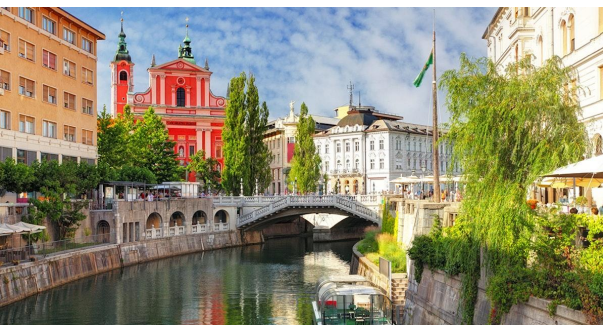


# Towards AI-driven Food Science and Society: Opportunities and Challenges

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# PROTECTING OUR PLANET STARTS WITH YOU



**BIKE MORE  
DRIVE LESS**



**EDUCATE**

When you further your own education, you can help others understand the importance and value of our natural resources.



**Volunteer!**

Volunteer for cleanups in your community. You can get involved in protecting your watershed too!



**reduce  
REUSE  
recycle**

Cut down on what you throw away. Follow the three "R's" to conserve natural resources and landfill space.

**CONSERVE WATER**



The less water you use, the less runoff and wastewater that eventually end up in the ocean.

**choose sustainable**



Learn how to make smart seafood choices at [www.FishWatch.gov](http://www.FishWatch.gov).



Buy less plastic and bring a reusable shopping bag.



**Long-lasting  
light bulbs  
- ARE A -  
BRIGHT  
IDEA**

Energy efficient light bulbs reduce greenhouse gas emissions. Also flip the light switch off when you leave the room!

Trees provide food and oxygen. They help save energy, clean the air, and help combat climate change.



**PLANT  
A TREE**



**Don't send  
chemicals  
into our  
waterways.**

Choose nontoxic chemicals in the home and office.



[oceanservice.noaa.gov](http://oceanservice.noaa.gov)

# Food scandals that rocked the foodservice industry

- Horse meat scandal
  - Horse meat burger instead of beef
- Pret A Manger
  - Limited labelling requirements for food
- KFC runs out of chicken
  - Changed their supplier



# Big Data + Digitalization



Nutrients (per 100 gm)	Unit	Staple Foods							
		Maize flour	Millet Flour	Rice	Cassava fresh	Cassava flour	Matooke (plantain)	Beans	Groundnut
Energy	Kilocalories	369	374	360	160	314	1227	347	567
Protein	Grams	7.3	10.9	6.6	1.4	2.6	1.3	21.4	25.8
Fat	Grams	1.8	4.2	0.6	0.3	0.7	0.4	1.2	49.2
Carbohydrate	Grams	79.2	72.3	79.3	38.1	76.6	31.9	62.6	16.1
Calcium	Milligrams	3.0	8.0	9.0	16.0	31.0	3.0	11.0	92.0
Iron	Milligrams	1.1	3.0	0.8	0.3	1.9	0.6	5.1	4.6
Zinc	Milligrams	0.7	1.7	1.2	0.3	0.7	0.1	2.3	3.3

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## Dietary intake measurements

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### Abstract

**Objective:** To provide a concise summary of field and laboratory methods for the measurement of dietary intake with particular reference to the assessment of energy and protein intake and to the pitfalls and difficulties that may be encountered in practice when implementing the methods both in the field and under laboratory conditions.

**Keywords**  
Dietary intake methods  
Measurement error  
Biomarkers  
Energy  
Protein  
Habitual

### Review of basic concepts

*"It is easy to ask what people eat, but finding an answer can be a daunting task (Hobling, 1991)".*

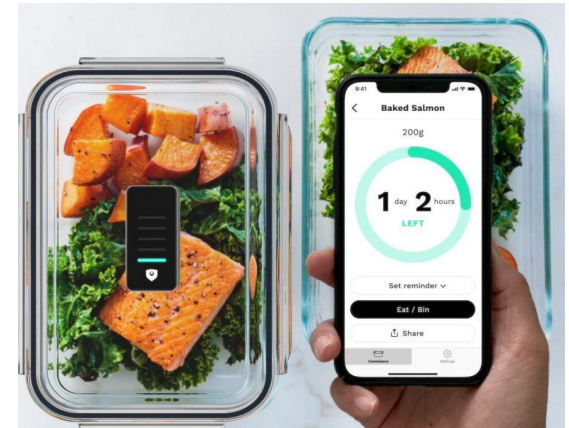
### What is dietary intake?

Dietary intake is generally considered to include all foods and beverages (hereafter referred to as food) consumed by

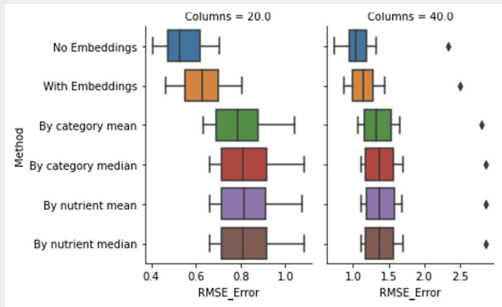
### Day-to-day variation

The food intake of individuals is not a static quantity. It varies both in type and amount from day to day, from week to week and from year to year. In general quantitative measurements of dietary intake can only be made over very short periods of time. This means that such measurements are unlikely to reflect the long-term habitual intake of individuals that for most purposes is the timeframe of interest.

When dietary intake data are used in order to assess the



# Missing value imputation in FCDB



# Food image extraction and normalization

## Named-Entity Recognition (NER)

Excessive **salt** intake has been associated with a higher incidence of **heart disease**.

## Named-Entity Linking (NEL)

Excessive **salt** [**FOODB**] intake has been associated with a higher incidence of **heart disease** [**UMLS**].

# Human Computer Interaction Tools for validation of AI results

FoodViz Recipes File text FoodNER annotation FoodNER resources Food Onto Map Index Food-Disease annotations CATERINA annotations Logout

Recipes

Curated?

