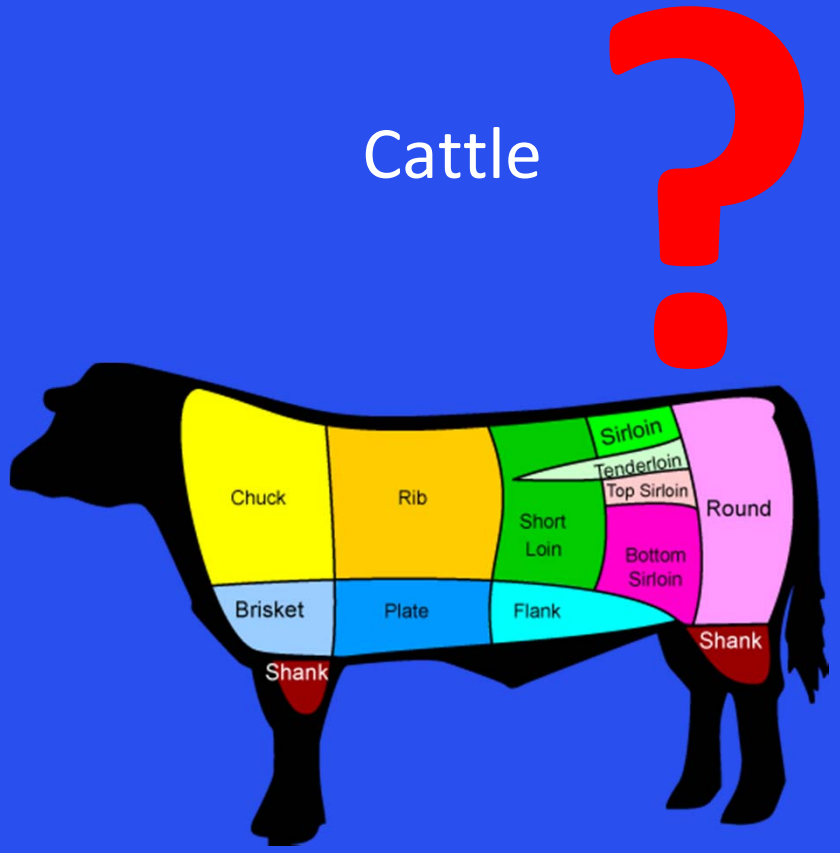
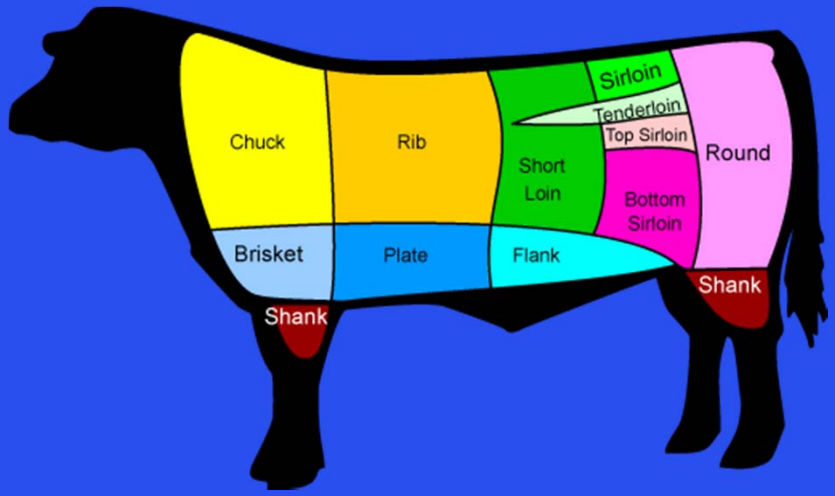


