



*Innovative and sustainable food ingredients and products*

# Development of a chewing gum with *Actinidia arguta* extract as an innovative mitigation strategy for firefighters' occupational exposure

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# Introduction

- Firefighters are exposed to several persistent organic pollutants including polycyclic aromatic hydrocarbons (PAHs), brominated flame retardants (BFR), among others [1].
- In 2022, IARC reclassified the occupational activity of firefighting as carcinogenic to humans (Group 1) [1].
- Most available mitigation strategies focus on better quality and fire resistance of personal protective equipment (PPE) and decontamination procedures of PPE [2].



There is a scientific and technological demand for mitigation strategies for occupational exposure.

[1] IARC Monographs on The Evaluation of Carcinogenic Risks to Humans. International Agency for Research on Cancer (2022)132, Lion, France.

[2] Horn, Gavin P et al. Journal of occupational and environmental hygiene vol. 19,9 (2022): 538-557.

## The proposed invention



Chewing gum (CG) as mitigation strategy

Essential oil



- Capacity to **retain the lipophilic pollutants**
- Provides pleasant aroma to the product

### Advantages

- Easy-use
- Affordable
- Sustainable

Dry kiwiberry (*Actinidia arguta*)



- Anti-inflammatory and antioxidant effect may offer protection against the pollutants.
- Allows reuse of kiwiberry that are not commercialized



# Main Objectives

1. CG development

2. CG characterization

3. Pollutant Removal Efficiency by the CG







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# CG development (The formulations)

Formulations		CGR	CGA	CGB	CGC
Appearance					
Composition	Essential oil	0.6%	0.6%	0.8%	0.8%
	Dry kiwi	Not present	0.2%	Not present	2%

CG-Chewing Gum\*

The formulations were developed in collaboration with Lusiteca- Produtos Alimentares PA.



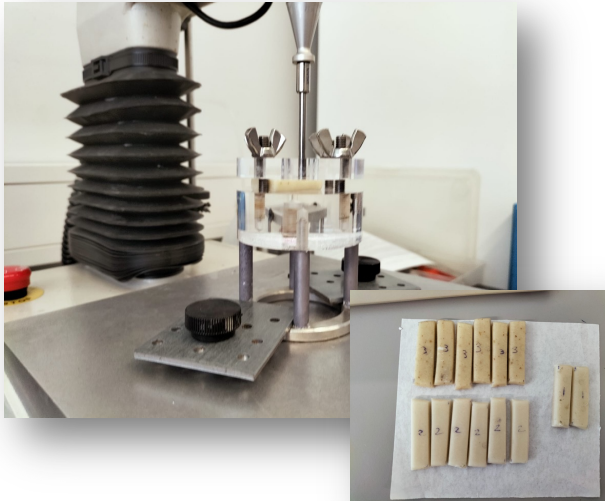
# Main Objectives

1. CG development

**2. CG characterization**

3. Pollutant Removal Efficiency by the CG

## Texture Profile Analysis (TPA)



## Rheologic Analysis (RA)



## Sensorial Analysis (SA)\*

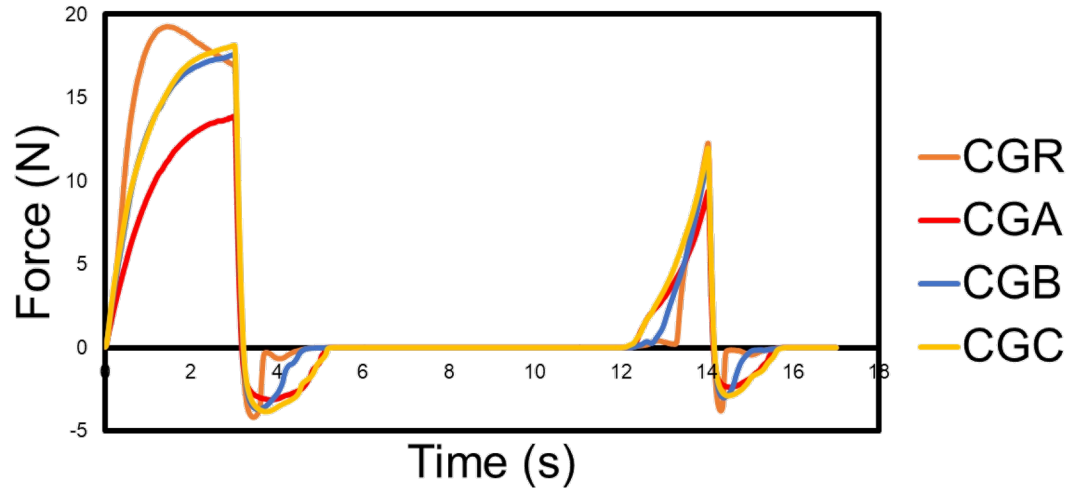


*\* The SA was conducted with a panel of military firefighters from the Special Protection and Relief Unit of the Republican National Guard.*