Filter recipes:

All categories:

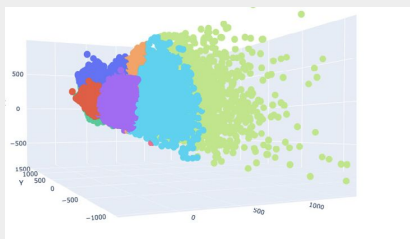
Recognized Entities for recipe 0recipe1006

Mix the **cream cheese**, **cream**, **cream** and **cream cheese** together in a bowl until evenly blended. Keeping the mixture in the bowl, scrape it into a semi-ball shape. Cover, and refrigerate until firm, at least 2 hours. Place a large sheet of waxed paper on a flat surface. Sprinkle with **cream**. Roll the **cream** on the **cream** until completely covered. Transfer the **cream** to a serving plate, or rewrap with waxed paper and refrigerate until needed.

Entity tags

Entity	Synonyms	Handard Tags	Handard Parent	Handard Closest	FoodOn	SnomedCT	OF
cream cheese	CREAM CHEESE	AG.01.s (Dairy produce); AG.01.s.02 (Cheese); AG.01.n (Dishes and prepared food); AG.01.n.18 (Preserve);	Food	Dairy produce	cream cheese	Cream cheese Cheese Cream	
beef	BEEF	AG.01.s.03 (Beef);	Food	Food		Beef	
olives	OLIVES	AG.01.n.01.s (Fruit containing stone);	Fruit and vegetables	Fruit containing stone		Olives	

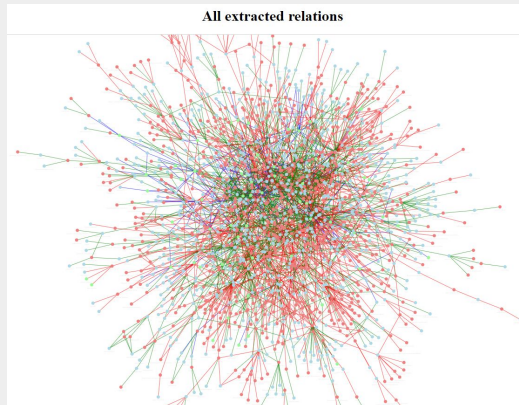
# Predicting nutrient values from food consumption data