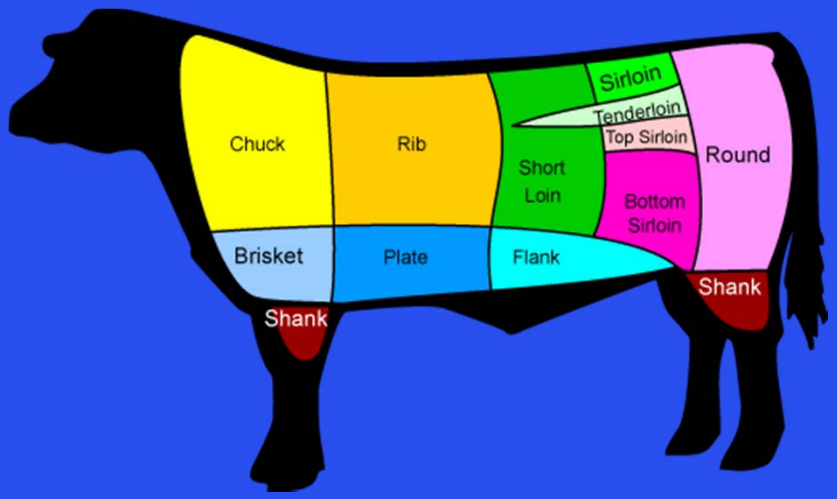
Beef Quality Prediction

What influences quality?



Beef Quality Prediction

- Muscle
- Cooking method
- Hang method (AT/TX)
- Post mortem ageing
- Ultimate pH/pH decline



Beef Quality Prediction

- Muscle
- Cooking method
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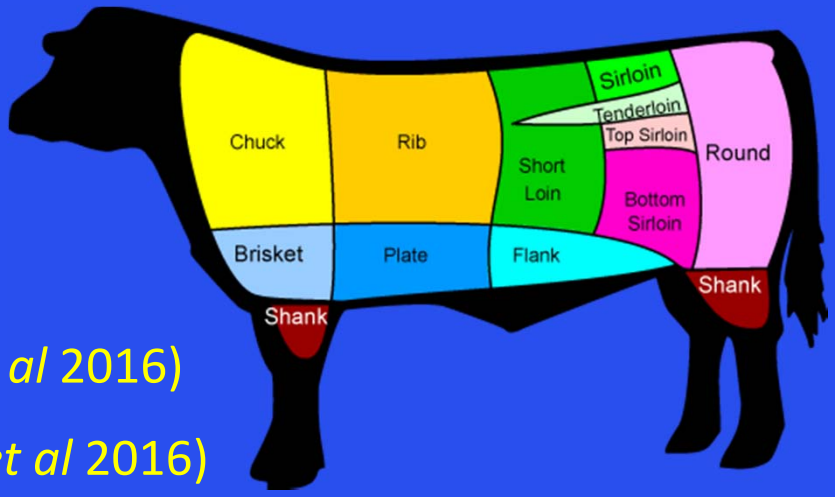
- Breed (beef/dairy) (Bonny *et al* 2016)
- Sex (bull/steer/cow) (Bonny *et al* 2016)
- Maturity (age/ossification) (Bonny *et al* 2016)
- Carcass weight/Growth path
- Marbling (IMF) (Bonny *et al* 2015)



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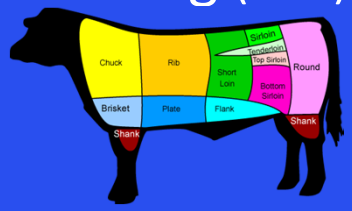

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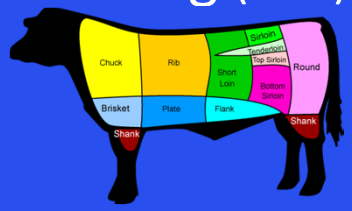

cut	Grill	Roast	Stir-Fry	Slow-cook	Braise
spinalis	83	73	83	79	84
tenderloin	85		79		
tenderloin	81	80	83	78	73
tenderloin	79				
cube roll	70	70	70	70	71
striploin	64	65	66	63	66
striploin	62	63	66	62	64
oyster blade	73	70	76	77	77
blade			49	54	
blade	60	64	66	66	68
chucktender		57	59	64	
rump	67	71	75	75	77
knuckle	42	53	50	57	53
knuckle			67	70	68
outside flat	51	51	54	64	65
outside flat			62	69	
eye round	51	55	53	55	57
topside	46		57	60	64
topside	42		59	64	64
topside	41	50	50	60	60

