Control of Mites and Insects in Pet Food Packages Using Controlled Atmospheres

Bhadriraju Subramanyam (Subi), PhD
Professor
Department of Grain Science and Industry
Kansas State University
Manhattan, KS 66506, USA

International Conference on Controlled Atmosphere and Fumigation in Stored Products, September 21-26, Chengdu, China: Session 1

Controlled Atmospheres for Mite and Insect Control

- Controlled or modified atmospheres
  - Use of the inert gases, N_2 and CO_2
  - Reduce atmospheric O_2 from 20.9 to ≤1%
  - Increase CO_2 from 0.03 to >40%
- Advantages
  - Increases shelf life of perishables/dry durables
  - Pesticide-residue free
  - Kills insects and mites and suppresses progeny
  - Replacing traditional IPM approaches


http://sgrl.csiro.au/storage/insects/Psocids_mites/mites.html

Controlled Atmosphere Research Projects

Project I

- Control of mites in pet food packages
- Package susceptibility to mite invasion

Project II

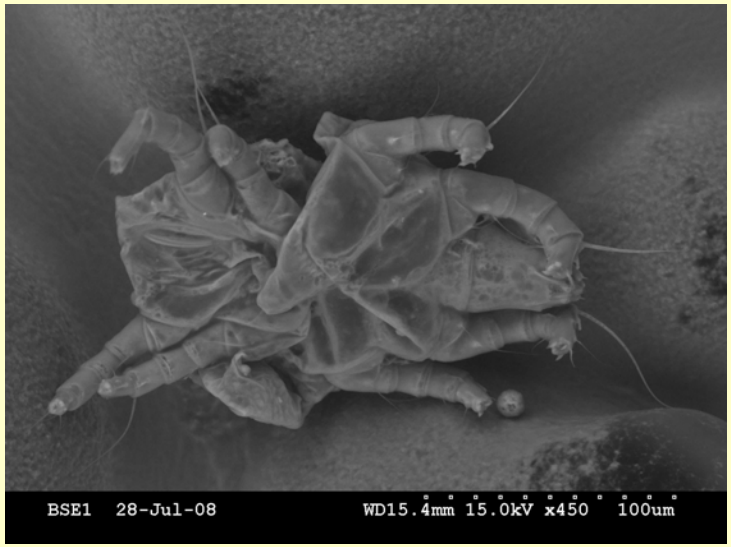
- Control of insects in low protein, grain-based pet product
- Suitability of product for insect reproduction
- Effect of various controlled atmosphere treatments on insects
- Package susceptibility to insect invasion and/or penetration

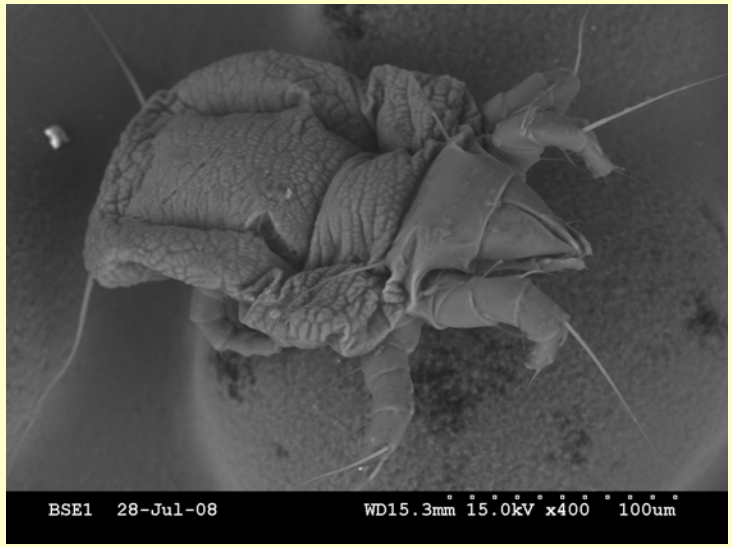
Project 1: Controlled Atmospheres and Mites

