Group ID: Group 3

Project name:

Product Ontology

Group members

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1.0 Initiation

Our project is for a product Ontology

1.1. Ontology scenario

Building a product ontology would be to provide a consensual knowledge model of the products domain that will be used by shops/supermarkets. for developing a shopping catalogue about groceries and other stuff .

A shop / supermarket uses this ontology (the product ontology) to help customer reaching the products they need comfortably and recommend complementary products (if the customer add apples to the cart the system will suggest bananas or cinnamon based on the "bought together") relationship. As we will detail in the use case below

Using product ontology makes the items organized into categories and labels them clearly to simplify counting and tracking by the staff for the stocktaking management easily.

Use Case:
Imagine a customer shopping in a supermarket with the intention to buy ingredients to make an apple cake. They add apples to their cart. Using the ontology, the supermarket's recommendation system identifies that apples are often bought together with bananas and cinnamon based on the "BoughtTogetherFood" relationship. The system then suggests these complementary items to the customer. Additionally, the ontology helps the staff locate the apples in the "Fruits" aisle and ensures that the stock levels are updated in real-time, facilitating efficient inventory management.

3.2.1 Ontology Purpose:

the product ontology organizes and standardized info about the products, their attributes (weight , expire date…etc.) , and the relationships (bought together)

1.1.2 Possible ontology Uses :

Organize products systematically

Stocktaking management

Recommendation systems

Searching & filtering

1.1.3. Possible ontology users:

Customers: to get more personalized shopping

The staff

Marketing and sales team

Data scientists: analyze shopping behavior

The system

1.2. Ontology scope

The key domain branches that we included are

1. **Product hierarchy:**
   Classes: Product, CleaningSupplies, food , PersonalCare, PetCare

   For our intended use, products are the heart of the ontology. Categorizing them helps in inventory management (tracking and managing product stock levels and their storage), shelf organization (optimizing product placement), marketing(developing targeted campaigns and promotions) and customer service (customers will benefit from improved product organization, availability and recommendation).

2. **Storage and location**

   Class: StorageLocation (subclasses aisle , freezer, fridge)

   Knowing where products are stored and located is of supreme importance for inventory management, customer navigation and restocking which are all relevant to our ontology

3. **Manufacturer**

   Class: Manufacturer (subclasses Local , Imported)

Origin information is important for marketing, customer trust and labeling.

4. **Consumer and demographics**
   Classes: Consumer (Subclasses Human and Animal)

Understanding the target audience is key in building marketing strategies. It also plays an important role in product placement.

1.3. Ontology knowledge sources :

The two knowledge sources that we decided to include are:

1. A food Ontology (FoodOn):
Dooley, D.M., Griffiths, E.J., Gosal, G.S. *et al.* **FoodOn: a harmonized food ontology to increase global food traceability, quality control and data integration**. *Npj Sci Food* **2**, 23 (2018).
You can read the article here.

We chose this as a knowledge source for multiple reasons. The first is its relevance, as it focuses on food ontologies.The article included a tree visualization of 15 upper-level FoodOn topical branches which was helpful in planning our food domain. Further more, Articles published in Nature undergo a rigorous peer review process which ensures reliability of information and quality content . The article's comprehensive framework and focus on properties and relationships helped us in creating a structured and detailed ontology.

2. GPC (Global Product Classification) Browser

The GS1 (the organization behind global standards for barcodes and product identification) provides **the Global Product Classification (GPC)** system which is a hierarchical framework for categorizing products across industries.
Using it as a knowledge source was to ensure that our ontology aligns with industry best practice and can be easily integrated with other systems. Its comprehensive coverage of product categories helped us in covering all product types found in a supermarket. Added to that, its hierarchical structure served as a foundation for our ontology's hierarchy

So to summarize:

FoodOn: Provides a comprehensive framework for food categorization and properties.

GPC Browser: Ensures alignment with industry standards and facilitates integration with other systems.

2.0 Ontology Design

2.1. The conceptualization approach

We followed the **top-down conceptualization approach**, where we started from general concepts and refined them into specific ones. We began with the broad field of **products**, identifying high-level categories like **Food**, **Cleaning**, **Personal Care**, and **Pet Care**.

From there, we divided these into more specific subcategories. For example:

- Under **Food**, we included **Vegetables**, **Fruits**, **Meat**, and **Bakery**.
- Under **Cleaning**, we added **Laundry**, **Dish Care**, and **Fabric Softener**.

We continued refining until we reached detailed classes, such as **Skin Care** under **Personal Care** and **Pet Food** under **Pet Care**. Additionally, we included relationships and properties, such as how products are stored (e.g., **Fridge** or **Freezer**) and detailed attributes like **Weight**, **Brand**, and **Production Date**.

This approach allowed us to create a clear and organized structure, moving systematically from abstract ideas to specific details

2.2. Define concept glossary and relationship glossary

2.2.1 Concept glossary

The table below shows our concept glossary

Concept	Definition	Source	Synonyms
cleaning product	an item that can be offered to a market to satisfy the desire or need of a customer.	https://en.wikipedia.org/wiki/Product	
Food	is any substance consumed by an organism for nutritional support, and is usually of plant, animal, or fungal origin	https://www.refseek.com/search?q=Food+	

	and contains essential nutrients such as carbohydrates, fats, proteins, vitamins, or minerals.		
BeautyProducts	are composed of mixtures of chemical compounds derived from either natural sources or synthetically created ones, and have various purposes, including personal and skin care. They can also be used to conceal blemishes and enhance natural features	https://en.wikipedia.org/wiki/Cosmetics	Cosmetics
CleaningSupplies	essential items like soap and disinfectants that help maintain hygiene and prevent the spread of infections, emphasizing their importance in public health and safety environments	https://www.wisdomlib.org/concept/cleaning-supplies	cleaning product
PersonalHygine	involves those practices performed by a person to care for their bodily health and well-being through cleanliness.	https://en.wikipedia.org/wiki/Hygiene#Personal_hygiene	
Human	The most common and widespread species of primate, and	https://en.wikipedia.org/wiki/Human	homo sapiens