Beef Quality Prediction

- Muscle
- Cooking method
- Hang method (AT/TX)
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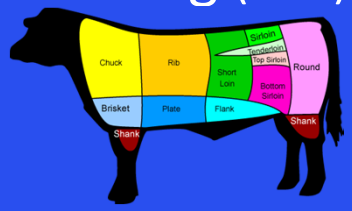

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topside	46		57	60	64
topside	42		59	64	64
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Can we grade beef for eating quality?

Can we grade beef for eating quality?

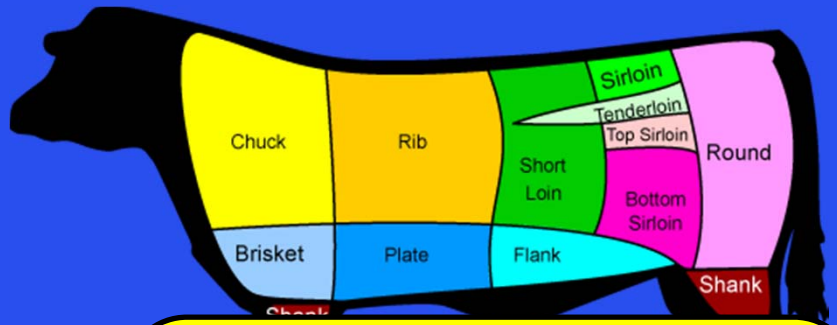
YES!

Beef Quality Prediction

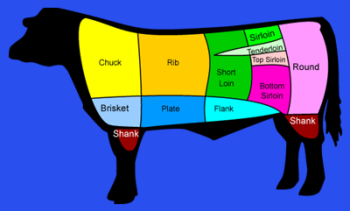
Consumers

Consumers are predictable

Cattle

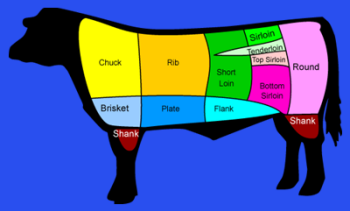


Carcass and animal factors can predict quality



Quality based beef grading system

Information



Quality based beef grading system

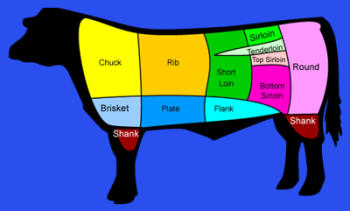
Information

Producer

Retailer/Consumer

The mass market
Commercial Brands
Official marks

Processor



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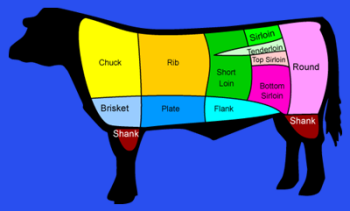

What next?

- Prediction of quality
  - Using carcass and animal traits
  - Other measures?
  - Poland
- More collaborative partners
  - Spain
  - Portugal
- Integration into the supply chain
  - Industry
  - Processors

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striploin	62	63	66	62	64
oyster blade	73	70	76	77	77
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blade	60	64	66	66	68
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knuckle	49	53	50	57	53
knuckle			67	70	68
outside flat	51	51	54	64	65
outside flat			62	69	
eye round	51	55	53	55	57
topside	46		57	60	64
topside	48		59	64	64
topside	44	50	50	60	60

