The University of Reading

Emerging innovations in food processing technologies

Professor Keshavan Niranjan

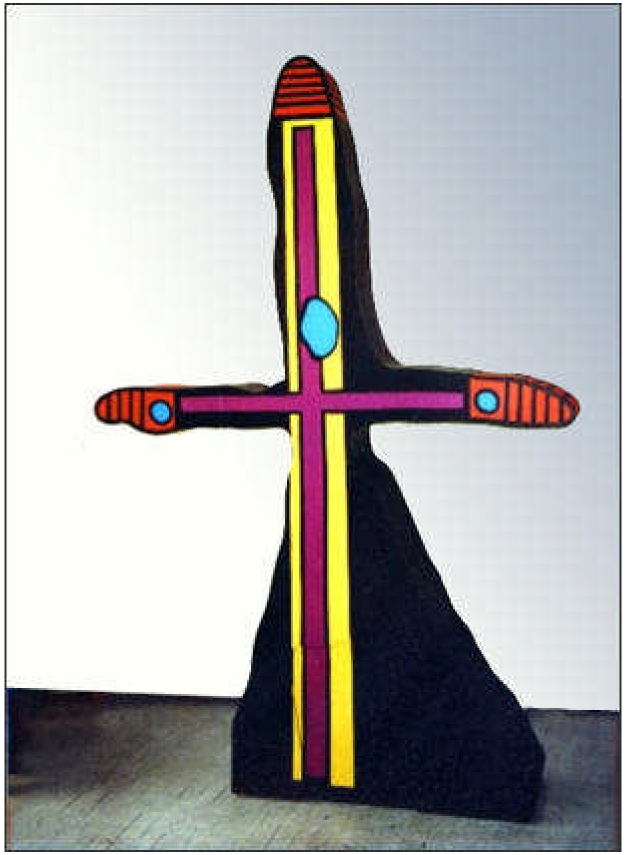
Department of Food and Nutritional Sciences

University of Reading (UK)

Scope

- Context of innovations in manufacturing
- Types of technological innovations in processing and packaging
- Practical examples of innovations resulting from research at Reading
- Concluding remarks