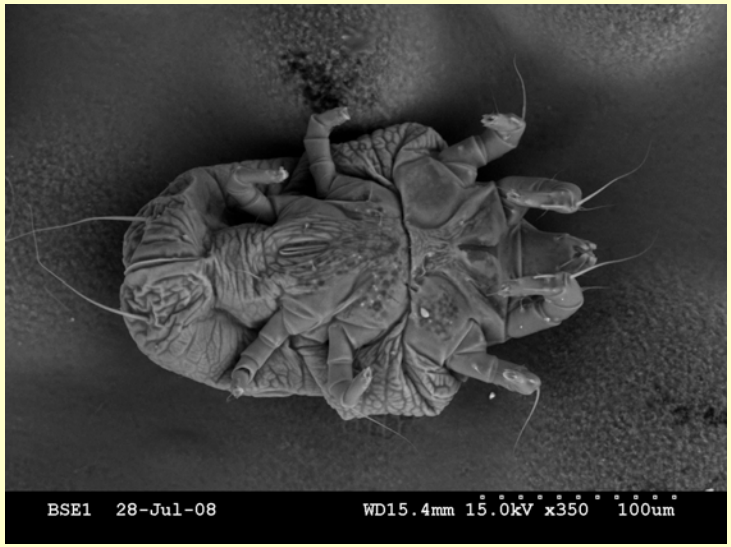
- Mites cultured from infested samples originating in Thailand
- Identified *as Suidasia medanensis* (=*pontifica*) Oudemans (Acari: Suidasiidae)*
- Reported from pet food at supermarkets in Recife, Brazil (de Sousa et al. 2005)
- Reported from grain stores in Greece (Palyvos et al. 2008)
- Found in house dust (Fernández-Caldas et al. 1993)

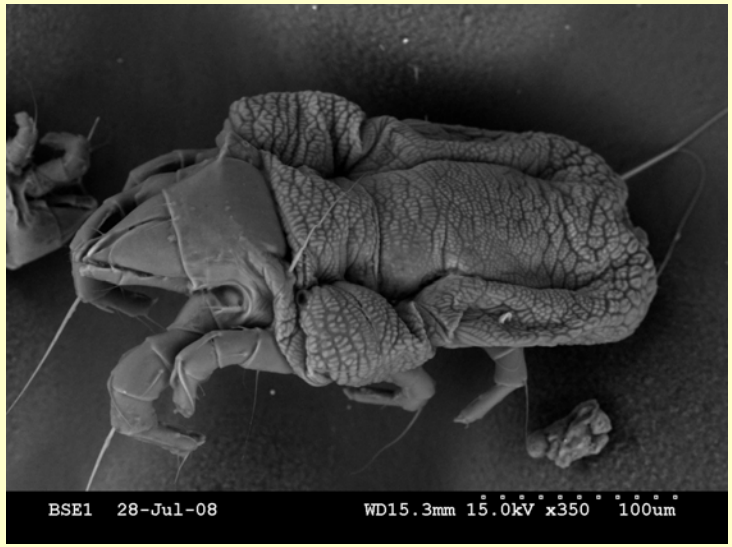
*Thanks to Nickolas E. Palyvos, Agricultural University of Athens, Greece, for identification of the species

Scanning Electron Micrographs of *Suidasia medanensis*









Biology of *Suidasia medanensis* (Mercado et al. 2002)

- 26°C and 86% RH (on tetramin fish food + yeast)
- Egg-to-adult development: 11-13 days
- Reproductive period: 10 – 36 days
- Eggs/female: 62 – 177
- Adult longevity: 15 – 75 days

Laboratory Rearing

- Reared on pet food (26-28% moisture) in 0.45-L glass jars at 25°C and 70% RH, in a small growth chamber
- Pet food has 26-28% moisture
- Mixed ages of mites were used in experiments