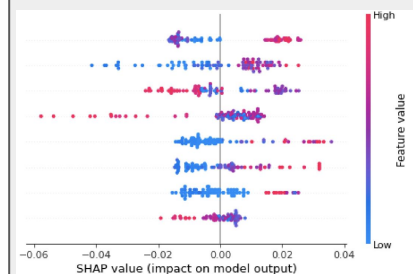
# Food image recognition



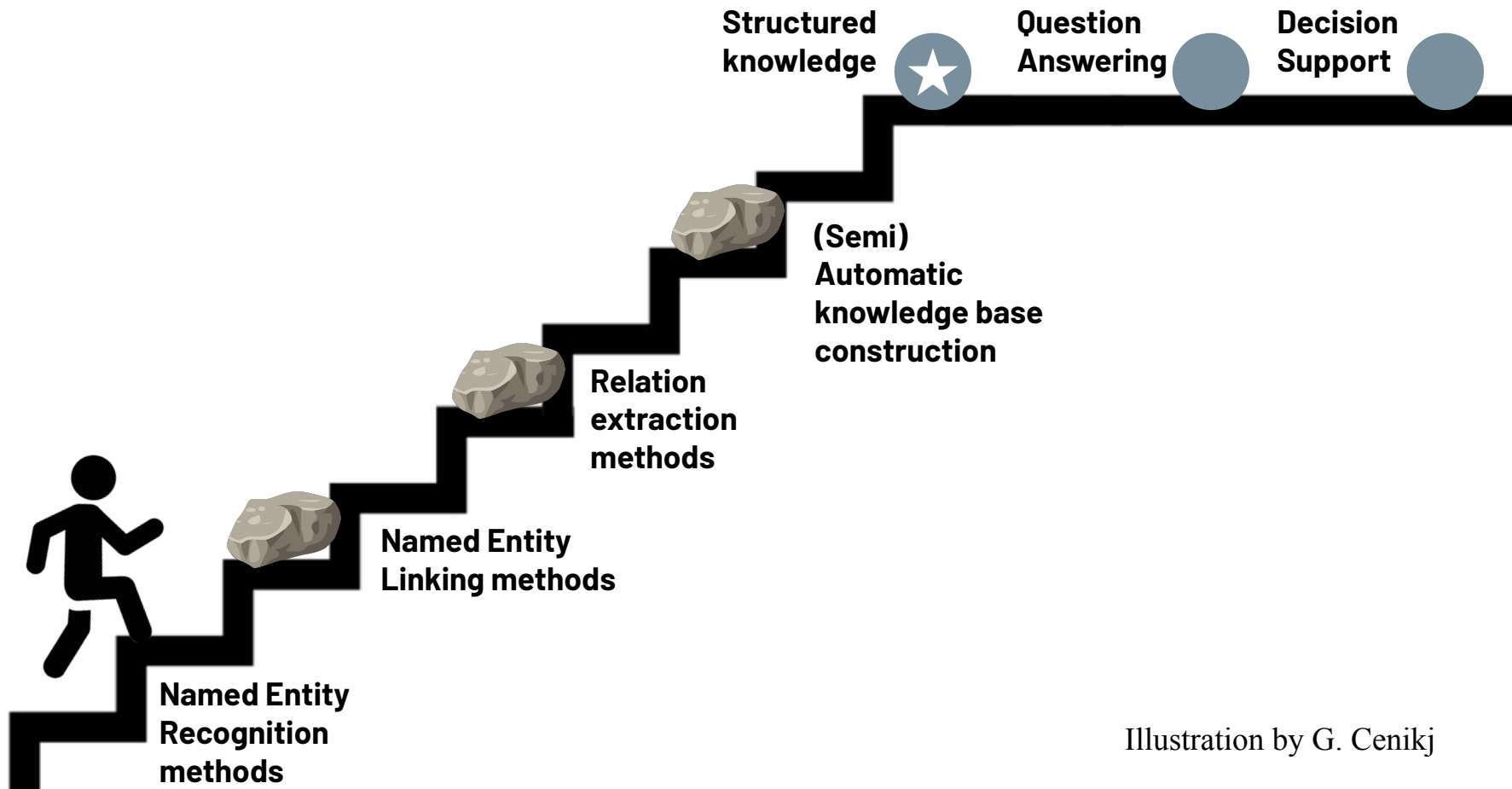
# Food-Chemical-Disease KG



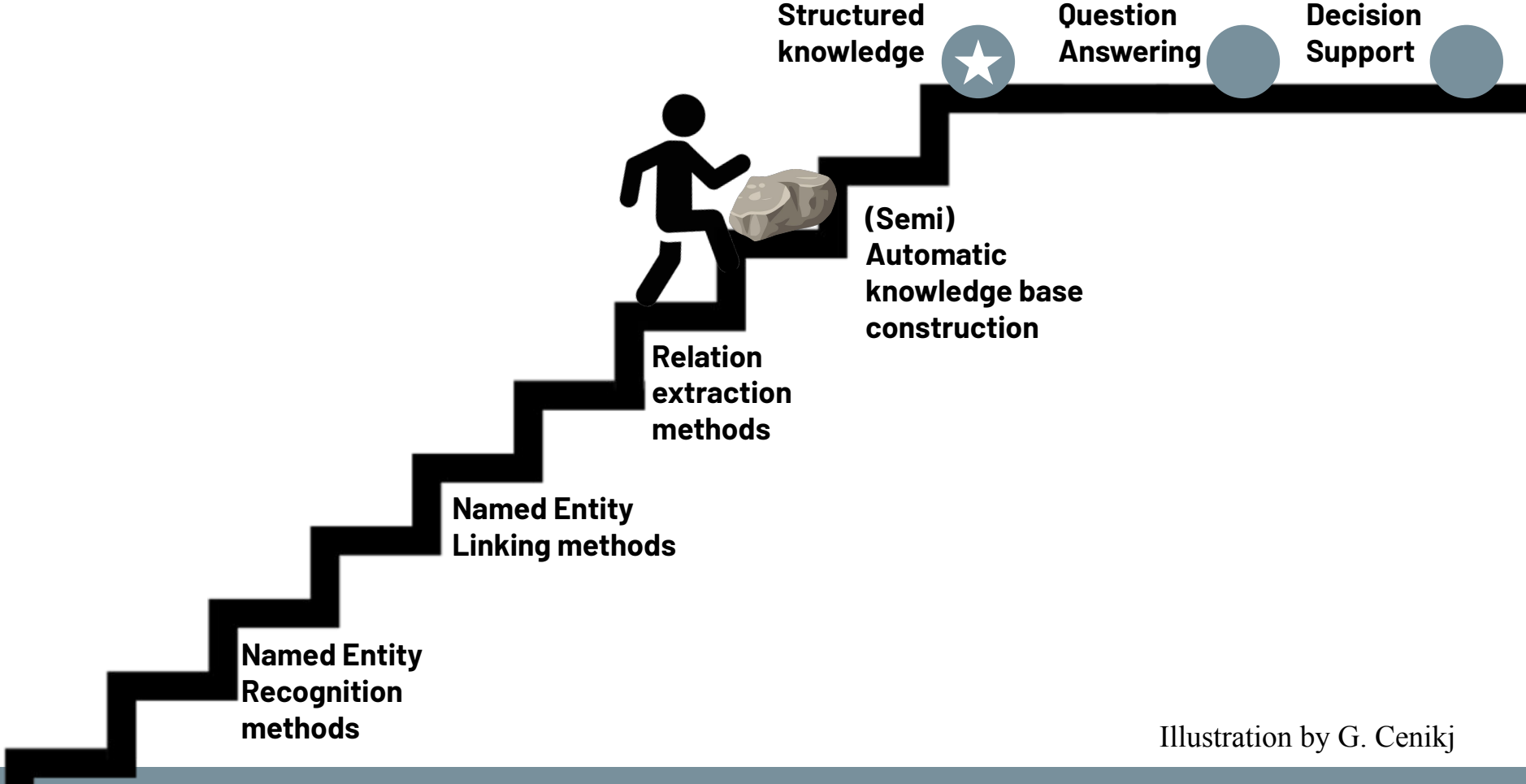
# Explainable Food-Health Analysis



# From Language Technologies to Decision Support



# State in the Biomedical Domain



# State in the Food Domain in 2020

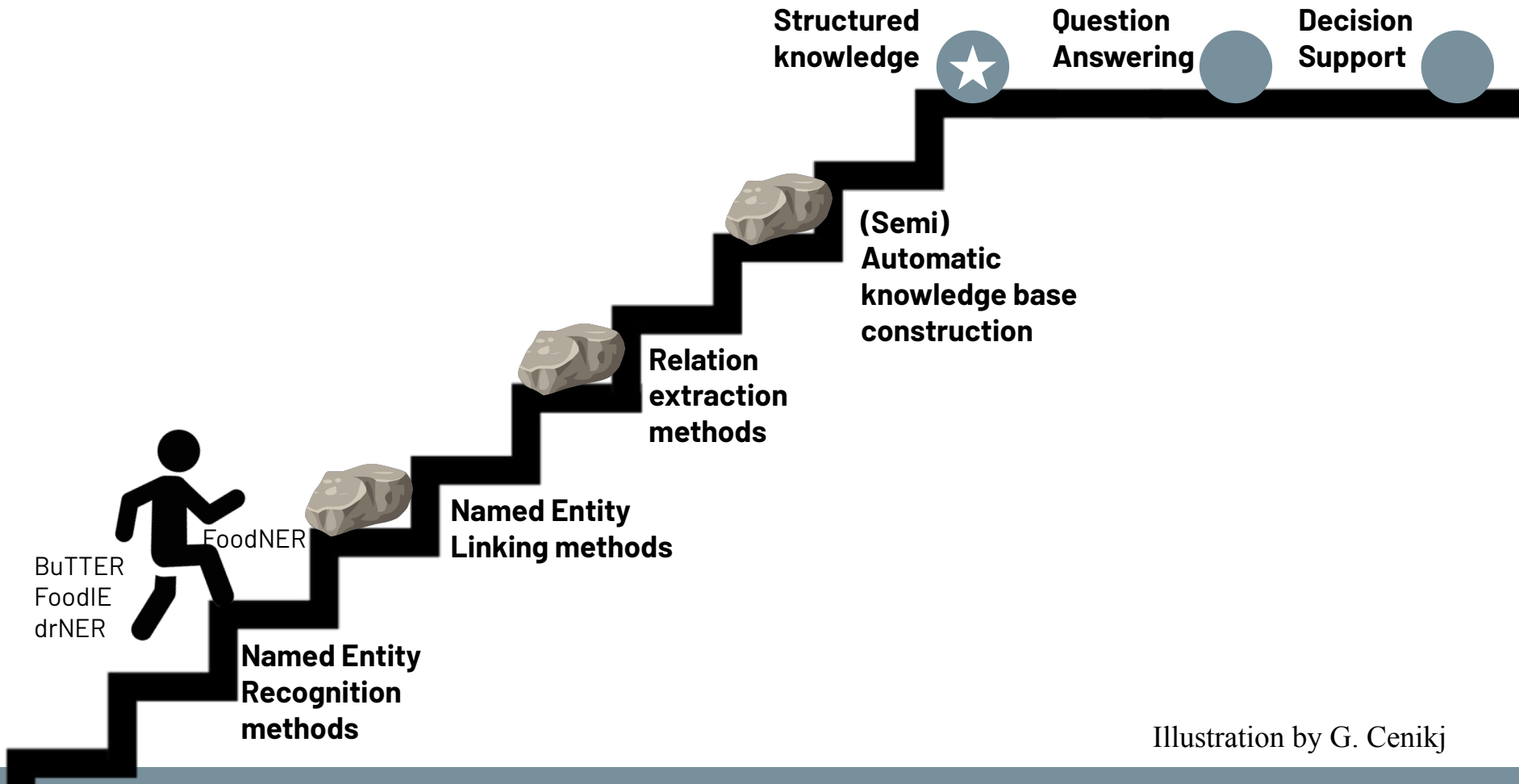
