Identifying Sustainable Packaging Materials for Food Groups Through Clustering of Gas Permeability

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Introduction

Food packaging is essential for maintaining the safety, quality, and shelf life of food products by acting as a barrier against moisture, oxygen, and contaminants. Key metrics, **water vapor transmission rate (WVTR), oxygen transmission rate (OTR),** influence food spoilage through moisture absorption and oxidation. **Permeability of carbon dioxide** also play crucial in modified atmosphere packaging (MAP). While plastics like polyethylene are widely used for their versatility, they contribute to significant environmental waste, with 95% of plastic packaging materials being non-recycled.

Sustainable alternatives are gaining attention as solutions to reduce the environmental impact of packaging. However, these materials often show inferior barrier properties compared to conventional plastics, which challenges their suitability for various food types. For instance, high-fat foods need low oxygen transmission, whereas fresh produce requires higher gas permeability for respiration**. A systematic understanding of sustainable packaging materials that meet specific food group needs is crucial to maintain food quality and prevent waste**.

Objective

The study aims to fill that gap by **developing clustering algorithms to group sustainable packaging materials according to their gas permeability characteristics**— oxygen, water vapor, and carbon dioxide—and then **identify which materials are best suited to the barrier needs of different food groups.**

Methods

The study will utilize a text-mined dataset (Lentschat, 2021) from 50 scientific articles, published between 2000 to 2016, on packaging materials and their gas permeability properties. Clustering algorithms will be applied to group sustainable packaging materials based on their permeability metrics