Manufacturing….at cross roads



The highly transient nature of food business poses a number of

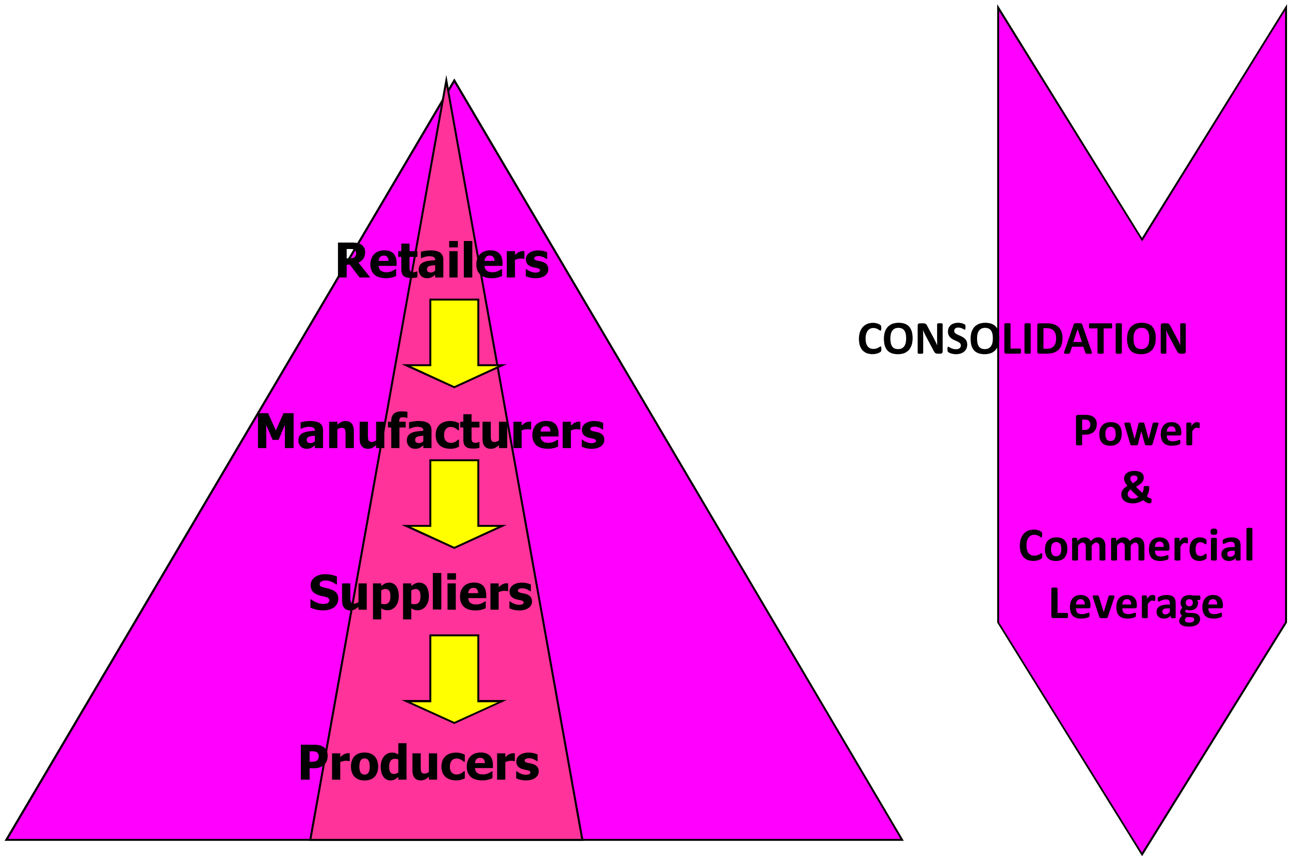
challenges to food industry personnel,

who are primarily charged with the responsibility of delivering safe and quality-assured products to consumers

Challenges posed by…

- Manufacturing environment
- Market
- Regulatory Environment
- Human resource and Training

Manufacturing Environment



The pressure to cut costs

❖Has resulted in ***lower capital investment on technology including automation*** and R&D

❖***Downsizing of R&D***

ATTITUDE CHANGES

❖***Innovation only encouraged in new product development***

❖***Technology/Processing is seen as a service infrastructure; NOT a strategic driver for business***

❖***Fewer processing/technology specialists in employment***

The PSP Link

Thermal
Non thermal
Biochemical
Biophysical

<u>Structural scales</u>
Macro
Micro
Nano

Product

Quality
Health

Thermal Processing

- New technologies have transformed the way the food is heated.
  - Microwave, infrared, Ohmic – all involve non thermal energy supply, which the food absorbs and converts to heat
  - Novel temperature gradients and high heat fluxes

Nonthermal Methods In Food Preservation

- Irradiation
- X-Ray
- **Pulsed Electric Fields**
- Plasma
- Oscillating Magnetic Fields
- Ultrasound
- **High Hydrostatic Pressure**
- Chemicals and Biochemicals

Non thermal *vis a vis* thermal processing

- Thermal and non-thermal are rarely competing alternatives in practice
- Thermal processing is here to stay, while non thermal will be used for niche applications
- Innovative thermal processing has transformed, and will continue to transform, food processing and preservation

Innovative Packaging

- Processing and packaging go hand in hand
- Packaging must strike the right balance between
  - functionality,
  - environmental legacy and
  - cost
- Packaging innovations are in the areas of using low environmental impact materials and imparting smart functionality (e.g. antimicrobial, temperature abuse detection, tamper proof etc

Low C foot print food packaging

Producing compostible food packaging (e.g punnets), by using cereal straw as the dominant cellulosic material.

Use pulp moulding, similar to paper technology, but with inferior cellulose

Environmental legacy is significantly lower than paper!

Prototypes produced

- Pizza disks
- Egg boxes
- Cartons
- Cup and bottle carriers
- Medical trays
- Flower pots