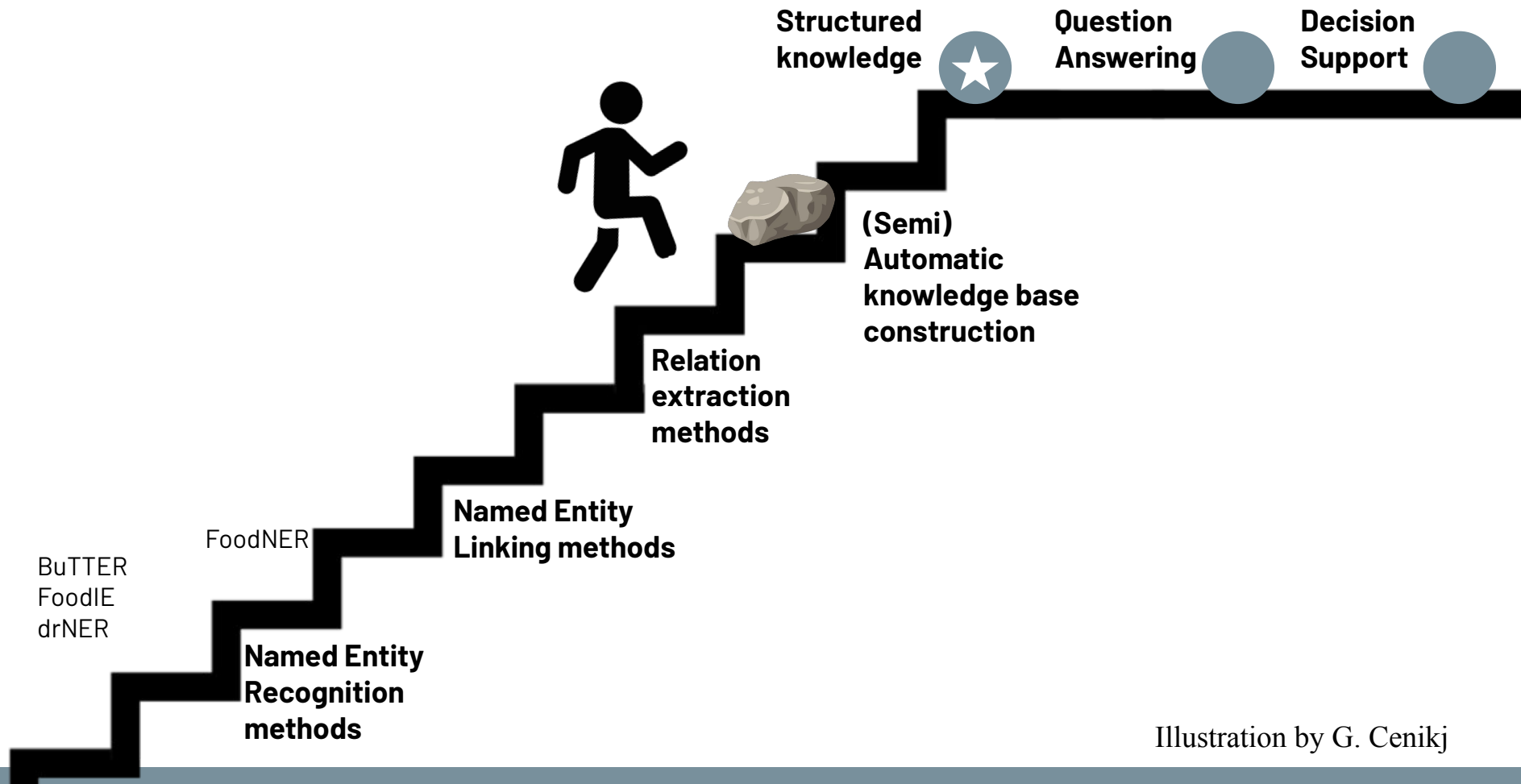


Illustration by G. Cenikj



# State in the Food Domain



# FoodViz Tool

FoodViz with FoodNER [Recipes](#) [Free text FoodNER annotation](#) [FoodNER resources](#) [Food Onto Map Index](#) [Food-Disease annotations](#)

Recipes

Currated?