Trial I: Effectiveness of Three O_2 Levels on Mite Mortality

- 10 ml vials (4.8 cm long & 1.7 cm diam) with 0.19 ± 0.03 g (*n* = 4) of diet or 0.45 g of bleached flour
- Each vial had either 20 *S. medanensis* or 10 *T. castaneum* adults
- 0.5, 1.0, and 2.0% O_2, remainder N_2 in cylinders from Praxair company
- Pouches (45 g) were filled within 3-4 seconds
- Untreated pouches served as the control treatment (~20% O_2)
- Survival of mites and insects checked in the laboratory 3, 6, and 9 d after purging pouches

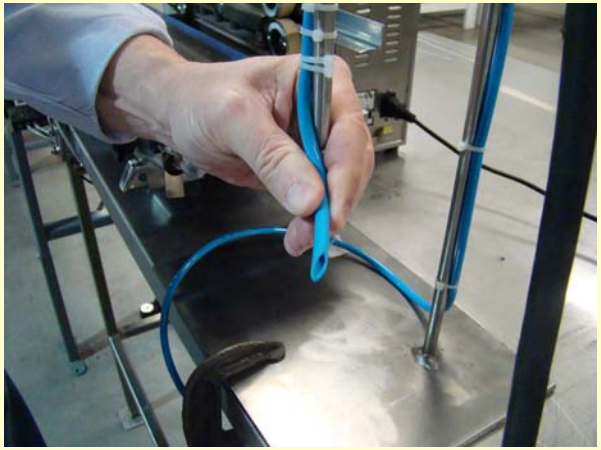
Mites and Insects for Exposure

- Pet food vials with 20 *S. medanensis*
- Flour with 10 adults of *T. castaneum*

Cylinders and Certified Gases

- Gas cylinders with certified gases (0.5, 1.0, and 2.0% of O_2, remainder N_2) were purchased from Praxair company

Purging Packages with Controlled Atmospheres



- A foot pedal initiates gas flow
- 3-4 seconds per pouch
- Pouch is then heat-sealed

Heat-Sealing of Pouches

Expected and Observed O_2 Levels in Pouches

Expected O_2 (%)	Observed O_2 (%)
0.5	0.58 ± 0.01
1.0	1.03 ± 0.01
2.0	1.98 ± 0.00

n = 4 replications for observed values
Control packages had an O_2 level of 19.95 ± 0.04 (*n* = 3)

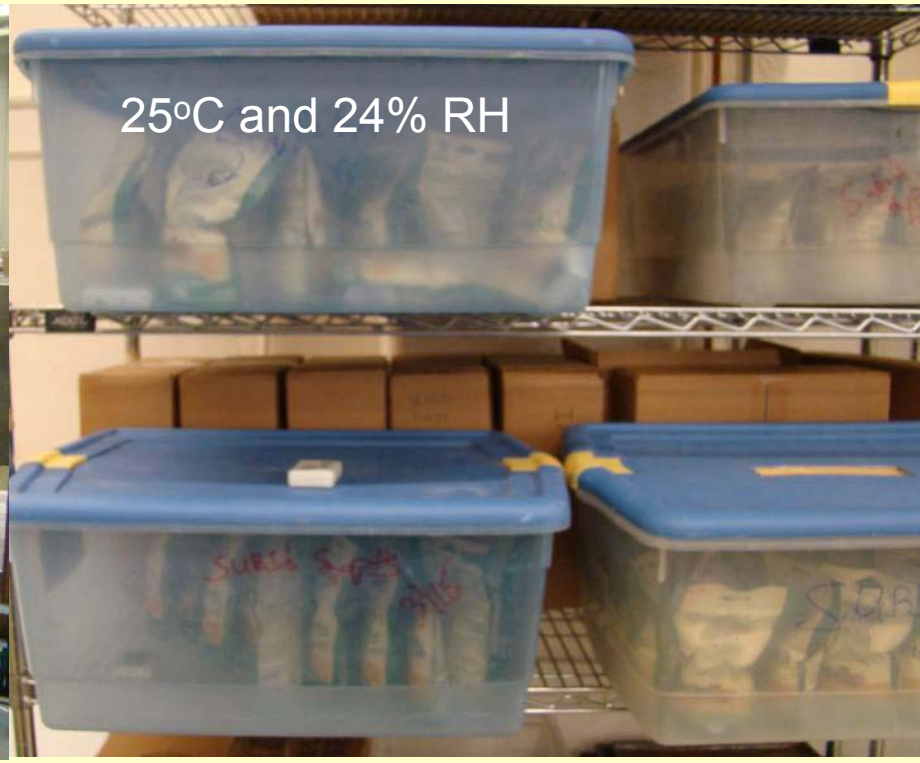
Survival of Mites and Insects in Control and Treated Pouches