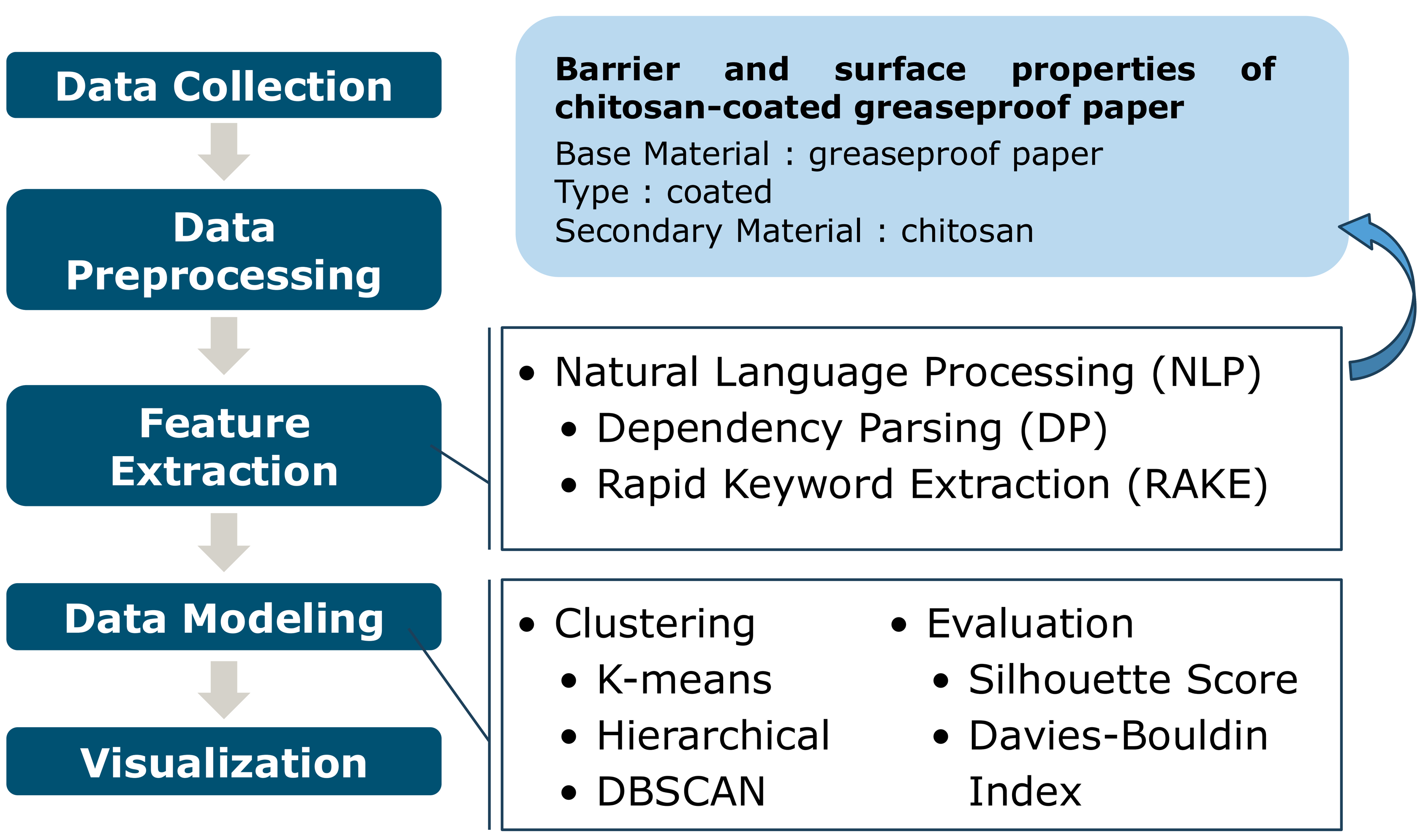

Figure 1. Data analysis process flowchart

Expected Outcomes

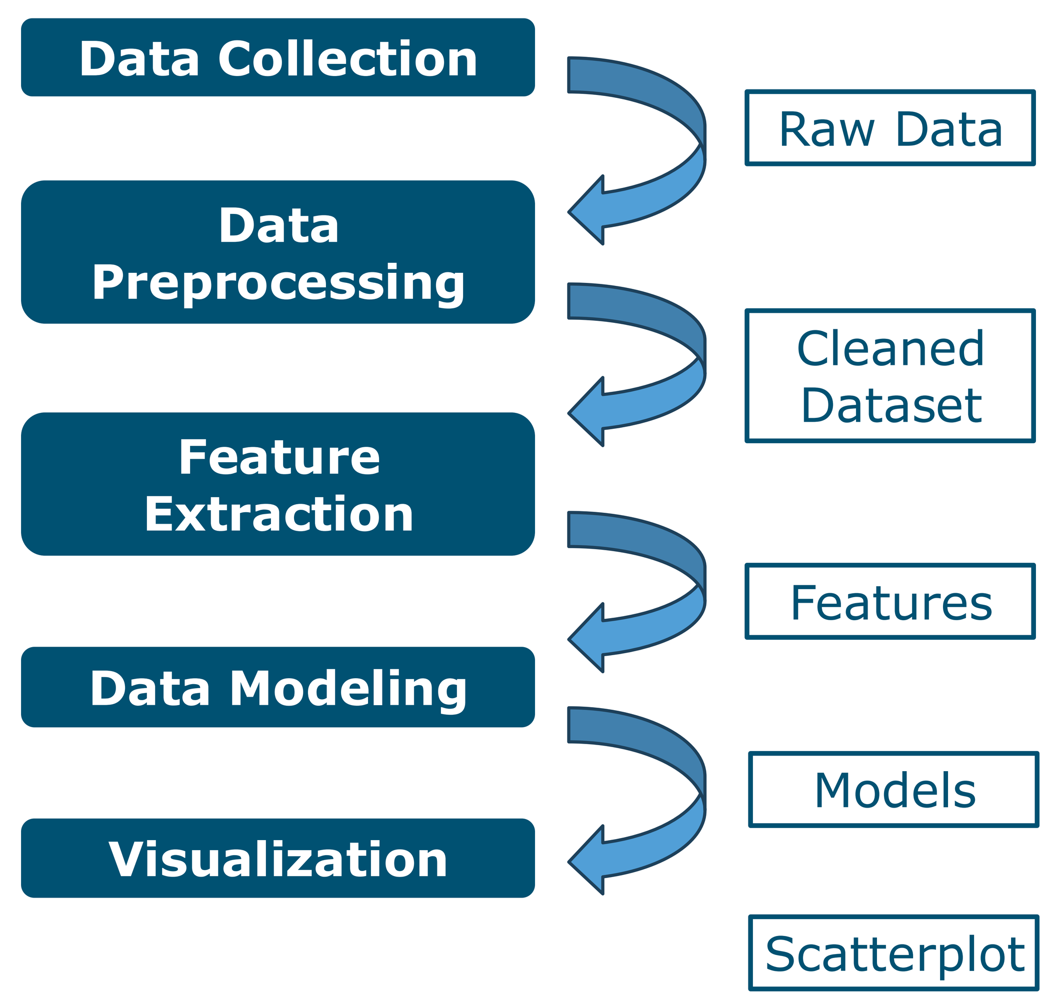

Figure 2. Expected outcomes for each step of the data analysis process.