Filter recipes

All categories

[Orecipe1006](#)

[Orecipe1013](#)

[Orecipe1046](#)

[Orecipe1058](#)

[Orecipe106](#)

[Orecipe1078](#)

[Orecipe1090](#)

[Orecipe1102](#)

[Orecipe1110](#)

[Orecipe1122](#)

[Orecipe1134](#)

[Orecipe1142](#)

[Orecipe1166](#)

[Orecipe1174](#)

[Orecipe1186](#)

[Orecipe1197](#)

[Orecipe1218](#)

[Orecipe1231](#)

[Orecipe1251](#)

[Orecipe1263](#)

[Orecipe1271](#)

[Orecipe1283](#)

[Orecipe1295](#)

## Recognized Entities for recipe **Orecipe1006**

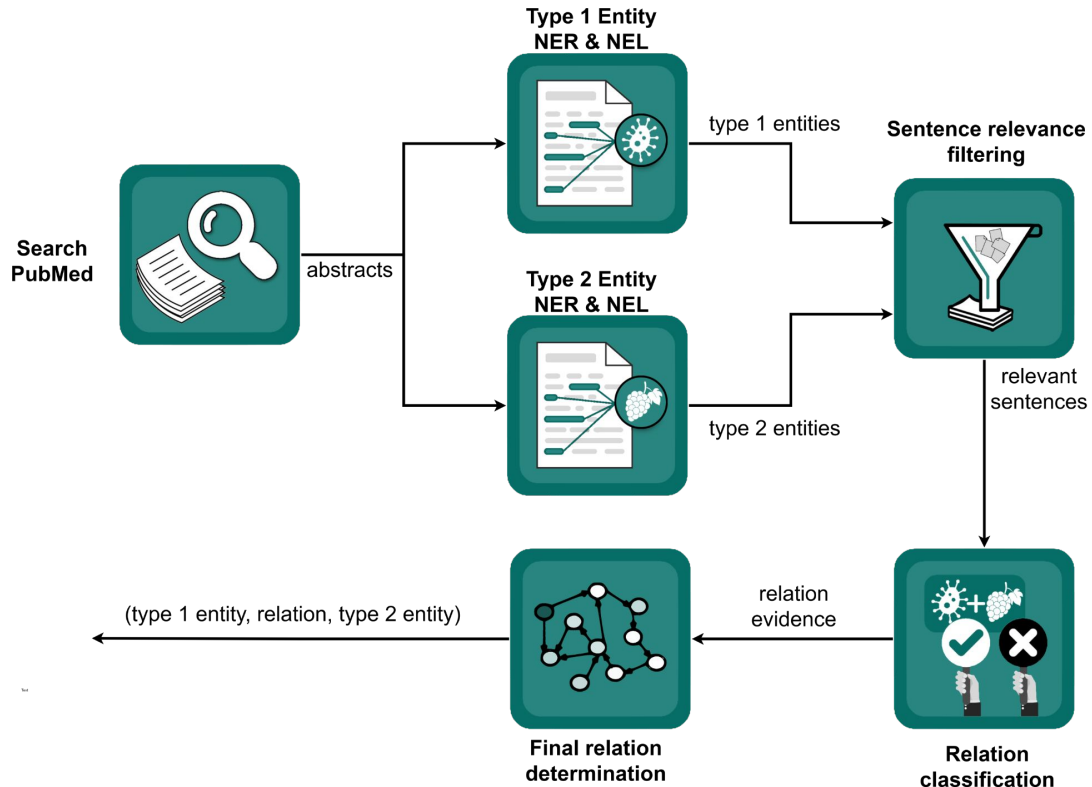
Mix the **cream cheese**, **beef**, **olives**, **onion**, and **Worcestershire sauce** together in a bowl until evenly blended . Keeping the mixture in the bowl , scrape it into a semi-ball shape . Cover , and refrigerate until firm , at least 2 hours . Place a large sheet of waxed paper on a flat surface . Sprinkle with **walnuts**. Roll the **cheese ball** in the **walnuts** until completely covered . Transfer the **cheese ball** to a serving plate , or rewrap with waxed paper and refrigerate until needed .