Acknowledgements

- Meat and Livestock Australia
- Murdoch University
- The Beef CRC
- Alan Gee from Cosign, Australia
- Ray Watson from Melbourne University
- John Thompson from the University of New England
- University of Blaise-Pascal
- ProSafeBeef
- The French Livestock Institute (IDELE)
- Direction Générale de l'Alimentation (DGAL)
- France AgriMer
- The Charolais Institute
- Charal
- The Syndicat de Défense et du promotion de la Viande de Boeuf de
- The National Institute of Agricultural Research (INRA)
- The gourmet restaurants 'Jean Denaud"
- ProOptiBeef
- The Irish Department of Agriculture, Food and the Marine
- Egide/Fast and Egide/Polonium funds from the French, Australian and Polish governments

Cut v/s scientific names

M. triceps brachii caput longum	Blade (BLD096)
M. serratus ventralis cervicis	Chuck (CHK078)
M. supraspinatus	Chuck Tender (CTR085)
M. longissimus dorsi	Cube Roll (CUB045)
M. spinalis dorsi	Cube Roll (CUB081)
M. semitendinosus	Eye round (EYE075)
M. rectus femoris	Knuckle (KNU066)
M. vastus lateralis	Knuckle (KNU099)
M. biceps femoris (syn. gluteobiceps)	Silverside (OUT005)
M. infraspinatus	Blade (OYS036)
M. biceps femoris (syn. gluteobiceps)	Rump cap (RMP005)
M. tensor fasciae latae	Rump tail (RMP087)
M. gluteus medius	Eye of rump centre (RMP131)
M. gluteus medius	Eye of rump side (RMP231)
M. longissimus dorsi	Shortloin (STR045)
M. psoas major	Tenderloin (TDR062)
M. adductor femoris	Topside (TOP001)
M. semimembranosus	Topside (TOP073)

Accuracy of the discriminant analysis

	Predicted grade (n)				
Actual Grade	2	3	4	5	Total
2	28303	6211	395	154	35063
3	10152	30919	11398	1752	54221
4	492	5902	16514	8914	31822
5	143	309	2657	11684	14793
Total	39090	43341	30964	22504	135899

	Predicted grade %				
Actual Grade	2	3	4	5	Total
2	80.72	17.71	1.13	0.44	100
3	18.72	57.02	21.02	3.23	100
4	1.55	18.55	51.89	28.01	100
5	0.97	2.09	17.96	78.98	100
Total	28.76	31.89	22.78	16.56	100

Consumer testing

Untrained

19,492 Consumers

X 7 samples

- 1 medium quality ‘link’ sample
- 6 experimental samples
  - ranging in quality
- *Latin* square design

0	**1**	**2**	**3**	**4**	**5**	**6**
0	**2**	**4**	**1**	**6**	**3**	**5**
0	**3**	**1**	**5**	**2**	**6**	**4**
0	**4**	**6**	**2**	**5**	**1**	**3**
0	**5**	**3**	**6**	**1**	**4**	**2**
0	**6**	**5**	**4**	**3**	**2**	**1**

Consumer Demographics

Gender	Male	Female	Unreported			
Australia	148	191	02			
France	672	826	2			
Ireland	921	755	64			
Northern Ireland	3 938	4 994	60			
Poland	3 217	4 030	13			
Income	**a**	**b**	**c**	**d**	**e**	**Unreported**
Australia	0	0	0	0	0	339
France	128	446	493	302	129	2
Ireland	184	727	773	0	0	56
Northern Ireland	2 760	4 814	1 224	0	0	194
Poland	817	1 033	2 184	2 234	940	52
Occupation	**Trade**	**Professional**	**Admin[1]**	**Technical**	**Service**	**Labourer**
Australia	43	95	52	31	38	10
France	39	232	542	130	0	100
Ireland	147	519	213	282	110	28
Northern Ireland	924	2 093	1 125	627	709	633
Poland	297	517	1526	479	815	834
	Unemployed	**Student**	**Retired**	**Homemaker**	**Other**	**Unreported**
Australia	4	56	6	4	0	0
France	82	82	257	26	8	2
Ireland	34	170	0	203	0	34
Northern Ireland	617	944	0	1 177	0	143
Poland	219	1190	0	103	1 257	23