Day	Species	Untrt. (Control)	0.5% O_2	1.0% O_2	2.0% O_2
3	*T. castaneum*	10.0±0.0	0.0	0.0	1.0±1.0
	S. medanensis	5.3±0.9	0.8±0.8	0.0	0.0
6	*T. castaneum*	10.0±0.0	0.0	0.0	0.0
	S. medanensis	3.5±1.5	0.0	0.0	0.0
9	*T. castaneum*	0.0	0.0	0.0	0.0
	S. medanensis	0.0	0.0	0.0	0.0

Independent samples were examined over time
Each mean is based on *n* = 4 replications

Tests with High Mite Density


Purged packages


25°C and 24% RH

Trial II. Survival of High Density of Mites at Three O_2 Levels

Day	Untrt (Control)	0.5% O_2	1.0% O_2	2.0% O_2
2	356.0±132.0	0.0	0.0	0.0
4	172.0±3.1	0.0	0.0	0.0
6	130.0±15.0	0.0	0.0	0.0
8	160.0±22.7	0.0	0.0	0.0

Independent samples were examined over time
Each mean is based on *n* = 3 replications

Trial IIIa. Use of O_2 Scavengers Inside Pouches

Oxygen levels inside pouches with ascorbic acid

Day	1 g Ascorbic acid	5 g Ascorbic acid	10 g Ascorbic acid
1	1.23 ± 0.19	1.26 ± 0.03	1.47 ± 0.14
13	0.61 ± 0.03	0.66 ± 0.11	0.66 ± 0.04

Two-way ANOVA:

- No significant differences among treatments (F=0.94; df=2, 6; P=0.441)
- Significant differences between days (F=57.87; df=1, 6; P=0.0003)
- Interaction of treatment x days (F=0.60; df = 2, 6; P=0.5807)

Ascorbic acid was placed in vials of 4.9 cm long and 2.6 cm diam (24 ml volume)

Trial IIIb. Commercial Iron Powder Sachets

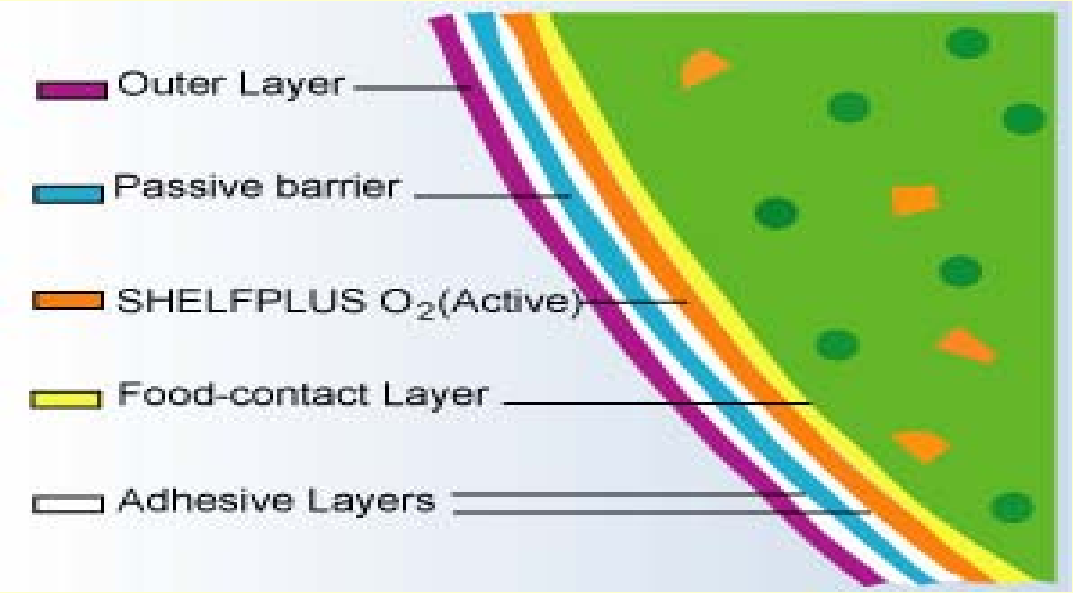
- Bulk (5 kg) dog bone pet product intended for Japan
- 3 commercial sachets per 5 kg
- O_2 levels over time