	the last surviving species of the genus Homo and the broader australopitheci ne subtribe, are great apes characterized by their hairlessness, bipedalism, and high intelligence		
PetCare	The care and medical treatment of pets (domestic animals).	https://en.wiktionary.org/wiki/petcare	
Meat	the flesh of an animal when it is used for food	https://dictionary.cambridge.org/dictionary/english/meat	Flesh
Drinks	is a liquid intended for human consumption. In addition to their basic function of satisfying thirst, drinks play important roles in human culture	https://en.wikipedia.org/wiki/Drink	
Vegetables	parts of plants that are consumed by humans or other animals as food.	https://en.wikipedia.org/wiki/Vegetable	
Bakery	is an establishment that produces and sells flour-based baked goods made in an oven such as bread, cookies,	https://en.wikipedia.org/wiki/Bakery	

	cakes, doughnuts, bagels, pastries, and pies		
Fruits	the fleshy or dry ripened ovary of a flowering plant, enclosing the seed or seeds. Thus, apricots, bananas, and grapes, as well as bean pods, corn grains, tomatoes, cucumbers, and (in their shells) acorns and almonds, are all technically fruits. The term is restricted to the ripened ovaries that are sweet and either succulent or pulpy.	https://www.britannica.com/science/fruit-plant-reproductive-body	
SeaFood	is any form of sea life regarded as food by humans, prominently including fish and shellfish. Shellfish include various species of mollusks (e.g., bivalve mollusks such as clams, oysters, and mussels, and cephalopods such as octopus and squid), crustaceans (e.g. shrimp,	https://en.wikipedia.org/wiki/Seafood	

	crabs, and lobster), and echinoderms (e.g. sea cucumbers and sea urchins)		
Freezer	is a device similar to a refrigerator that maintains a temperature below the freezing point of water.	https://en.wikipedia.org/wiki/Freezer_(disambiguation)	Deepfreeze
Fridge	is a large metal container which is kept cool, usually by electricity, so that food that is put in it stays fresh	https://www.collinsdictionary.com/dictionary/english/fridge	
Aisle	linear space for walking with rows of non-walking spaces on both sides, and cross through shops, where they have shelving on either side	https://en.wikipedia.org/wiki/Aisle	
Consumer	is a person or a group who intends to order, or use purchased goods, products, or services primarily for personal, social, family, household and similar needs, who is not directly related to entrepreneurial	https://en.wikipedia.org/wiki/Consumer	

	or business activities		
Animal	something that lives and moves but is not a human, bird, fish, or insect.	https://dictionary.cambridge.org/dictionary/english/animal	
Bottle	a rigid or semirigid container typically of glass or plastic having a comparatively narrow neck or mouth and usually no handle	https://www.merriam-webster.com/dictionary/bottle	Jar
Tube	a long, thin container made of soft metal or plastic that is closed at one end and has a small hole at the other, usually with a cover, used for storing thick liquids	https://dictionary.cambridge.org/dictionary/english/tube	
Carton	is a box or container usually made of liquid packaging board, paperboard and sometimes of corrugated fiberboard.	https://en.wikipedia.org/wiki/Carton	

2.2.2. Relationship glossary

Relationship	Definition
BoughtTogetherFood	The subject BoughtTogetherFood with the object. Example: Sheep Mile Bought Together Food with corn flakes.
BoughtTogetherPersonalCare	The subject BoughtTogetherPersonalCare with the object.

	Example: AlguronicAcide Bought Together Personal Care with PremierDeadSea.
ContainedIn	The subject ContainedIn the object. Example: Every product Contained In some container type.
FoodType	The subject FoodType of the object. Example: Every food has a Food Type of product state.
ProducedBy	The subject ProducedBy the object. Example: Every product is produced by Manufacturer.
StoredIn	The subject is StoredIn the object. Example: Every cleaning supplies Stored In storage location.
UsedBy	The subject is UsedBy the object. Example: Every Personal care is Used By human.
hasStoredProducts	The subject hasStoredProducts from the object. Example: Every storage location has Stored Products from product.
Calories	The subject has Calories. Example: Every food has Calories.
ExpireDate	The subject has an ExpireDate. Example: Every product has an Expire Date.
ProductionDate	The subject has a ProductionDate. Example: Every product has a Production Date.
Rating	The subject has Rating. Example: Every product has Rating.
Weight	The subject has Weight. Example: Every product has Weight.
Label	Reused from dc terms http://purl.org/dc/terms

3.0 Logical Coding in .OWL File

To perform this step, you will define logical statements using Protégé.