# CG Characterization (TPA)

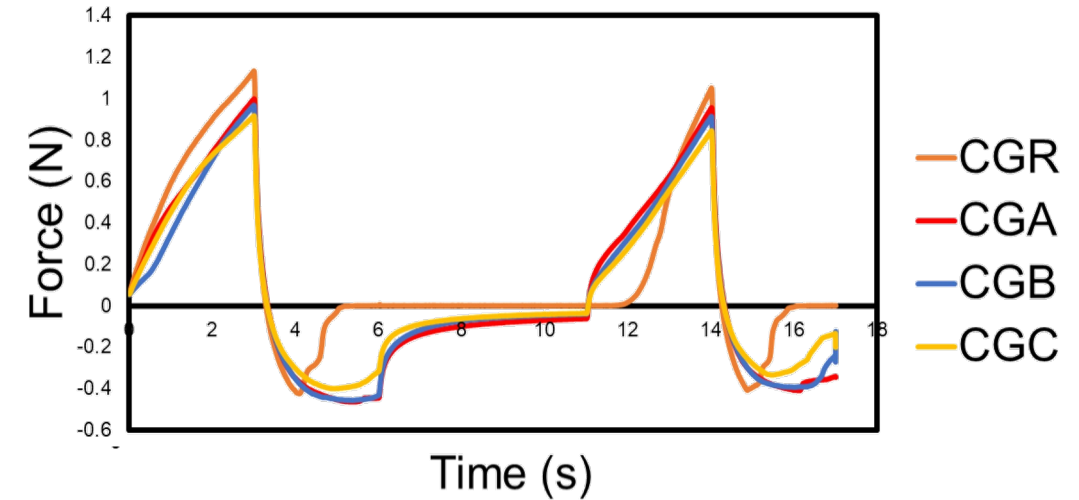
### Textural Profile Analysis (Dry CG)



After 10 minutes  
of chewing



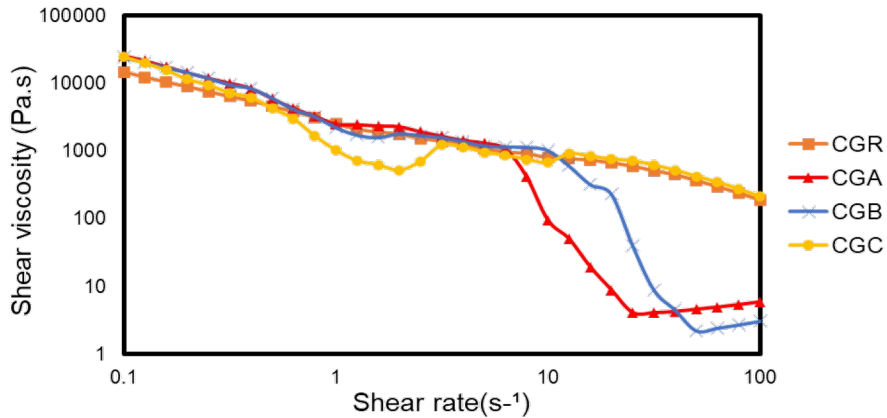
### Textural Profile Analysis (Chewed CG)



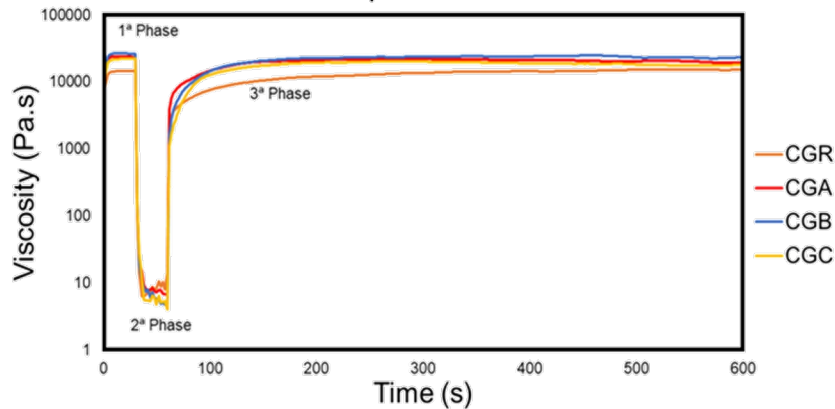
- All CG formulations display very **similar texture profiles**
- After chewing similarity increases