Features

Table 1. Expected features derived from NLP, including materials and their anticipated gas permeability indices

Materials	Based Material	Type	Secondary Material	Composition	OP	OTR	WVP	WVTR	Pco2	co2TR	temp	RH
chitosan-coated greaseproof paper	greaseproof paper	coated	chitosan	[2.4]	[0.01, 2]	[0.001, 0.2]	nan	nan	[0.001, 10]	[0.0001, 1]	25	95
poly (lactic acid) nanocomposites	polylactic acid	nanocomposite	montmorillonite	[0.15]	nan	nan	$1.160 * 10^{-10}$	$1.160 * 10^{-8}$	nan	nan	38	52
Carrot puree films	Carrot puree	individual	nan	[0.4,0.6]	[20.20, 20.34]	[4.80, 4.84]	nan	nan	nan	nan	25	83

Scatterplot

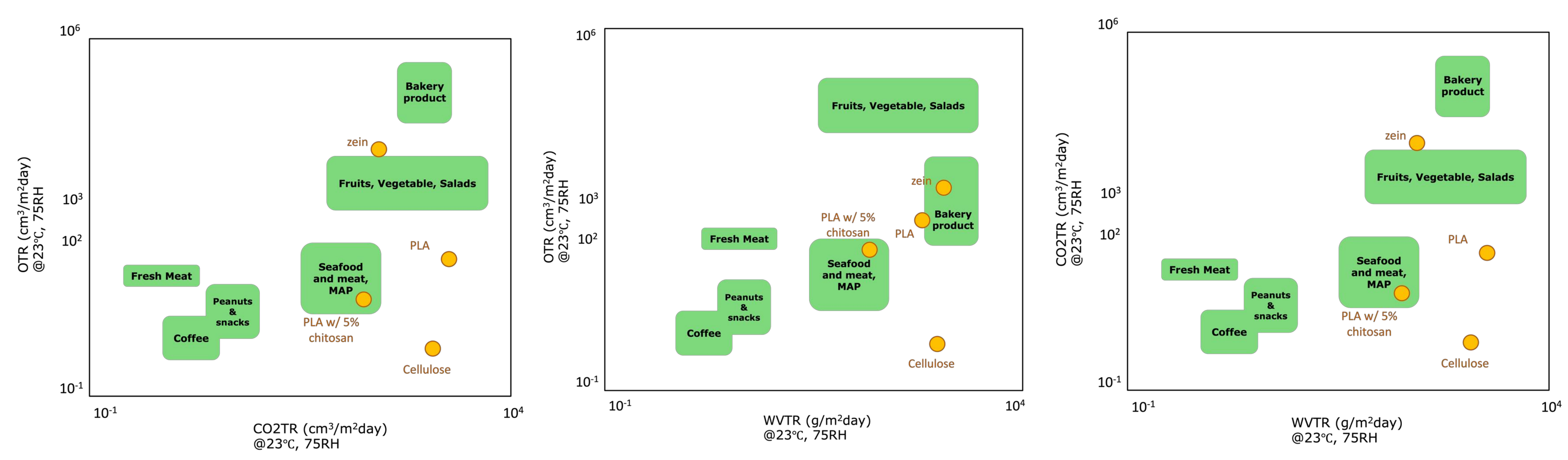

Figure 3. Expected scatterplot showing clustering of sustainable packaging materials by gas permeability (O_2, H_2O, CO_2) with food group requirements.

Application

The study enables optimized packaging selection by systematically matching sustainable materials with food groups based on gas permeability needs, ensuring better food quality and shelf life. Additionally, it promotes the adoption of eco-friendly packaging solutions, helping reduce reliance on conventional plastics and lowering environmental impact.

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