3.1. Define Classes

Below is a screen shot of the entity hierarchy

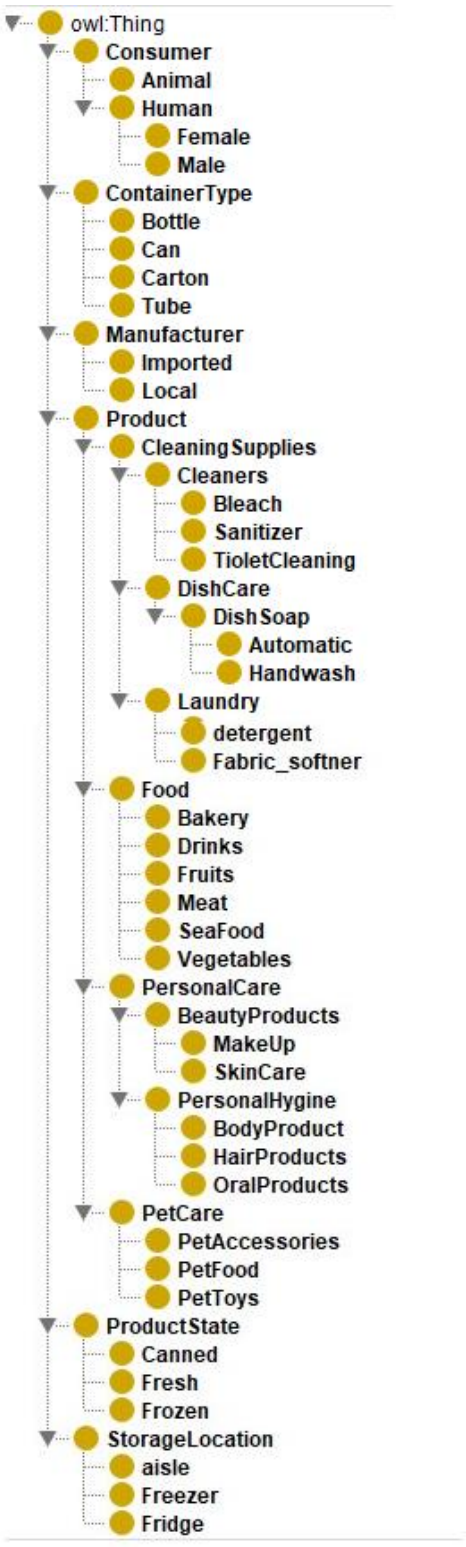
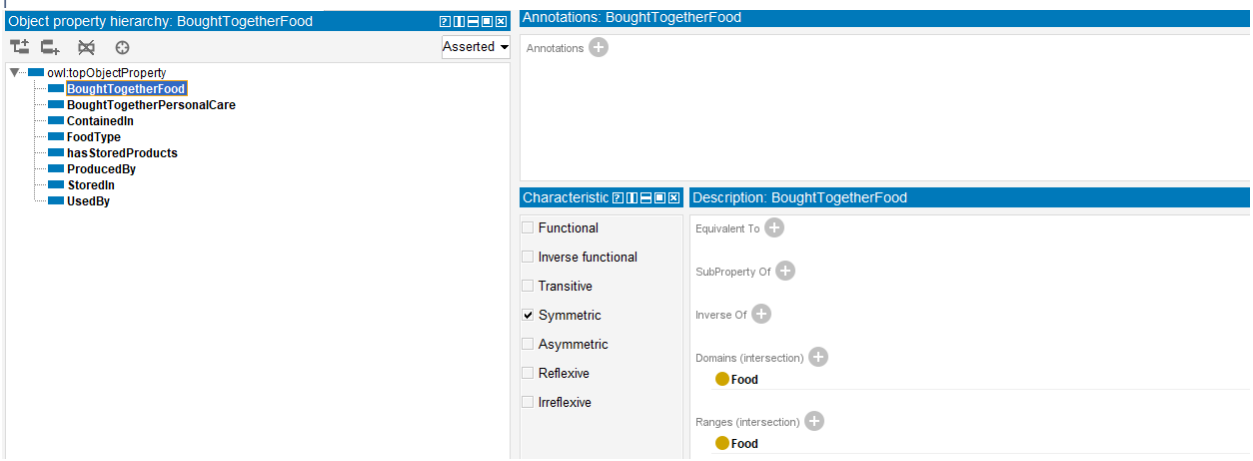
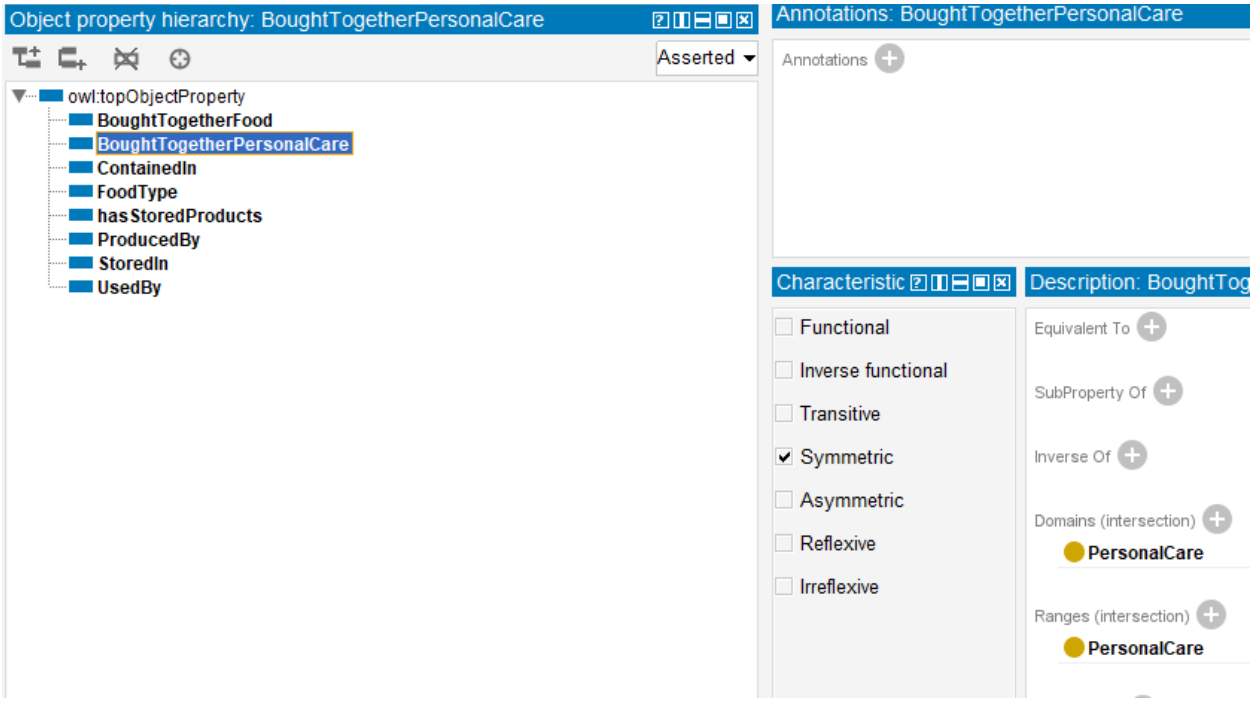


