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Development and evaluation of plant-based 3D-printed oral dispersible films for personalized nutrition for athletes

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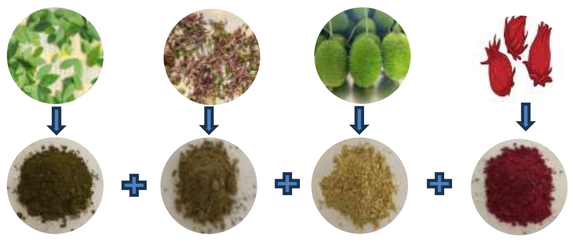
INTRODUCTION & AIM

Athletes lose minerals and electrolytes through perspiration, leading to fatigue and cellular damage and supplementation of certain micronutrients and their combination promote cellular health because nutrient deficiency is the one of the major causes of DNA damage in human because several minerals play important roles as substrates or cofactors in DNA replication and DNA repair and also involve neutralization of endogenous and exogenous genotoxins. Deficiency in specific nutrient can damage DNA and chromosomal instability. Various polyphenols, zinc iron, Mg, Ca and Selenium have consistent role in protection of DNA or cellular damage. Therefore, there is good basis for considering the possibility that supplementation in those who already have adequate intake does not cause harm to athlete. In regard to this, a road map was proposed for plant based diet packed with micronutrients and Phyto-nutrients are main catalysts to enable the body to function at peak performance, support higher energy demands, protect against exercise-induced oxidative stress with intense exercise and also provide sustainable food solution for optimizing sports performance in athletes. However, emphasize the sports nutrition is not a one size fits all solution, as each athlete has specific nutritional needs. Hence, nutritional customization with 3D food printing can allow the creation of tailored food for individual athletes.

1. To In present investigation fabrication of oral disintegrating films (ODFs) were developed through extrusion-based 3D printing using extracts of *Alternanthera sessilis*, *Sauropus androgynous* popularly known as *multivitamin* plant leaves and fruit vegetable of *Momordica dioica* extracts combined with HPMC K4M/E5, pullulan, moringa gum, ghatti gum, glycerol, roselle calyx powder, and fructo-oligosaccharide.
2. To evaluate physicochemical, phytochemical and mineral composition of fabricated plant based ODFs