Consumer Demographics

Adults in the home	0	1	2	3	4	5+	Unreported
Australia	0	29	207	64	29	10	0
France	4	311	877	189	83	33	3
Ireland	0	138	707	379	311	181	24
Northern Ireland	505	1 136	3 844	1 678	1 178	576	75
Poland	45	1 001	2 457	1 816	1 304	631	6
Children in the home	**0**	**1**	**2**	**3**	**4**	**5+**	**Unreported**
Australia	118	56	116	39	9	1	0
France	959	240	222	62	13	2	2
Ireland	531	517	247	212	85	46	102
Northern Ireland	2	5 890	1 099	1 130	421	163	287
Poland	5 080	1 349	537	125	35	8	126

Age (years)	<20	20-30	31-45	46-50	>50	Unreported
Australia	35	37	267			0
France	50	413	431	137	468	1
Ireland	0	603	509	213	393	22
Northern Ireland	3935	2404	2611			42
Poland	502	4123	1804		822	9

Consumer Demographics

Frequency	7	4-5	2-3	1	0.5	0.25	Never	Unreported
Australia	10	51	180	85	13	0	0	0
France	24	225	757	377	107	4	1	1
Ireland	46	214	648	314	64	50	5	9
Nth Ireland	470	1471	4026	1649	422	263	15	42
Poland	31	162	1416	2134	1663	1740	85	110

Appreciation	Important	Like	Indifferent	Unimportant	Unreported
Australia	200	127	12	0	0
France	411	871	211	2	0
Ireland	534	551	243	34	18
Nth Ireland	3027	3486	1544	233	102
Poland	1393	1696	2260	1795	116

Doneness	Blue	Rare	Med/rare	Medium	Med/well done	Well done	Unreported
Australia	0	0	128	95	116	0	0
France	5	330	-	919	166	28	0
Ireland	0	149	139	352	334	392	14
Nth Ireland	50	208	1138	1570	1952	3415	59
Poland	269	169	324	2020	3495	950	33

Weighting for MQ4 calculation
Boundaries between quality grades

Unsatisfactory (2) = -2.8+0.02tn+0.05ju+0.08fl+0.03ov

Good every day (3) = -7.92+0.04tn+0.04ju+0.1fl+0.13ov

Better than every day (4) = -14.36+0.07tn+0.04ju+0.11fl+0.2ov

Premium (5) = -20.85+0.09tn+0.05ju+0.13fl+0.24ov

The consumer scores are inserted into each equation, and the equation with the largest solution is the predicted quality grade

We are interested in 2v3, 3v4 and 4v5

=

Subtract one equation from the other then divide the whole equation by the sum of the coefficients for the sensory scores

$$L3\text{-}L2 = \frac{-5.12+0.02tn+-0.01ju+0.02fl+0.1ov}{(0.02+-0.01+0.02+0.1)}$$

$$L4\text{-}L3 = \frac{-6.44+0.03tn+0.00ju+0.01fl+0.07ov}{(0.03+-0.00+0.01+0.07)}$$

$$L5\text{-}L4 = \frac{-6.48+0.02tn+0.01ju+0.02fl+0.04ov}{(0.02+-0.01+0.02+0.04)}$$