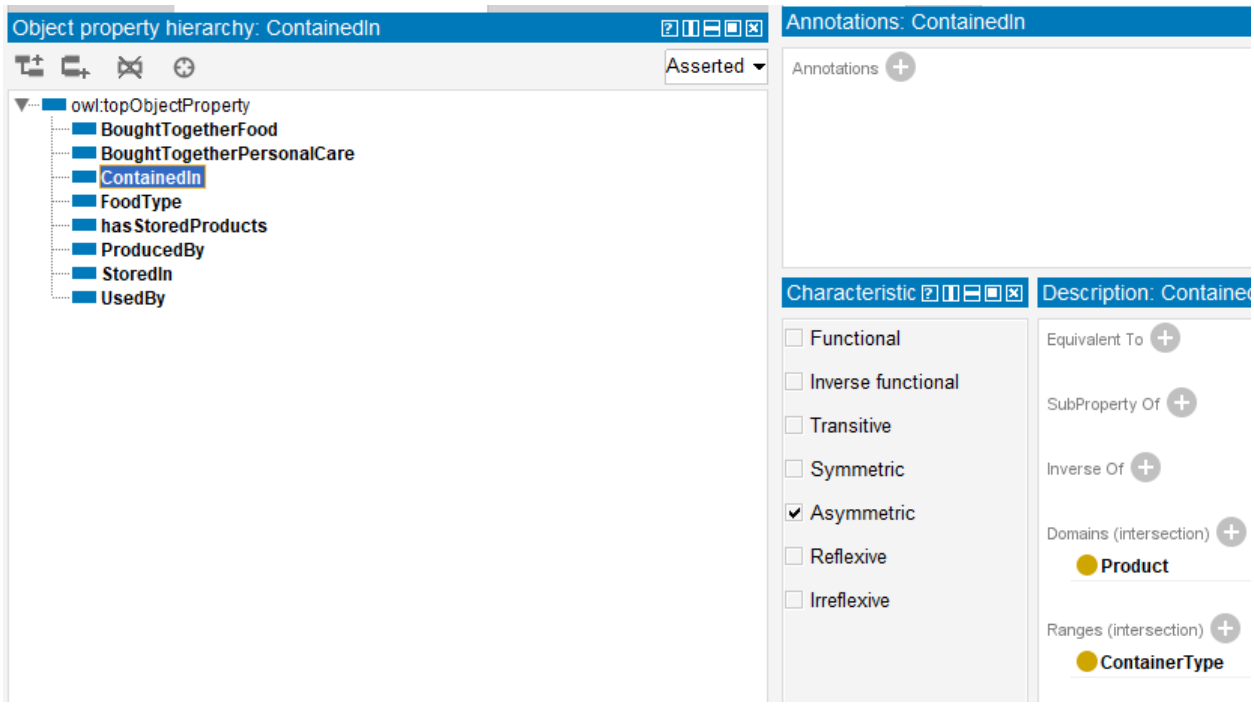
Figure 1Hierarchy

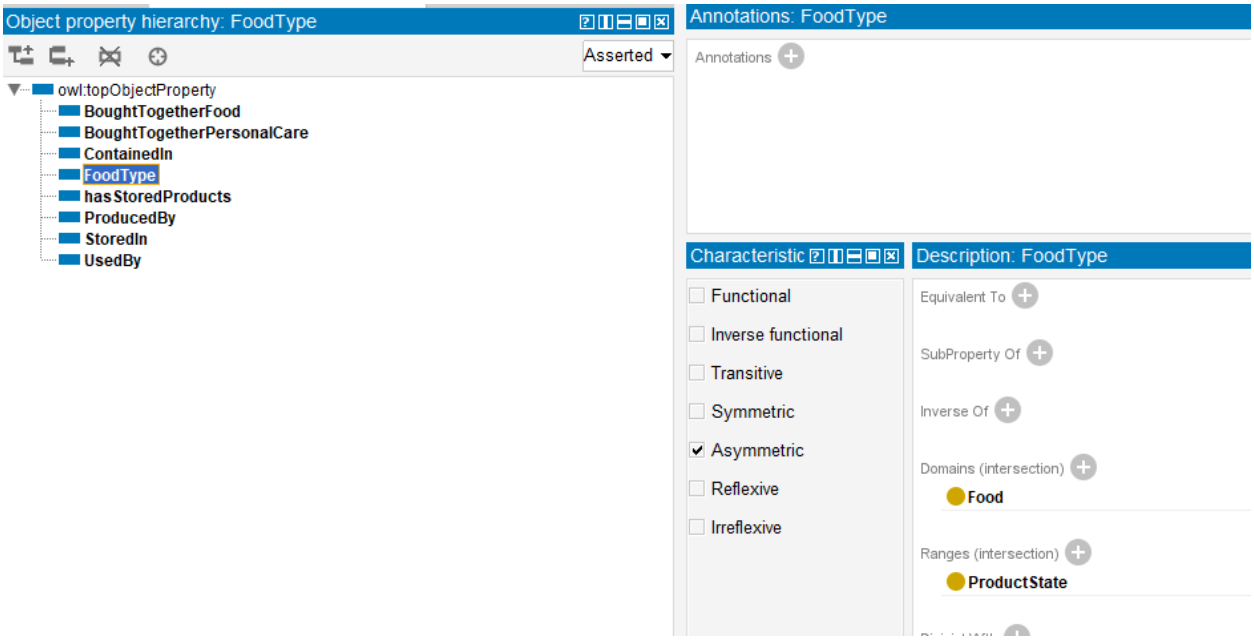
3.2. Define Object Properties and Data properties

