Challenges in Ontological Modelling of Ingredient Substitution in Food Recipes

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TAISTI in a nutshell

- EEA and Norway grants - Financial contribution of Iceland, Liechtenstein and Norway
- Programme „Applied Research”
- Project title: Development of a Technology based on Artificial Intelligence for inferring SubsTitutable recipe Ingredients
- 2 year project (1 July 2021 – 30 June 2023)

Objectives

Foundational analysis of ingredient substitution and to investigate how to capture and model it explicitly:

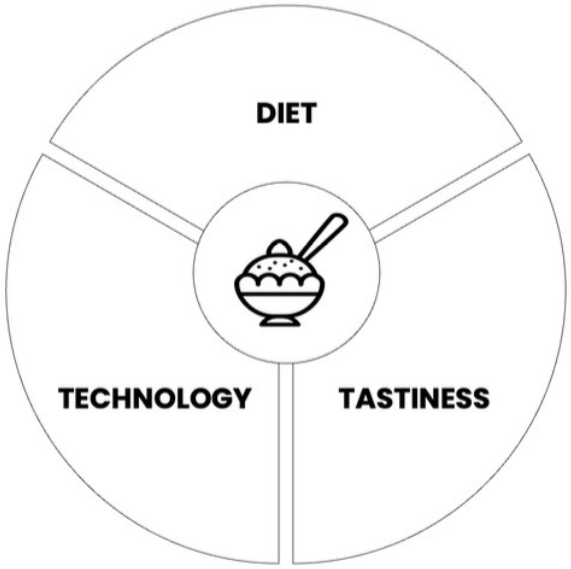
- How to model substitutes for ingredients in food recipes?
- What related concepts should be taken into account to define the substitution's context (e.g., conditions, goals)?
- How to link the proposed model to existing food models and recommended design patterns?

Aspects of a dish, conditions, constraints

Scenario1: Substitution due to lack of product.
Objective: The substitute must replicate nutritional value, i.e., also be a good source of fiber.

Scenario 2: Substitution due to the need to exclude a particular product for health reasons.
Objective: The substitute must meet health requirements.

Scenario 3: Substitution due to the need to exclude a specific product for health reasons.
Objective: The substitute must meet the technological requirements, i.e., it must give the same sweetness to the dish as sugar.



Recipe ingredient substitute: binary or n-ary relation?

Conceptualization of substitutions in existing ontologies and knowledge graphs.

Ontology	Substitution	Context	Limitations
FoodOn	a (symmetric) relation: 'has food substance analog'	dietary and allergen analysis	no links with food preparation process, recipes
	subclasses of class: 'food product analog'		
FoodKG	heuristics based on explicit semantics and embeddings	dietary restrictions nutritional change	no ontological conceptualization
ONE	no term(s) for substitution		
ONS	no term(s) for substitution		

Recipe ingredient substitute: binary or n-ary relation?

Competency questions:

1. What ingredient is being replaced with another ingredient or a set of ingredients? What are the dietary features of the ingredient?
2. What are the food technology features of the ingredient?
3. What are the nutrition values the ingredient has?
4. What is the quantity of the ingredient being processed in the recipe? What is the unit of the quantity?
5. What is the objective of ingredient substitution?
6. What conditions (dietary, technological) are specified for selecting the target ingredient? How is the ingredient processed in the given recipe?
7. What is the ratio for substitution of one ingredient into another?
8. What ingredient substitutions are possible in the recipe?
9. What ingredient substitutions are available in the recipe given dietary constraints? What are available substitutes for a given food item? What are substitutes for the ingredient in the recipe?

Recipe ingredient substitute: binary or n-ary relation?