# CG Characterization (RA)

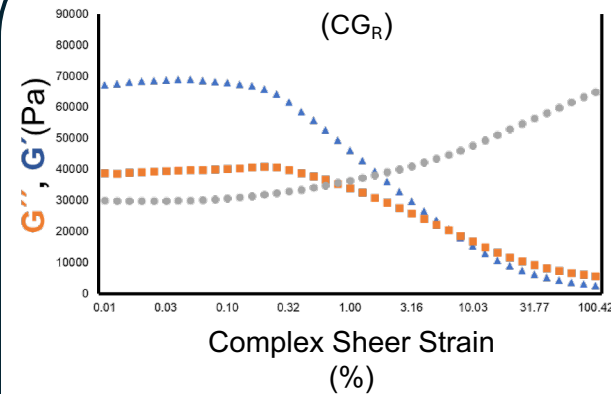
Amplitude Sweep Test



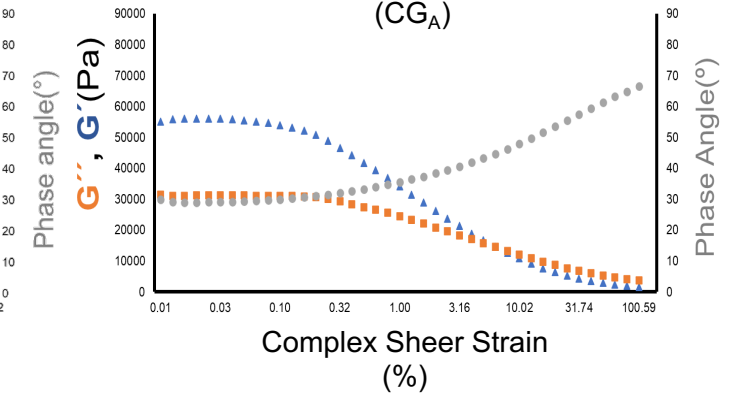
Three Step Shear Rate Test



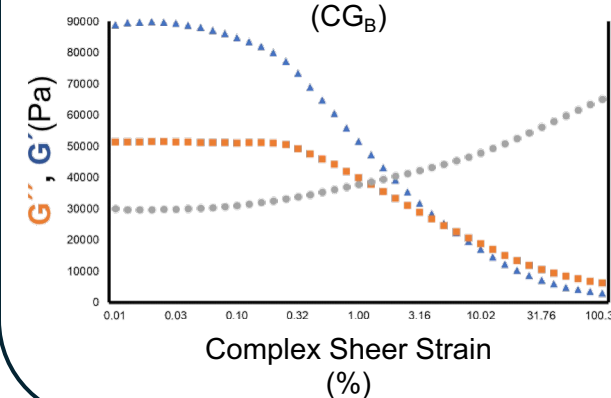
Linear Viscoelastic Region  
(CG<sub>R</sub>)



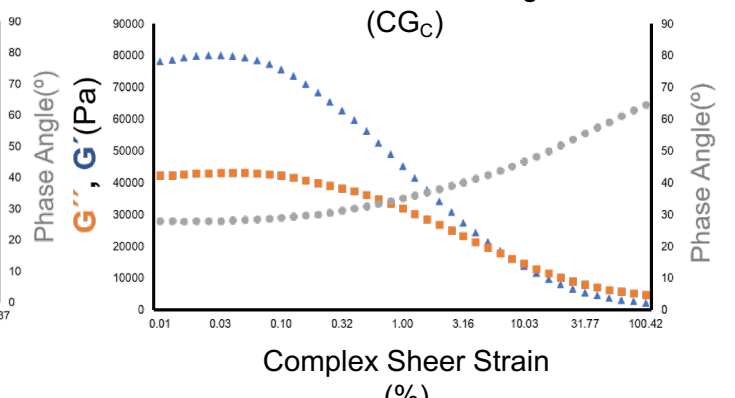
Linear Viscoelastic Region  
(CG<sub>A</sub>)



Linear Viscoelastic Region  
(CG<sub>B</sub>)