### Entity tags

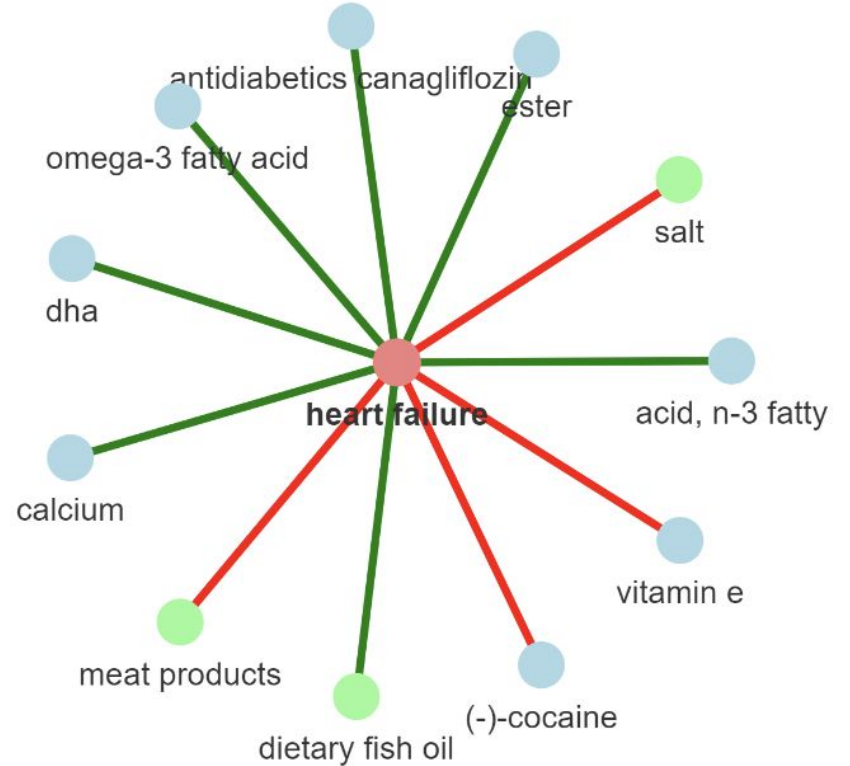
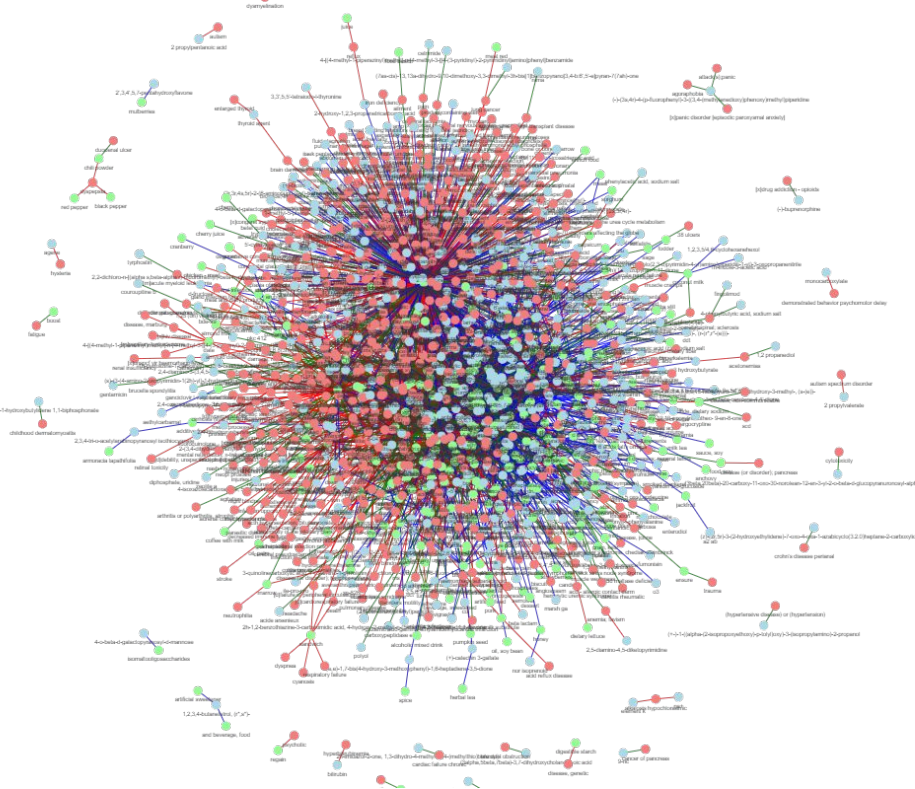
Entity	Synonyms	Hansard Tags	Hansard Parent	Hansard Closest	FoodOn	SnomedCT	OF
cream cheese	CREAM CHEESE	AG.01.e [Dairy produce];AG.01.e.02 [Cheese];AG.01.n [Dishes and prepared food];AG.01.n.18 [Preserve];	Dishes and prepared food	Dairy produce	cream cheese	Cream cheese Cheese Cream	
beef	BEEF	AG.01.d.03 [Beef];	Animals for food	Food		Beef	
olives	OLIVES	AG.01.h.01.e [Fruit containing stone];	Fruit and vegetables	Fruit containing stone		Olives	
onion	ONION	AG.01.h.02.e [Onion/leek/garlic];	Fruit and vegetables	Onion/leek/garlic	onion (whole) Allium cepa	Onion	of:Onion



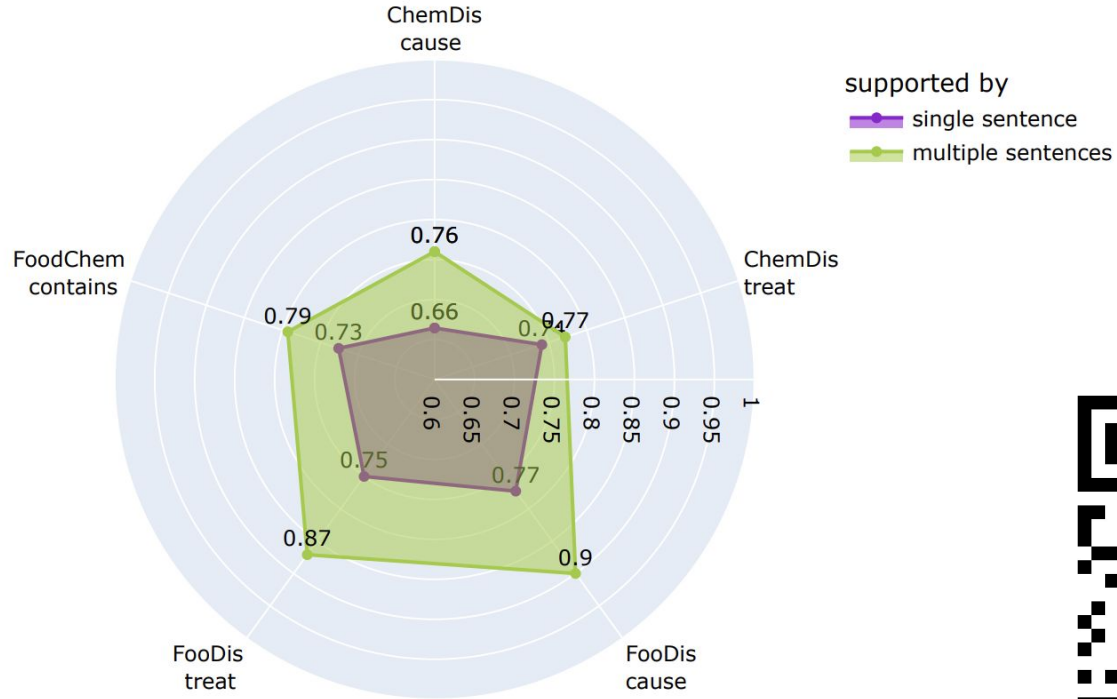
# Food, Chemical, Disease Knowledge Graph