- Modeling ingredient substitutes - two major settings:
  1. without context, i.e., as general substitutes
  2. taking into account the context of a specific recipe and its food technological aspects and other factors, such as dietary constraints, goals, and technological conditions
- In the latter case, the relation expressing substitution becomes *n*-ary
- To model *n*-ary relation using OWL, it is reified to a class

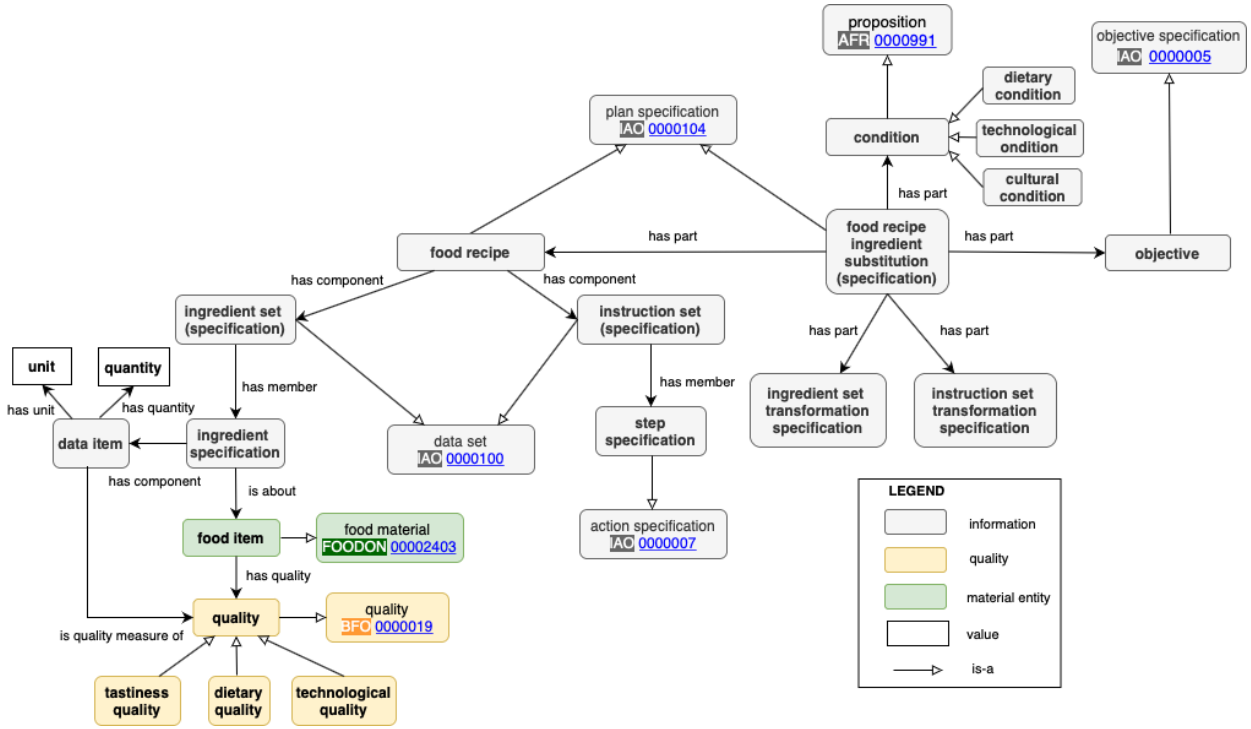
Recipe ingredient substitution: process or specification?

- **Food recipe** specifies a procedure on how to prepare a dish
- It is not a process per se (spanning a time period) but rather a specification of a process to be performed to prepare a dish
- A major modeling decision: to model ingredient substitution in recipes on the level of *specification* rather than processes

Ingredient specification

- A complex entity:
  - food items (materials)
  - quality measure of unit and quantity
- A simple one or a complex one:
  - disjunction of ingredients (’goat or sheep meat or both’)
  - conjunction (’dill and fennel’, ’green and dry onions’, or combinations of spices)
  - *optional* -> ’empty’ substitution?

Food Recipe Ingredient Substitution Ontology Design Pattern



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