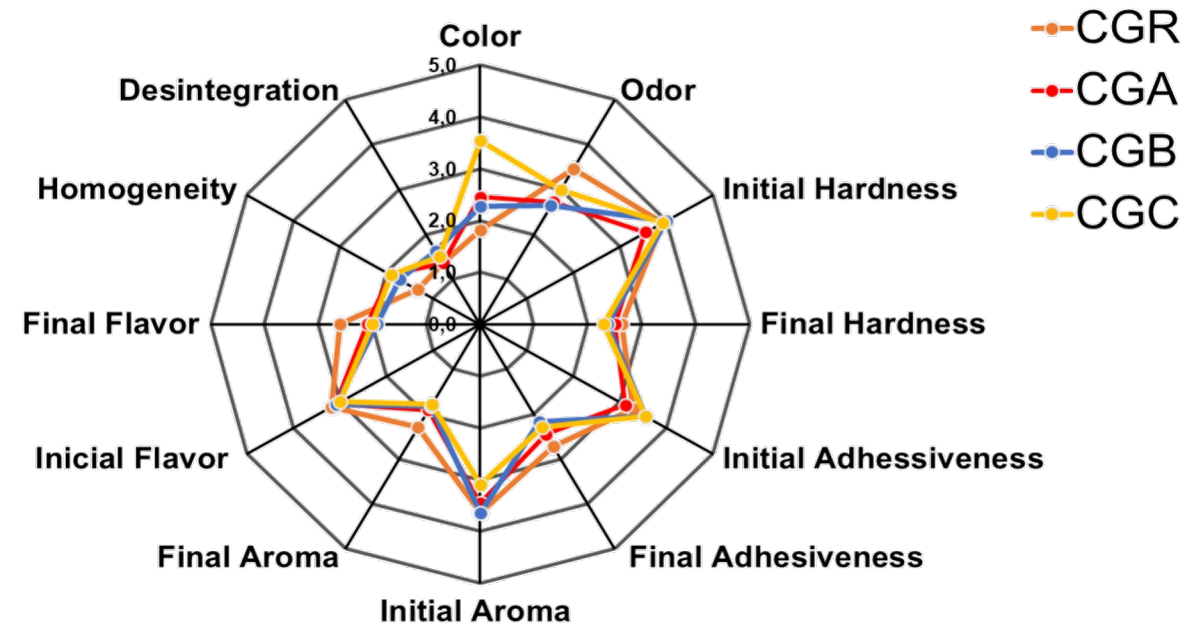
Linear Viscoelastic Region  
(CG<sub>C</sub>)



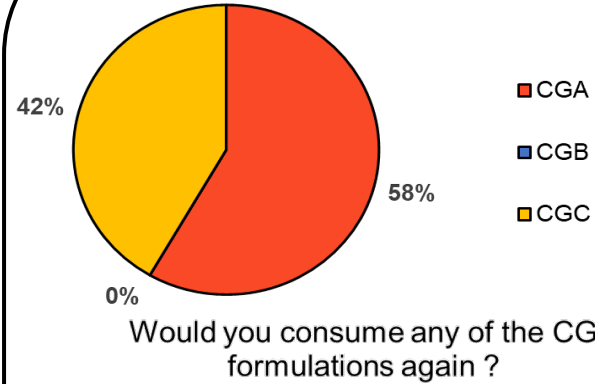
- After chewing, test formulations display **similar texture profiles and elastic behavior** within the linear viscoelastic region.
- All formulations display **shear thinning behavior with slight thixotropy**.