# Food, Chemical, Disease Knowledge Graph



# Food, Chemical, Disease Knowledge Graph



# Food Image recognition

## NutriNeet

86.72% accuracy across 512 different drinks and foods



Sandwich



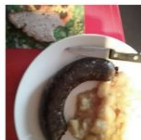
Sandwich  
Tiramisu  
Burger  
Chocolate Pudding  
Roulade



Beef Soup with Noodles



Creamy Vegetable Soup  
Carrot Soup  
Potato Goulash  
Beef Soup with Noodles  
Vegetable Soup



Buckwheat Bread, Sausage,  
Mashed Potatoes



White Bread with Olives  
Chanterelles with Eggs  
Baked Rice Pudding  
Chocolate Marshmallow  
Plums



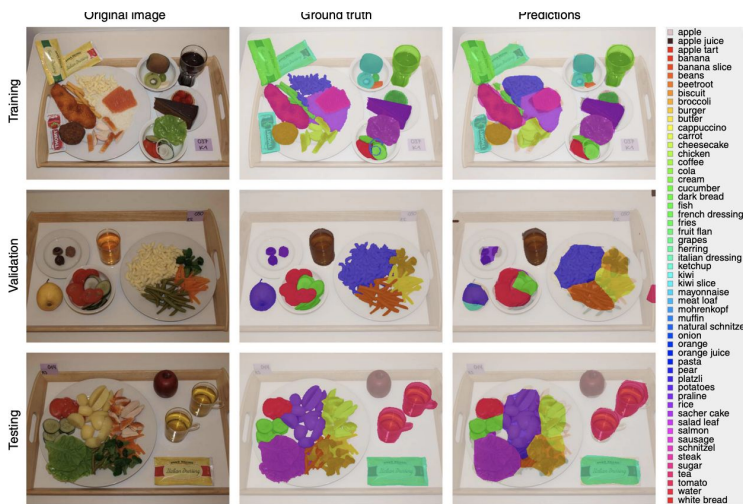
Coffee



Coffee  
White Coffee  
Muffin  
Chocolate Spread  
Turkey Stew

## Food segment recognition

92.18% accuracy - 124 study participants

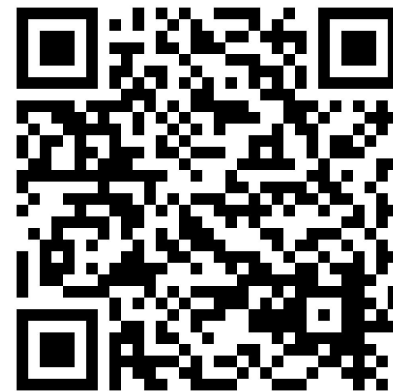
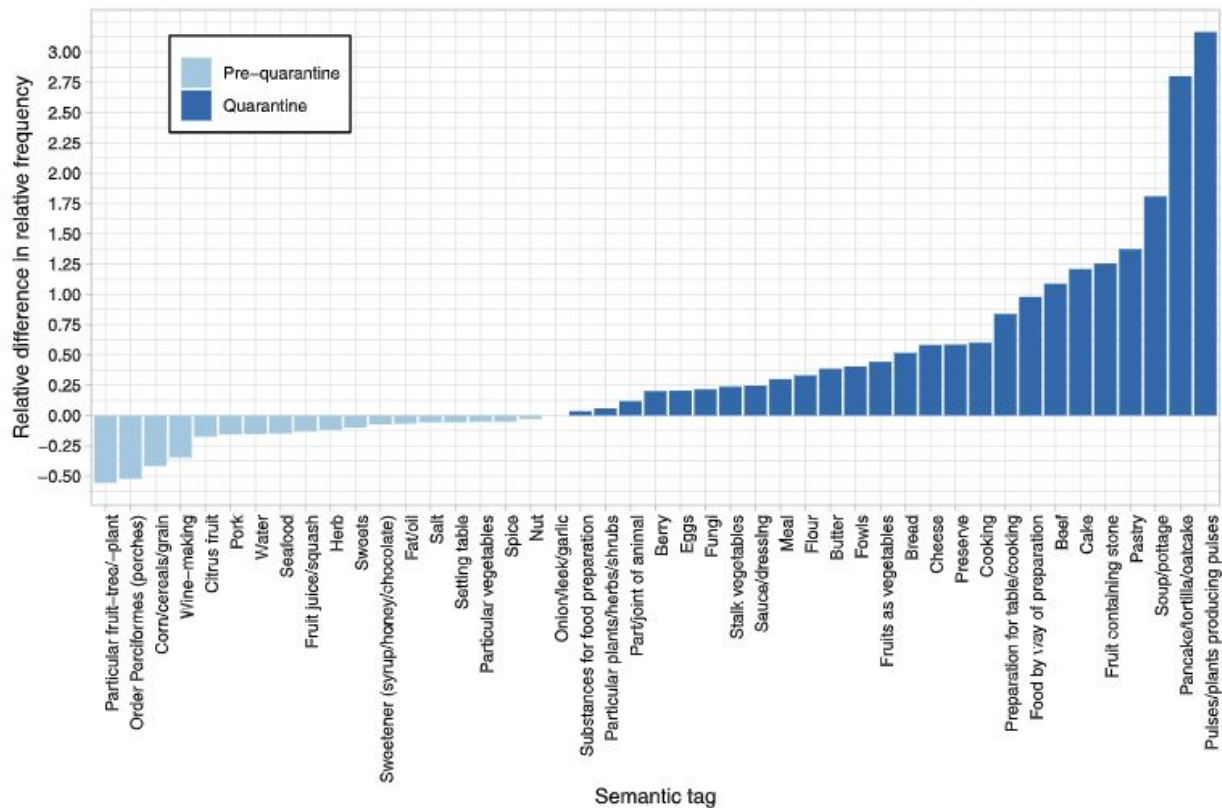