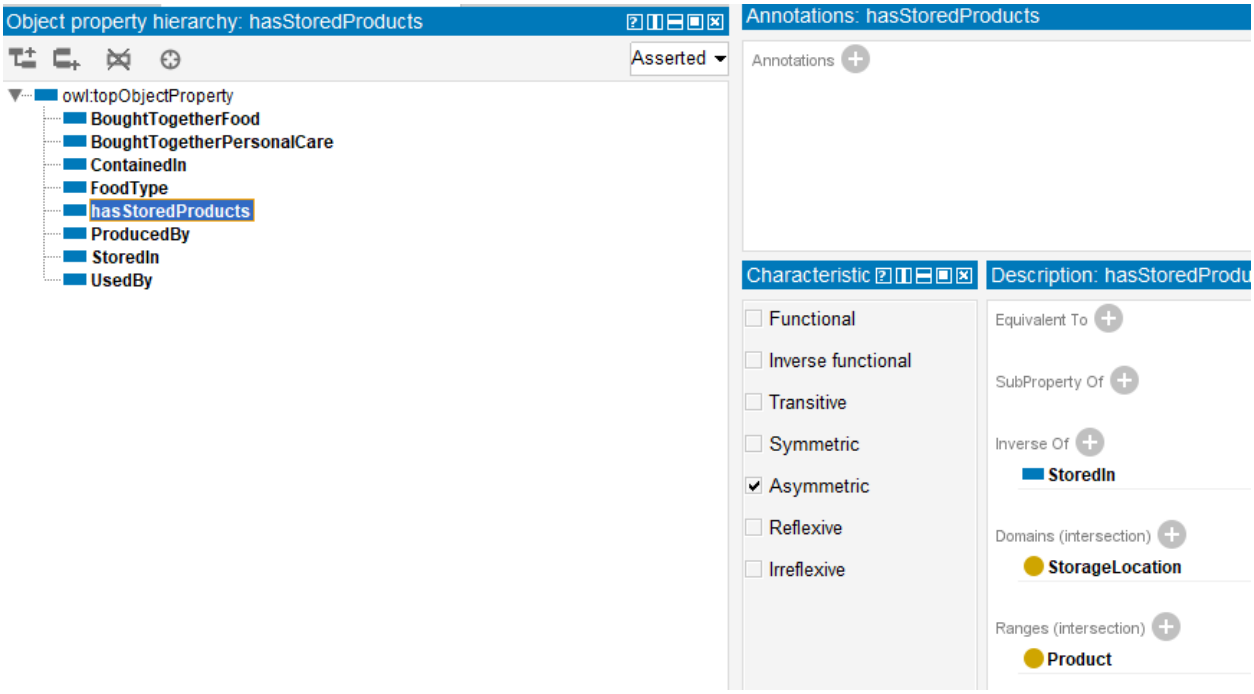
3.2.1.Object properties

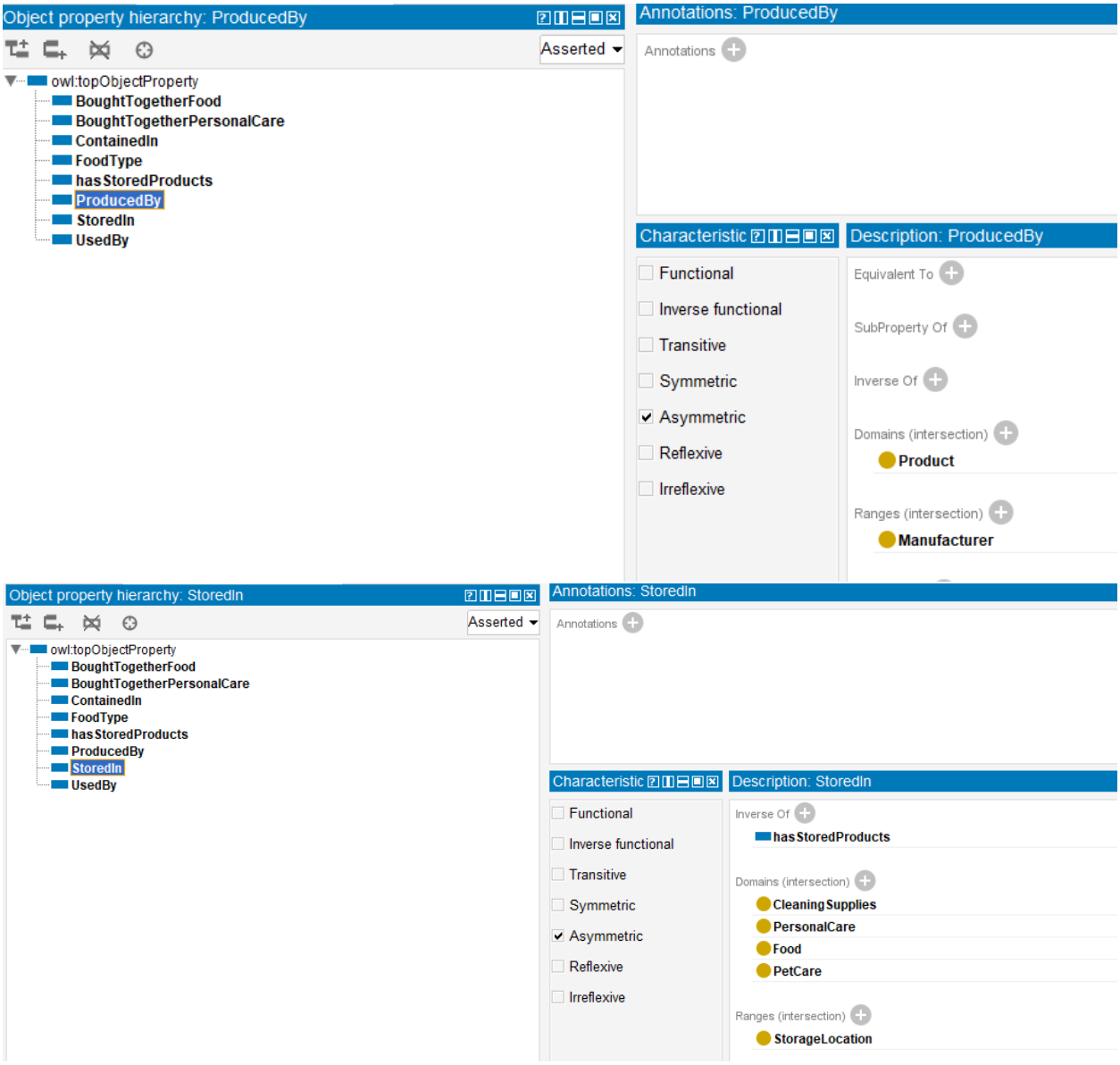


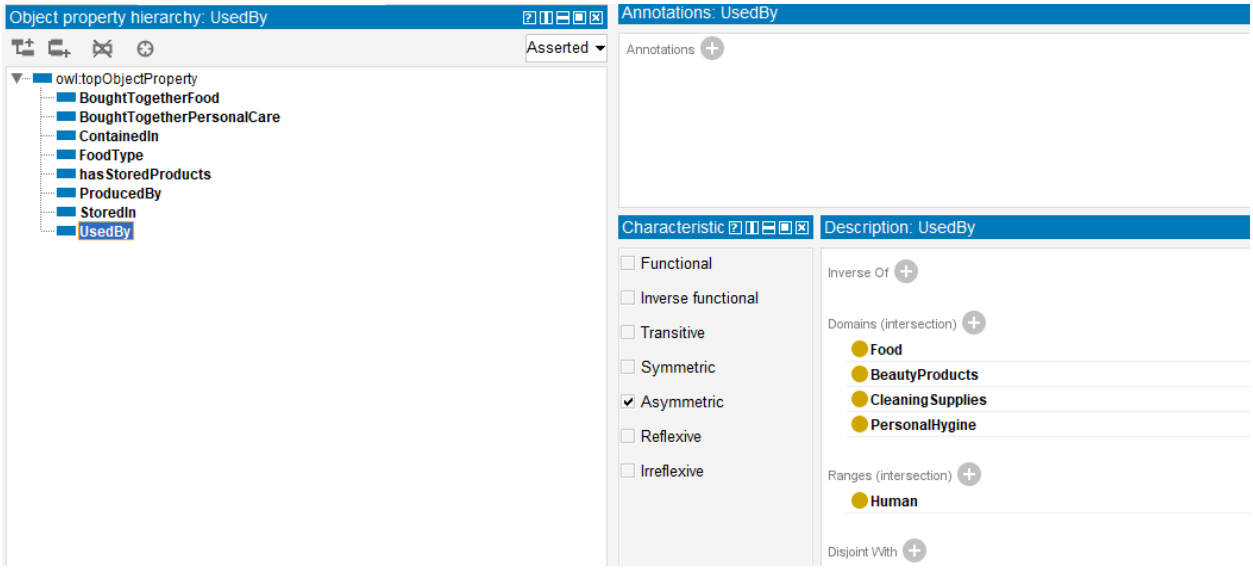



Object property hierarchy: ContainedIn
Asserted
owl:topObjectProperty
BoughtTogetherFood
BoughtTogetherPersonalCare
ContainedIn
FoodType
hasStoredProducts
ProducedBy
StoredIn
UsedBy
Annotations: ContainedIn
Annotations
Characteristic
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: Containe
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
Product
Ranges (intersection)
ContainerType


Object property hierarchy: FoodType
Asserted
owl:topObjectProperty
BoughtTogetherFood
BoughtTogetherPersonalCare
ContainedIn
FoodType
hasStoredProducts
ProducedBy
StoredIn
UsedBy
Annotations: FoodType
Annotations
Characteristic
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: FoodType
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
Food
Ranges (intersection)
ProductState


Object property hierarchy: hasStoredProducts
Asserted
owl:topObjectProperty
BoughtTogetherFood
BoughtTogetherPersonalCare
ContainedIn
FoodType
hasStoredProducts
ProducedBy
StoredIn
UsedBy
Annotations: hasStoredProducts
Annotations
Characteristic
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: hasStoredProdu
Equivalent To
SubProperty Of
Inverse Of
StoredIn
Domains (intersection)
StorageLocation
Ranges (intersection)
Product