Boundaries between quality grades

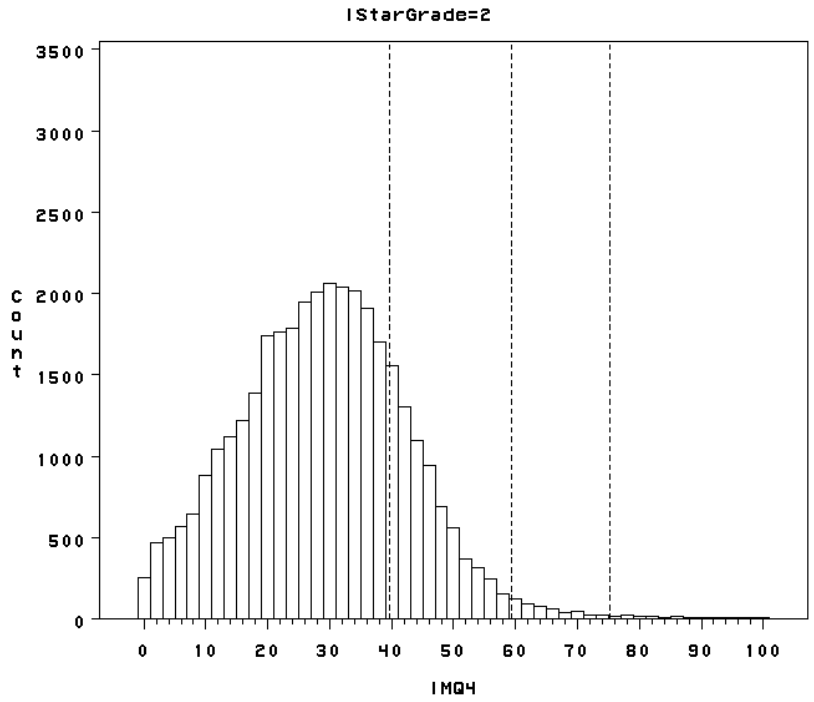
2v3 = -39.22≷0.19tn+-0.07ju+0.13fl+0.75ov