# CG Characterization (SA)

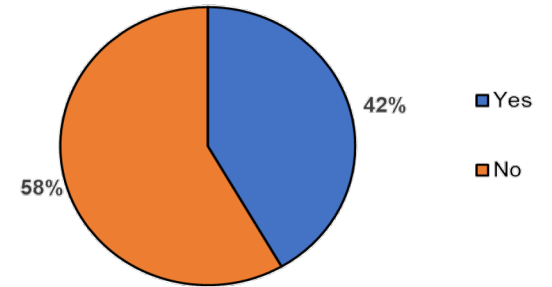
## Sensorial Analysis



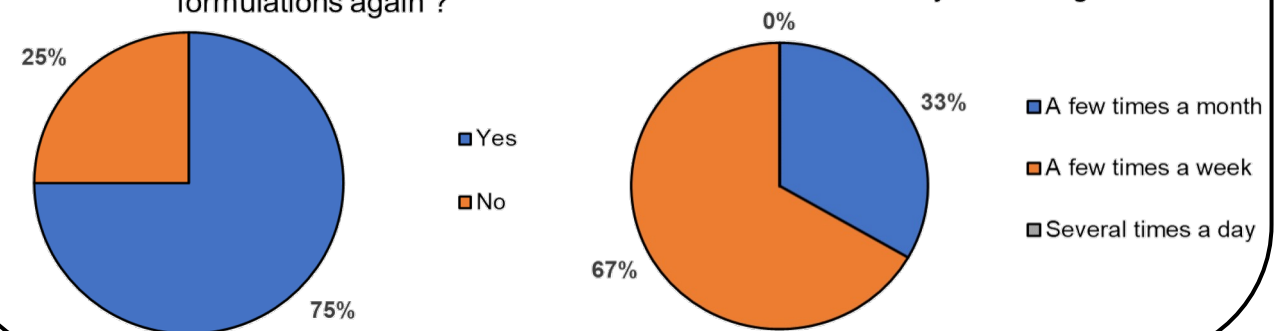
## Formulation Preference



## Do you chew gum often?



## How often do you chew gum?



- SA results indicated that **CG<sub>A</sub>** and **CG<sub>C</sub>** are the preferred formulations
- Hardness and Adhesiveness correlate with the TPA results



# Main Objectives

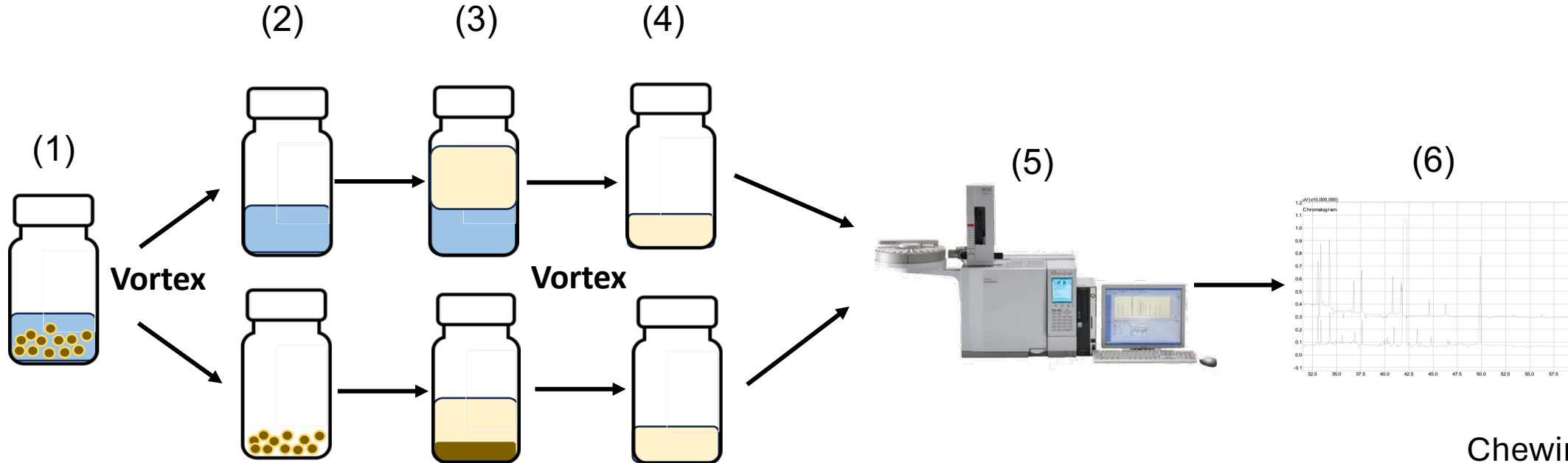
1. CG development

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**3. Pollutant Removal Efficiency by the CG**

# Pollutant Removal Efficiency by the CG (Methodology)

## General Procedure – Simulations with CG and Artificial Saliva



### Steps

- (1) CG is contaminated with standard solution of 7 BFRs and 17 PAHs
- (2) Saliva and CG are separated
- (3) *n*-Hexane or Acetonitrile is added as extraction solvents
- (4) Extracts are concentrated
- (5) Extracts are analyzed via HPLC or Gas chromatography (GC)
- (6) Chromatograms are collected