Object property hierarchy: ProducedBy
Asserted
owl:topObjectProperty
BoughtTogetherFood
BoughtTogetherPersonalCare
ContainedIn
FoodType
hasStoredProducts
ProducedBy
StoredIn
UsedBy
Annotations: ProducedBy
Annotations
Characteristic
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: ProducedBy
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
Product
Ranges (intersection)
Manufacturer
Object property hierarchy: StoredIn
Asserted
owl:topObjectProperty
BoughtTogetherFood
BoughtTogetherPersonalCare
ContainedIn
FoodType
hasStoredProducts
ProducedBy
StoredIn
UsedBy
Annotations: StoredIn
Annotations
Characteristic
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: StoredIn
Inverse Of
hasStoredProducts
Domains (intersection)
CleaningSupplies
PersonalCare
Food
PetCare
Ranges (intersection)
StorageLocation



3.2.1.1Axioms

Cardinality restriction
Example 1: An Isle can have a maximum 1000 products

This cardinality restriction was used to ensure that the ontology reflects real-world constraints. In a supermarket, an aisle has limited physical space, and setting a maximum limit of 1000 products is important because it helps in managing inventory and optimizing shelf space. Not only that but this restriction also aids in maintaining the ontology's scalability and performance by preventing an excessive number of products from being associated with a single aisle.