3v4 = -59.8≷0.24tn+0.02ju+0.12fl+0.62ov

4v5 = -75.75≷0.21tn+0.07ju+0.23fl+0.49ov

Average coefficients to derive single weightings

MQ4= 0.28tn + 0.036ju + 0.37fl + 0.31ov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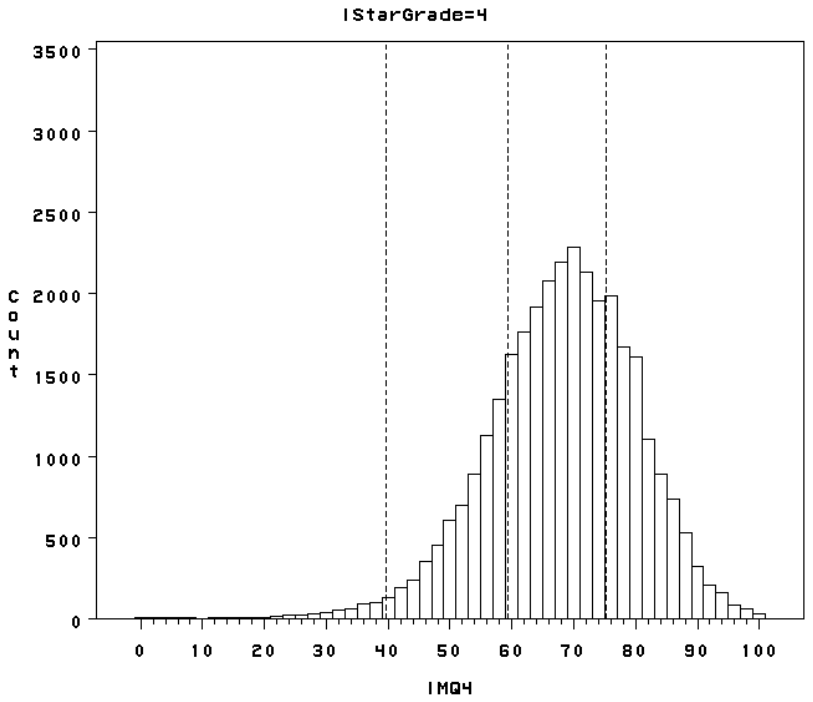
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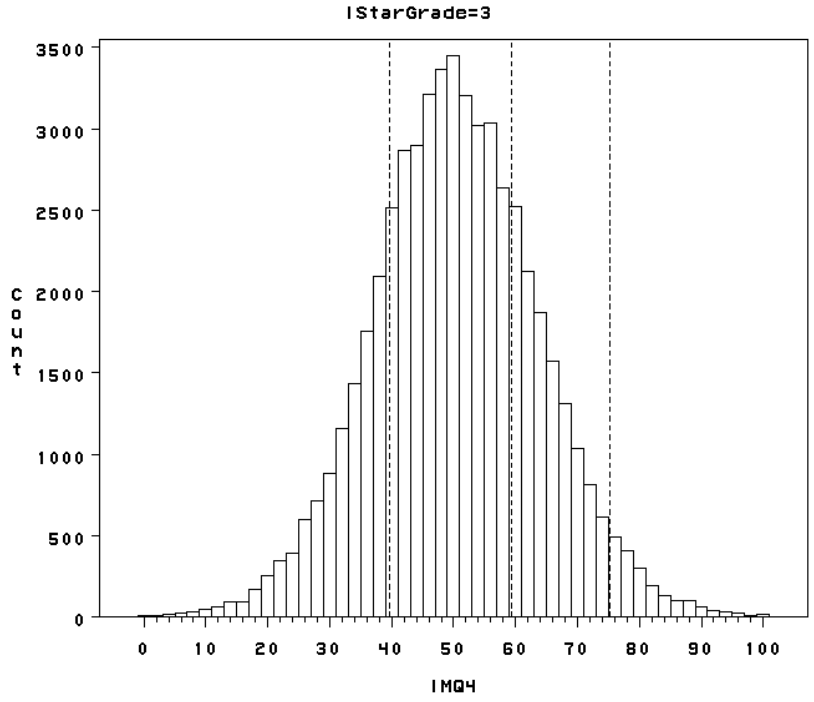
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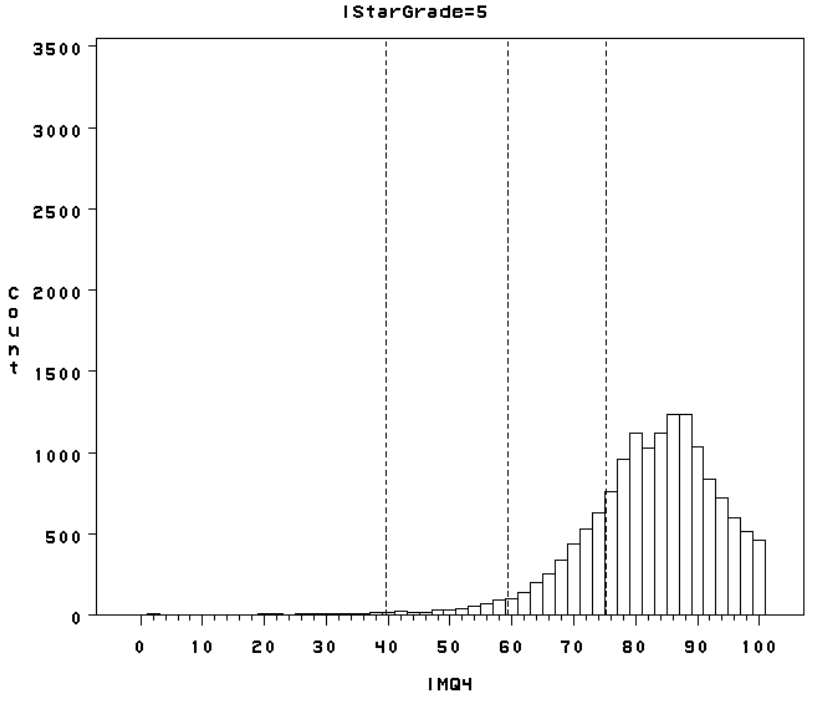
100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100