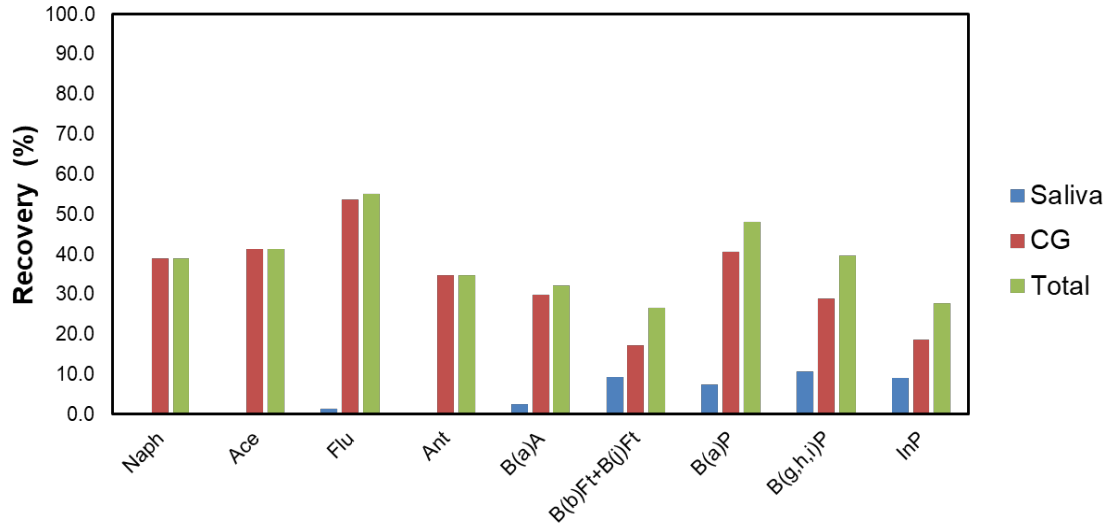
	PAHs	BFRs
Naph	B(a)A	BDE28
Acen	Chry	BDE47
Ace	B(b)Ft+B(j)Ft	BDE100
Flu	B(k)Ft	BDE99
Phe	B(a)P	BDE154
Ant	DB(a,l)P	BDE153
Fln	DB(a,h)A	BDE183
Pyr	B(g,h,i)P	
	InP	