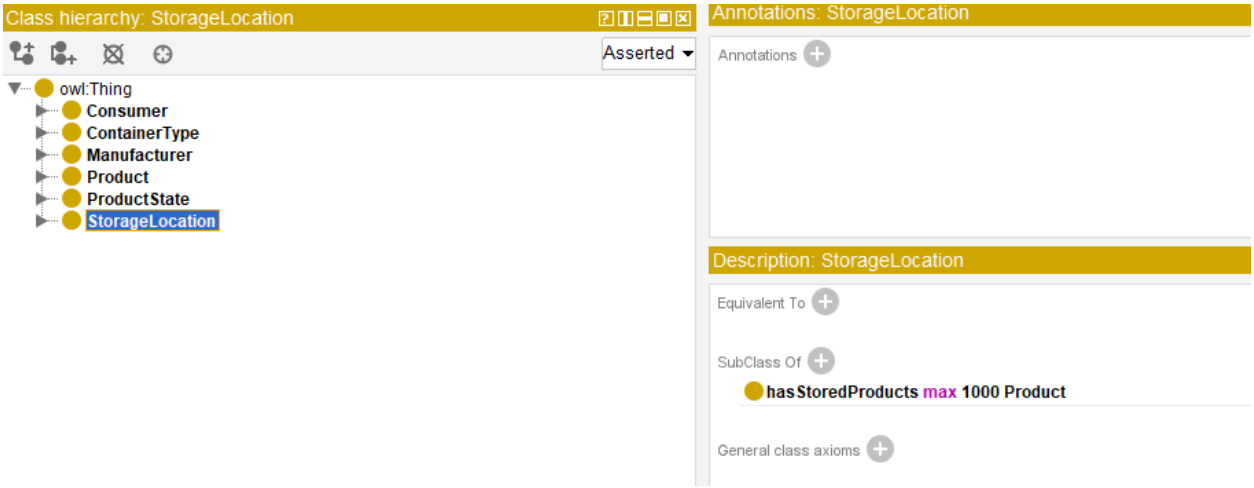


Figure 2Axiom one: cardinality restriction

Example 2: a product can be produced by exactly one manufacturer

This cardinality restriction ensures that each product is associated with only one manufacturer, reflecting the real-world scenario where a product is typically produced by a single entity. This has multiple advantages as it helps in simplifying tracking and managing product information, such as recalls or quality control.

Figure 3Axiom cardinality restriction manufacturer

Below are two axioms specifying disjoint classes

Disjoint classes are important because the clear distinction is important for product labeling, safety instructions, and regulatory compliance, ensuring that customers and staff can easily identify and use the products correctly.