METHOD

PLANT-BASED FAST-DISSOLVING ORAL DISPERSIBLE FILMS



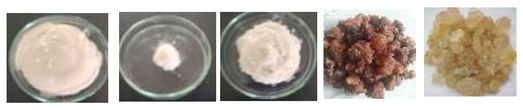
Sauropus androgynous

Alternanthera sessilis **leaves powder 10%**

Spine gourd fruit powder 15%

Roselle calyx powder as saliva stimulant 2%

Polymers



HPMC K4M 10% & E5 5%

Pullulan 5%

Moringa gum 10%

Ghatti gum 10%

Glycerol as plasticizer 15%

Monk fruit syrup as sweetener 3%

3D-Printer

3D-Printing

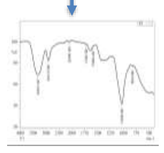
Oral disintegrating films

CHARACTERIZATION OF FILMS

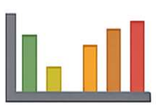
Thickness

Moisture uptake

SEM Analysis



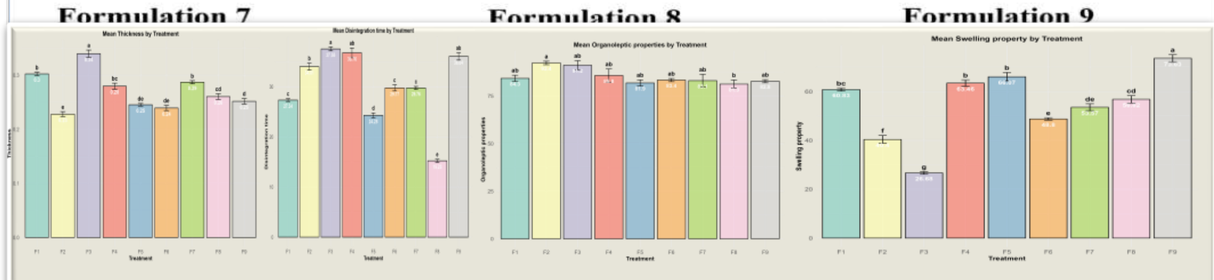
FTIR Spectroscopy

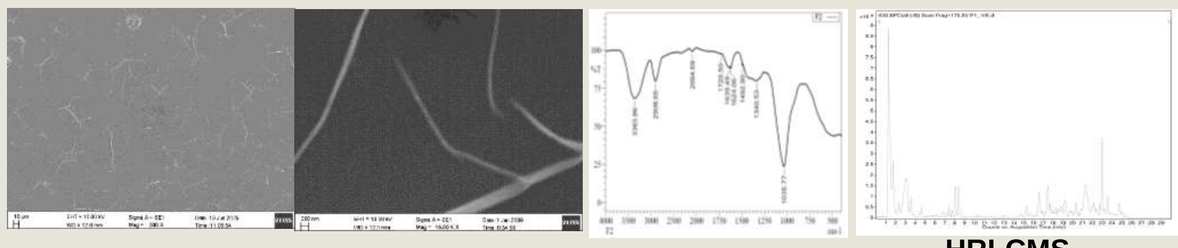


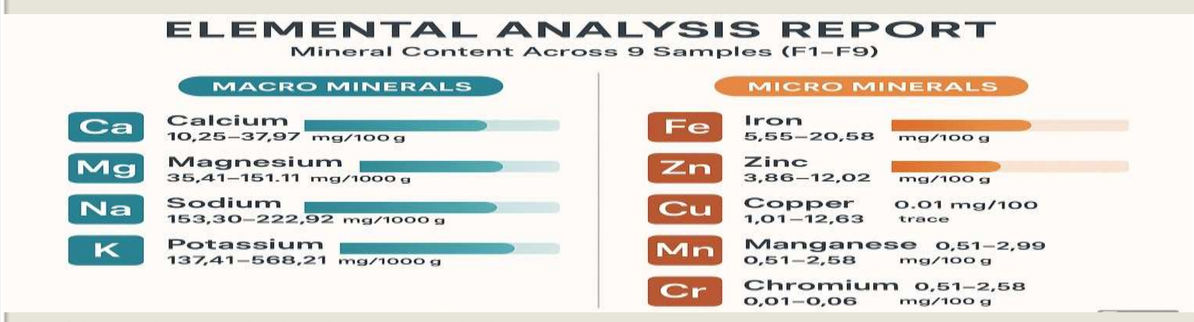
Elemental analysis

Fabrication of oral disintegrating films (ODFs) were developed through extrusion-based 3D printing using extracts of *Alternanthera sessilis, Sauropus androgynous* popularly known as *multivitamin* plant leaves and fruit vegetable of *Momordica dioica* extracts combined with HPMC K4M/E5, pullulan, moringa gum, ghatti gum, glycerol, roselle calyx powder, and fructo-oligosaccharide and the entire polymeric mixture under continuous stirring for 30 minutes to ensure even distribution. The resulting blend was degassed to eliminate air bubbles and cast using a 3D food printing system configured for aqueous suspensions. The printed films were dried at ambient temperature for 24 hours under undisturbed conditions.
samples were then cut into 4 cm^2 sections (2 cm × 2 cm) and stored in aluminium-laminated pouches to preserve their physicochemical integrity before characterization
Oral disintegrating films were evaluated for surface morphology by SEM (Scanning Electron Microscope), topological features through FTIR, elemental profile by ICP-MS, HR-LCMS-based targeted quantitative analysis for phytochemicals were carried out

RESULTS & DISCUSSION







The fabricated ODFs displayed consistent thicknesses (0.228 ± 0.008 mm to 0.340 ± 0.012 mm), rapid disintegration (15.23 ± 0.53 to 36.545 ± 0.65 s), and strong organoleptic scores (92.4 ± 1.60 to 91.2 ± 4.18/100). Moisture content (7.50 ± 0.13 to 6.154 ± 0.21%) and swelling index (26.68 ± 0.92 to 40.40 ± 2.80%) supported stability and mucosal compatibility. SEM images of all formulations revealed a uniform matrix with irregular depressions. FTIR confirmed functional groups such as C–O–C, phenolic O–H, and carbonyls, common among all the formulations, with H-bonded O-H bond vibration in *sauropus*-based films. ICP-MS identified macro elements such as K: 568.21, Na: 222.92, Mg: 72.23, and Ca: 19.74 mg/100g in Alternanthera-based ODFs; K: 137.41, Na: 218.15, Mg: 151.11, and Ca: 32.95 mg/100g in *Sauropus;* and K: 537.34, Na: 187.09, Mg: 65.65, and Ca: 37.97 mg/100g in *Momordica*-based films, and trace microelements Fe, Zn, Cu, Se, Mn, Cr, and Co were also identified. *A. sessilis*-based ODFs showed superior physicochemical traits, while *Sauropus*-based ODFs exhibited comparatively high mineral content, and 136 distinct phytonutrients (phytochemicals) with potential antioxidant potential, confirming their promise as sustainable, bioactive carriers for personalized nutrient delivery in athletes

CONCLUSION

A. sessilis-based ODFs showed superior physicochemical traits, while *Sauropus*-based ODFs exhibited comparatively high mineral content, and 136 distinct phytochemicals confirming their promise as sustainable, bioactive carriers for personalized nutrient delivery in athletes

FUTURE WORK / REFERENCES

Further studies are needed to reproduce oral films using a variety of vegetables to expand nutritional and therapeutic potential.

1. Formulations of orally disintegrating films should involve naturally available polymers to enhance film-forming properties and stability.
2. Furthermore, experimenting with different film casting techniques and comparing their results can help identify methods to produce the most uniform and desirable film characteristics.