## EU-organic and NutriScore logo recognition for packed foods

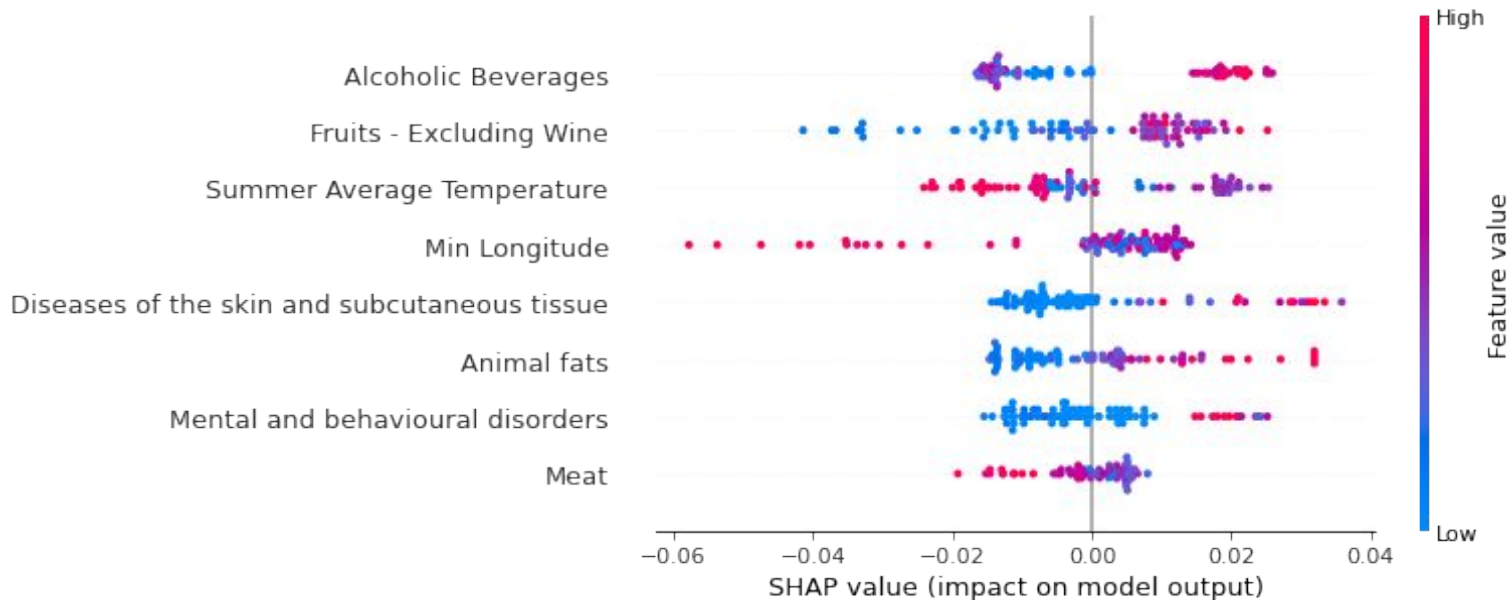
94% accuracy on NutriGreen dataset



# COVID-19 Impact on Food Consumption Patterns

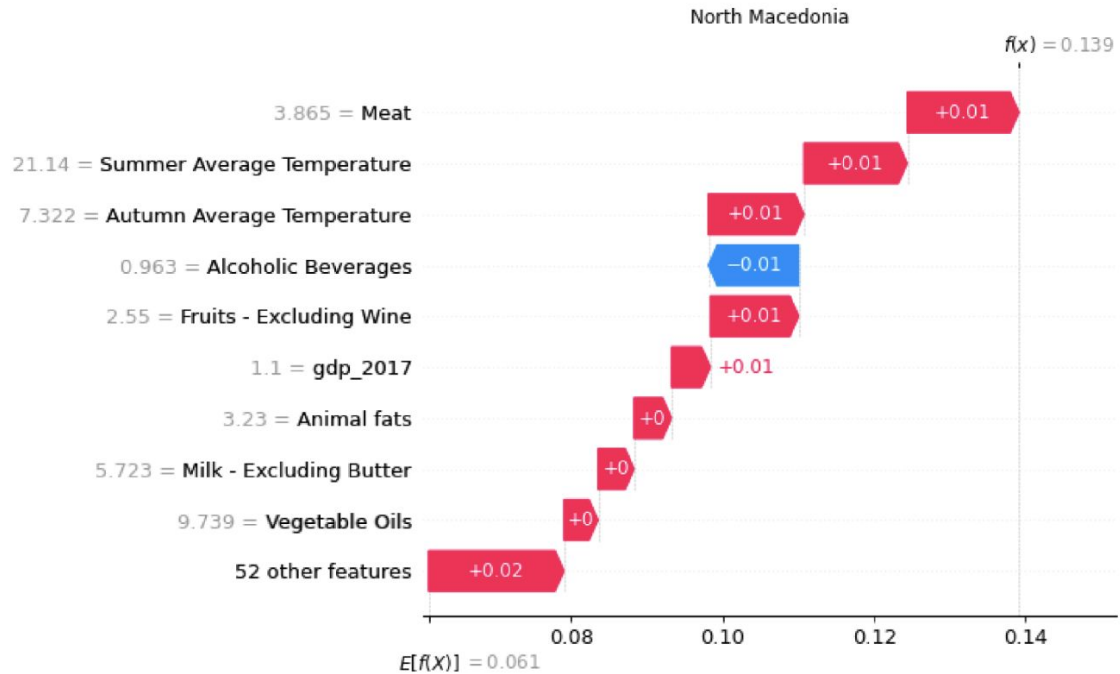


# FAO + WHO + Socio-economic Data for COVID-19 Mortality Prediction





# COVID-19 mortality rate



# Take Home Messages

- Limited food related data that is publicly available for learning
  - Support open science
- Instead of simple statistics let's use explainable AI

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