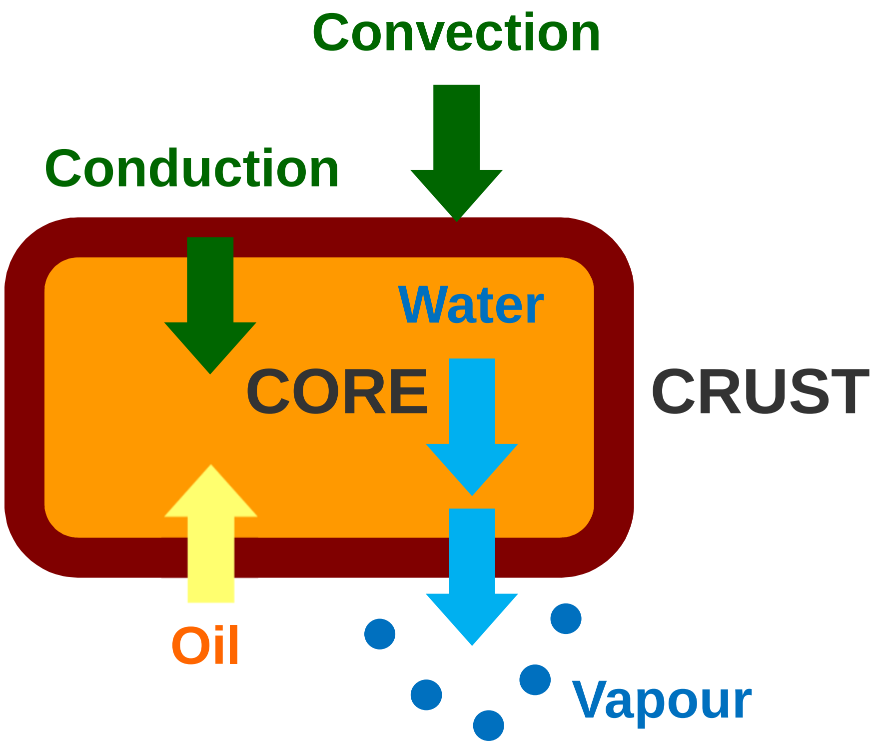
New Processing Technology does not necessarily mean Outlandishly New…..!

Innovative thinking and the use of modern experimental capabilities will enable us to get the best out of conventional technologies

Frying process

“**<u>Frying is a dehydration</u>** process that involves immersion of food in hot oil resulting in rapid heat and mass transfer”

- Temperature gradient between food and oil causes water loss and oil uptake
- Oil uptake also takes place due to pressure gradient between the pores and surrounding



Oil content in common fried food

Food	Oil Content (%)
Potato chips	30 - 40
Corn chips	33 - 38
Tortilla chips	22 - 26
French fries	12 - 15
Frozen pre-fried French fries	4 - 7
Battered products (chicken, fish)	14 - 17
Breaded products (chicken, fish)	13 - 20
Instant noodles	18 - 21
Doughnuts	15 - 24

Conventional strategies to reduce oil uptake

- Coating and breading materials
- Substitute as dough formulations

Hydrocolloids

- Pre-drying
- Osmotic dehydration
- Blanching

Pre-treatments

- Hot-air drying
- Super-heated air drying

Post-treatments

- Vacuum frying may increase or decrease oil content in fried food
- Thus, this frying process still remains ambiguous in producing low-fat fried food

Vacuum frying??

Approaches to lower adverse health impact – work undertaken at Reading

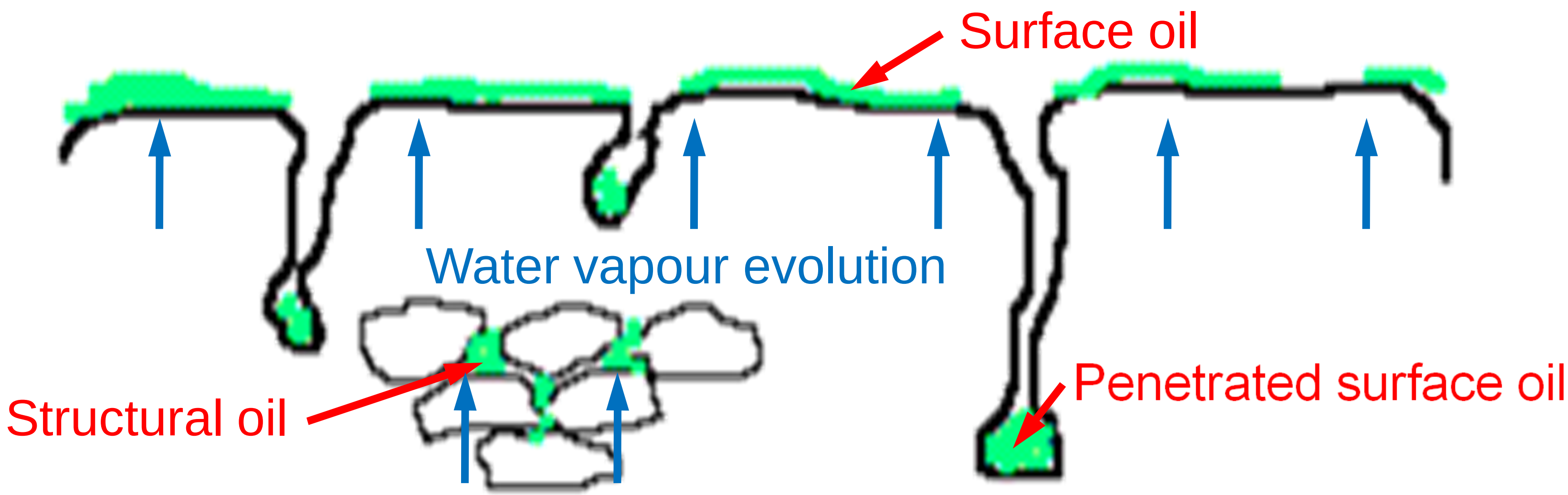
- **Approach 1 –** Reduce the oil content of fried products by combining atmospheric frying with post-frying vacuum application *in situ*;
- **Approach 2 –** Use blended oils having a nutritionally desirable and health promoting fatty acid profile