### Chewing simulation

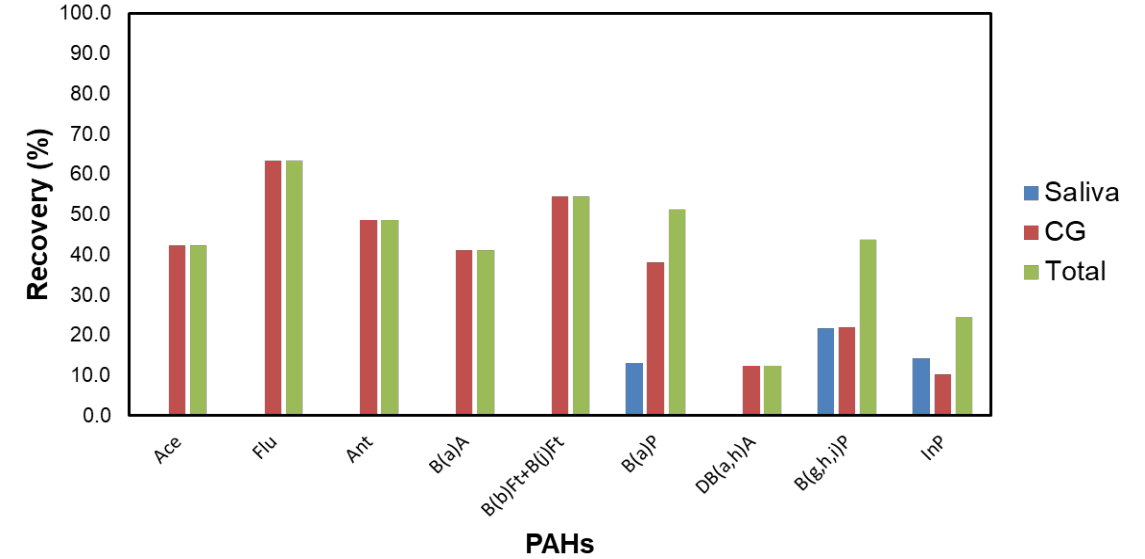


# Pollutant Removal Efficiency by the CG (HPLC)

**CGA**

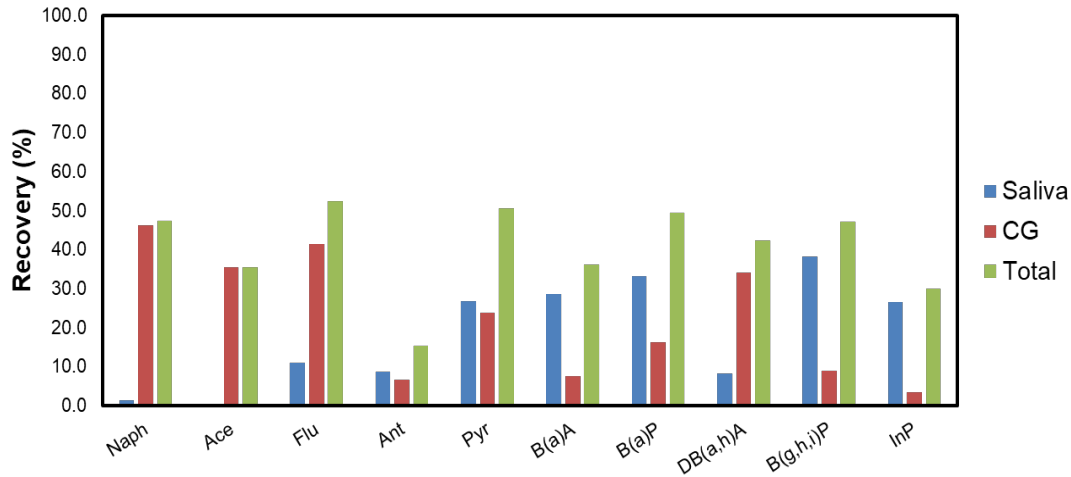


**CGB**



**PAHs**

**CGC**

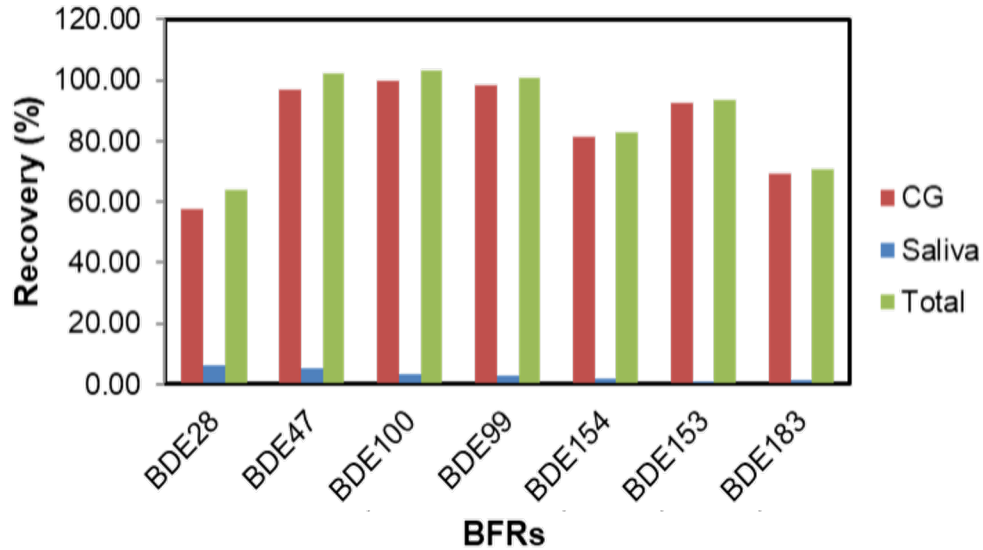


**PAHs**

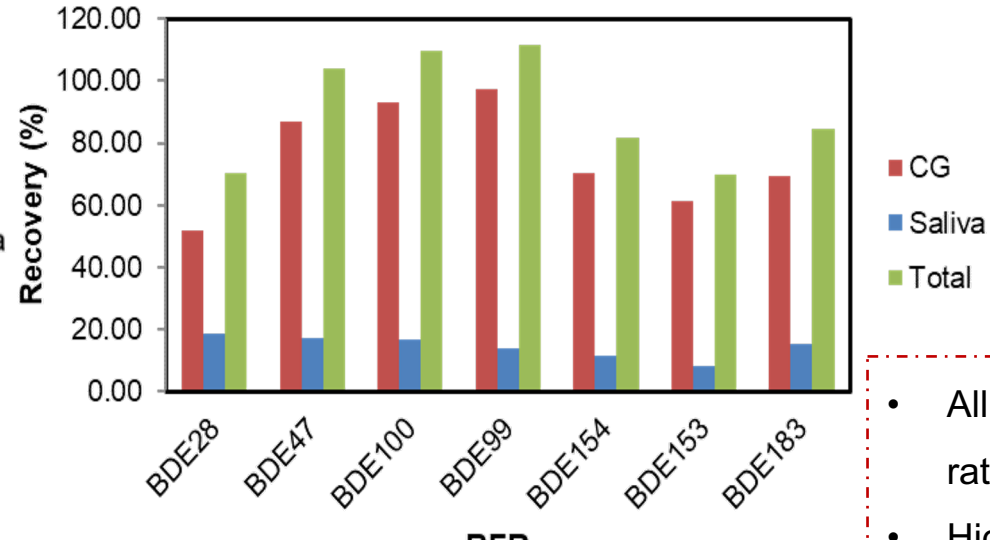
- The CG' formulations were capable of retain up to 10 PAHs.
- Overall, CGA and CGB exhibited higher recoveries values.