Date	Day	O_2 level (%)
Mar. 26, 08	0	20.00
Mar. 27, 08	1	0.19
Mar. 28, 08	2	0.32
Mar. 31, 08	5	0.10

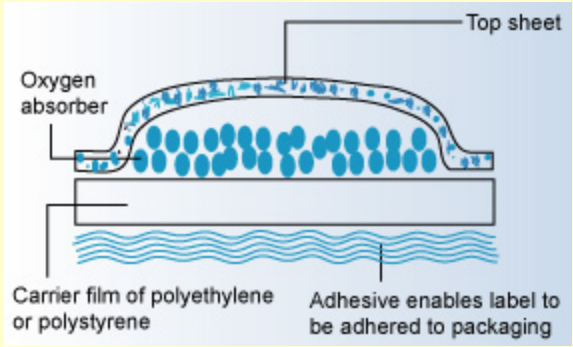
n = 1 replication

Mitsubishi Chemical Company

Incorporating Scavengers Into Packaging Structure



Ciba



Multisorb Technologies

Trial IV. Susceptibility of Pouches to Mite Infestation

- Pouches were purged with 1% O_2 level
- Control pouches consisted of unpurged pouches
- Each pouch was placed in a Rubbermaid™ cereal container (*n*=5 per treatment)
- Into each container, mite diet containing 767.3 ± 201.3 mites (*n*=4) were released
- Pet product inside pouches was examined under a stero-microscope for infestation after 16 d at 25°C and 24% RH.
- A similar procedure was used with individually wrapped dog bone product from the same company, and these packages were not treated with controlled atmospheres
  - Packages were placed individually in 0.95-L glass jars with lids
  - There were 20 packages in total

Package Susceptibility Tests

Project II. Controlled Atmospheres for Control of Insects in Low Protein Grain-Based Pet Product

- Not a pet food
- The grain-based pet product is biodegradable
- Sold in packages
- Purged with inert gases prior to shipping
- Infestation complaints led to a research project to examine efficacy of 6 controlled atmosphere treatment combinations
- Common pest species reported: *Tribolium castaneum* and *T. confusum*

Progeny Production of *Tribolium* species on the Grain-Based Pet Product

Species	Diet	No. F_1 adults at 28 days	No. F_1 adults at 56 days
T. confusum	Lab diet	352.3	1374.3
	Pet product	1.0	430.3
T. castaneum	Lab diet	339.7	987.8
	Pet product	0.3	309.8

n = 3 replications; diet infested with 50 mixed-age adults

Six Treatment Combinations

Treatment	$\%CO_2$	$\%O_2$	$\%N_2$
T1	12.0	0.5	87.5
T2	0.0	0.5	99.5
T3	0.0	2.0	98.0
T4	20.0	1.0	79.0
T5	40.0	5.0	55.0
T6	0.0	1.0	99.0
Control (air)	0.03	21.0	78.0

- Gases moisturized by passing through 60% glycerol solution (45-50% RH)
- Flow rate: 236 ml/min, regulated by 8 flow meters
- Insects exposed in vials (24 ml)
- Specially constructed glass tubes to confine vials during exposure