Scientific hypothesis

- A significant proportion of oil enters the product soon after the product is withdrawn from oil, caused by steam condensation accompanied by suction of surface oil into the structure.

Hypothesis…

“Applying vacuum lowers the water saturation temperature and initiates a higher degree of superheat – which results in continuous water release. This obstructs the surface oil from penetrating into the food structure. Further, the water vapour evolution can also force some of the structural oil to return to the surface”



When is it best to apply vacuum?

Protocol 1

- After frying, fried samples were lifted and drained for 3 min under atmospheric pressure (control)

Protocol 2

- 40 s before the end of frying, the chamber pressure was reduced to 13.33 kPa, followed by lifting and drainage for 3 min before breaking the vacuum

Protocol 3

- Similar to protocol 2, except that the pressure was lowered 3 s before the end of frying, lifted and drained for 3 min before breaking the vacuum

Protocol 4

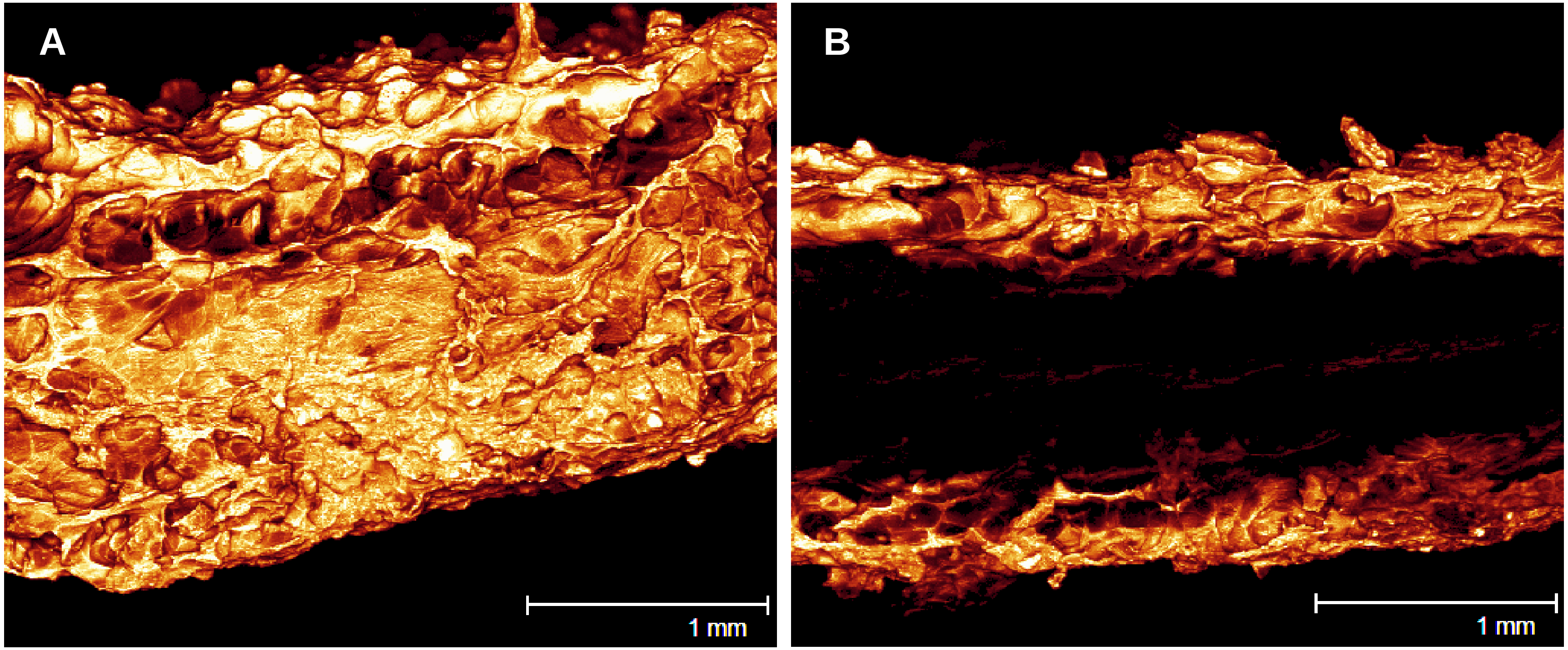
- Similar to protocol 2, except that the pressure was lowered immediately after frying, lifted and drained for 3 min before breaking the vacuum