# Pollutant Removal Efficiency by the CG (GC)

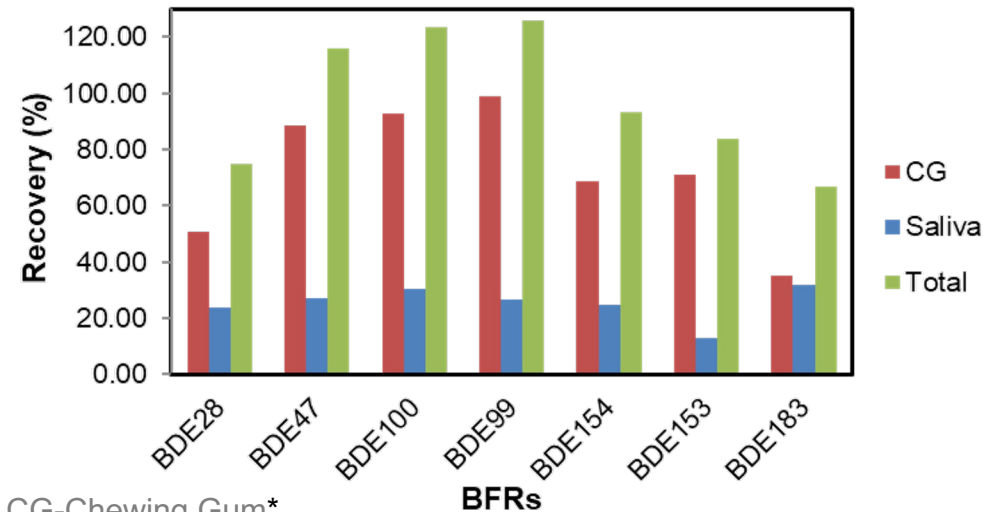
**CGA**



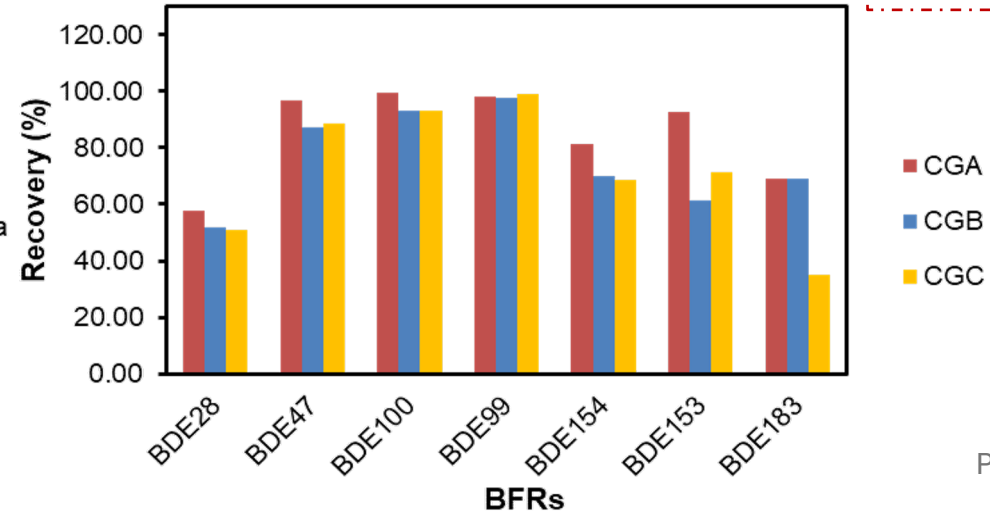
**CGB**



**BFRs**  
**CGC**



**BFRs**  
**All formulations**



- All CG' formulations display retention rates of 7 BFRs compounds.
- High recoveries can be observed across all formulations.

# Conclusions and Future Perspectives



## Main Conclusions

- All formulations reveal very similar texture profiles and rheological behavior.
- The CG showed good acceptability of the participants.
- The CG reveals promising retention of several BFRs.
- Overall, the analytical requires further optimization to obtain PAH higher recoveries.



## Future Perspectives

- All formulations will be used by participants during 2024 firefighting activities to evaluate the presence of fire-related pollutants in the oral cavity of firefighters.
- In the future, the protective capacity of the dry kiwiberry extract will be evaluated through *in-vitro* cell assays.



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Thank you for listening!

Any questions?