Growth chamber
Gas cylinders

Flow meters

Specially-designed glass tubes for holding vials

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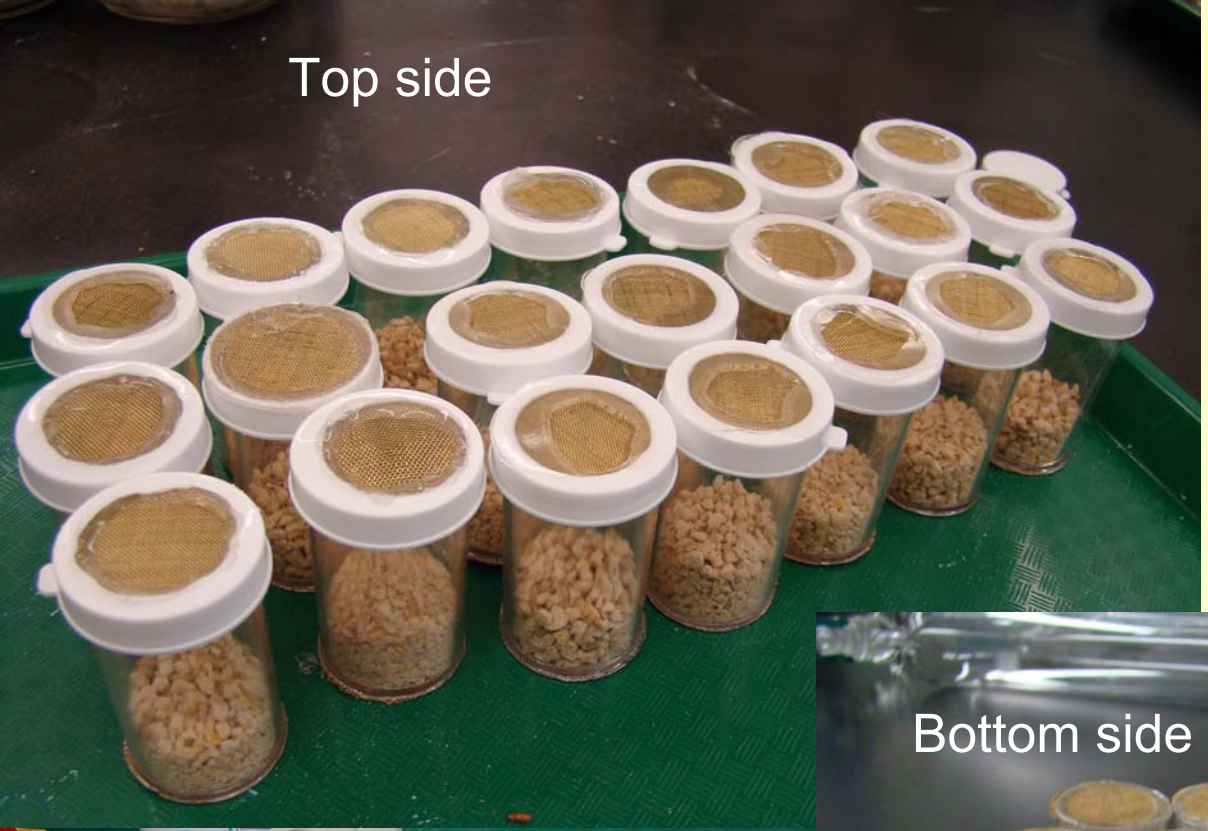
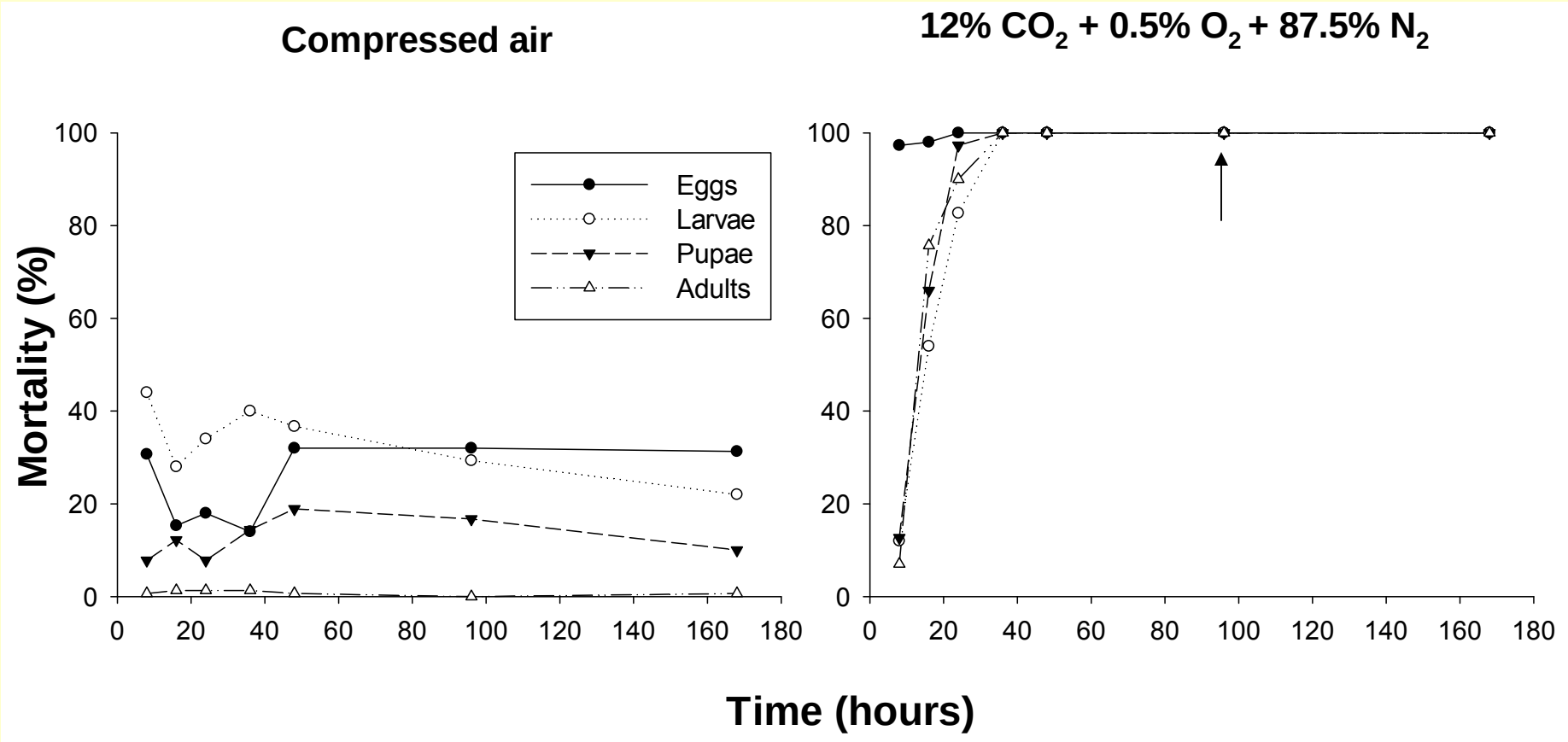