Summary of results

Protocol	Frying time (min)	Oil content[5] (g oil / 100 g defatted dry matter)	Moisture content[5] (g water / 100 defatted dry matter)
Protocol 1[1]	4	68.48 ± 8.17c	2.70 ± 0.64 (1.58% w.b.)a
Protocol 2[2]	3.5	71.10 ± 7.08c	1.30 ± 0.25 (0.71 w.b.)a
Protocol 3[3]	3.5	52.50 ± 4.39b	2.43 ± 0.92 (1.35% w.b.)a
Protocol 4[4]	3.5	37.12 ± 1.37a	2.16 ± 0.70a (1.46% w.b.)

[1]Frying and lifting the frying basket into the headspace under atmospheric pressure;
[2]Frying and low pressure application (13.33 kPa) 40 s before lifting the frying basket into the headspace;
[3]Frying and low pressure application (13.33 kPa) 3 s before lifting the frying basket into the headspace;
[4]Frying and lifting the frying basket into the headspace at a pressure of 13.33 kPa;
[5]Univariate ANOVA and Tukey's Test were used to determine significance difference ($p < 0.05$) among treatment as indicated with different letters within column

Confocal laser scanning microscopy



"…Confocal laser scanning microscopy (CLSM) images of cross sectional oil distribution in (A) atmospheric-drained potato chips and (B) vacuum-drained potato chips…"

Hypothesis…

“Oils deemed to be nutritionally desirable are generally not stable under frying conditions. Selective blending of oils allows to balance nutritional recommendations with frying stability”

Fatty acid composition

Major fatty acid	Palm olein	Canola oil	Blend (1:1)
C16:0 (Palmitic)	41.20 ± 0.19	4.87 ± 0.16	22.89 ± 0.06
C18:0 (Stearic)	4.00 ± 0.06	1.65 ± 0.05	2.88 ± 0.01
C18:1 (Oleic)	41.79 ± 0.16	63.13 ± 0.15	51.96 ± 0.05
C18:2 (Linoleic)	10.50 ± 0.18	19.19 ± 0.38	14.80 ± 0.17
C18:3 (Linolenic ω-3)	0.11 ± 0.02	8.19 ± 0.07	4.20 ± 0.05
Saturated (%)	45.20	6.52	25.77
Unsaturated (%)	54.40	90.51	70.96

Frying of par-fried French fries (sun flower) in canola oil

Major fatty acid	Fryer oil (Canola oil)	Initial oil (Sunflower oil)	Final oil	Mass Balance
C16:0 (Palmitic)	8.66	6.57	8.61	8.55
C18:0 (Stearic)	2.61	4.39	2.81	2.70
C18:1 (Oleic)	39.22	24.59	37.94	38.41
C18:2 (Linoleic)	39.82	62.64	41.79	41.07
C18:3 (Linolenic)	6.19	0.14	5.89	5.86

Mass balance shows that 95% of the oil in the product is canola

On the possibility of non-fat frying

AIR FRYING

On the possibility of non-fat frying (contd)

HOW ABOUT…………

Frying in molten glucose?

Frying in sorbitol, inulin, Maltodextrin?

Conluding remarks

- Health, sustainability and security will be the main innovation drivers in food technology
- Most innovations are not intended to replace currently practised technologies but to make them more effective
- Of course, some innovations can be competing alternatives, but it will take a lot of validation work before such innovations are commercially implemented.


Thank You!