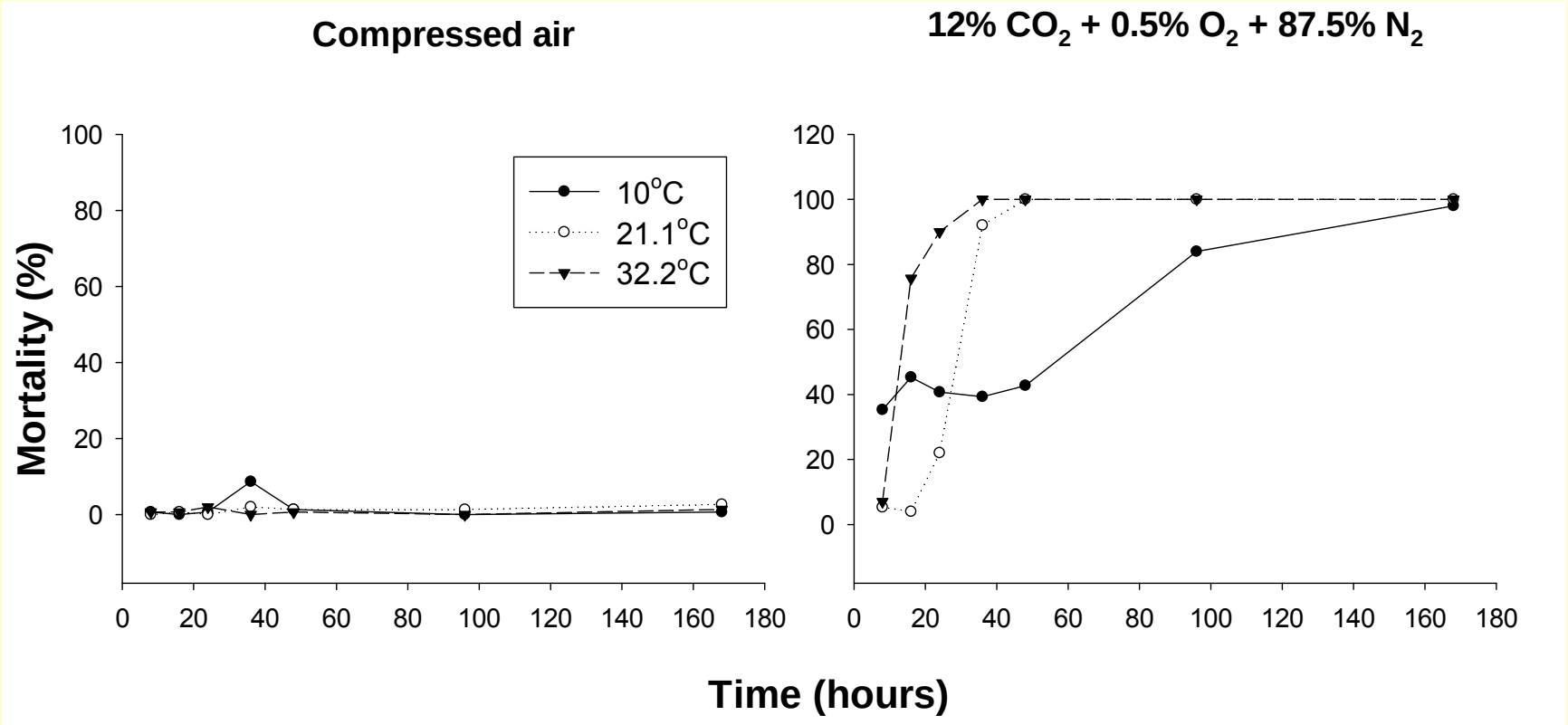
Plastic vials with grain-based pet product and insects

Vials had screens on both sides

Mortality of *Tribolium castaneum* at 32.2°C [T1 treatment]



Tribolium confusum Adult Mortality at Three Temperatures

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Package Susceptibility Tests

- Packages placed in large plastic containers
- Five species were released together
  - 10 *Plodia interpunctella* larvae
  - *250 Lasioderma serricorne* adults
  - 100 *Tribolium castaneum* adults
  - 400 *Oryzaephilus surinamensis* adults
  - 400 *Trogoderma variabile* larvae
- 3 replications
- Packages (independent samples) checked after 1 and 2 weeks post-infestation
- No insects were found inside packages

Conclusions

- The examples presented illustrate the effectiveness of controlled atmospheres for managing insects in packaged stored products
- Active packaging technology exists today
  - Ensure technology is cost-competitive with controlled atmospheres
  - Use as package liners to avoid product contamination
- Use of insect-resistant packaging in conjunction with controlled atmospheres shows promise as a pest control method for packaged dry, durable products

Thank You

Questions?