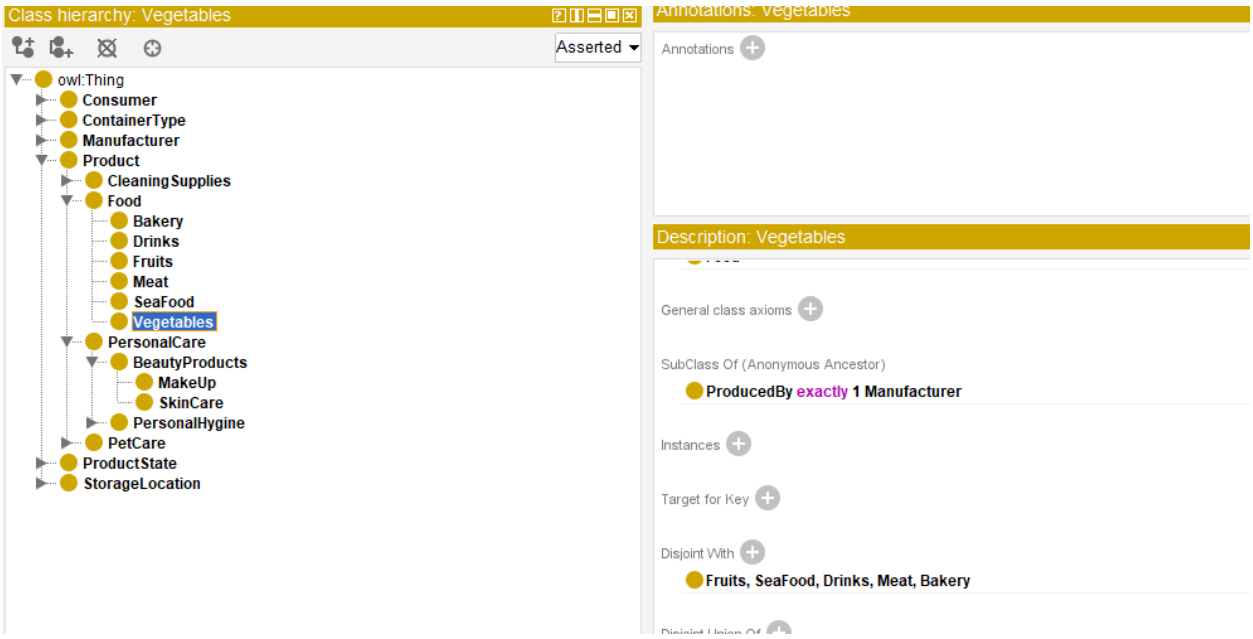


Figure 4Disjoint axiom vegetable

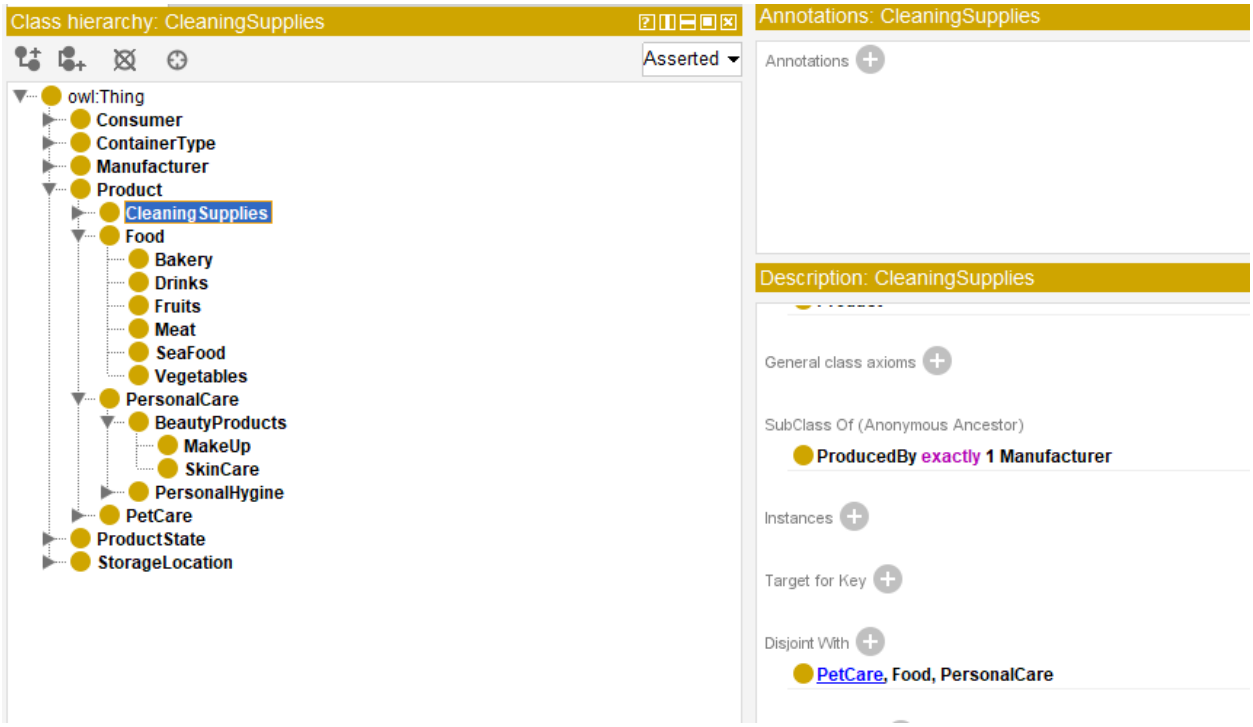


Figure 5Disjoint axiom cleaning supply

3.2.2. Data properties

The screenshots below highlight Six data properties.

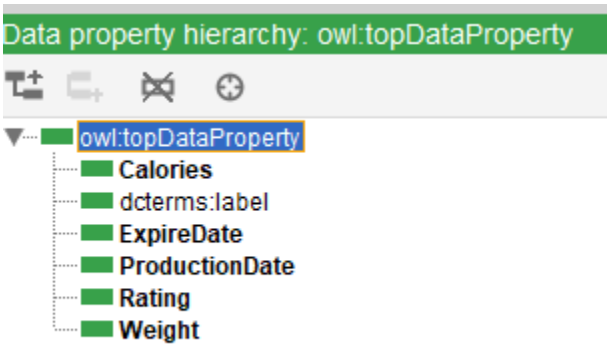


Figure 6Data properties

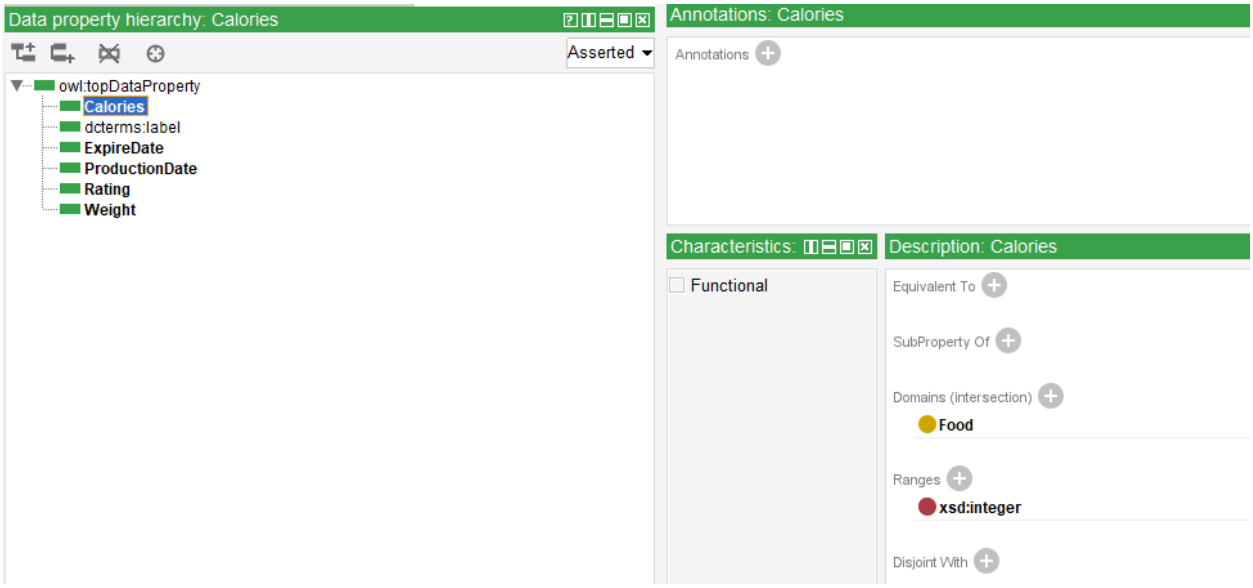


Figure 7 data properties calories

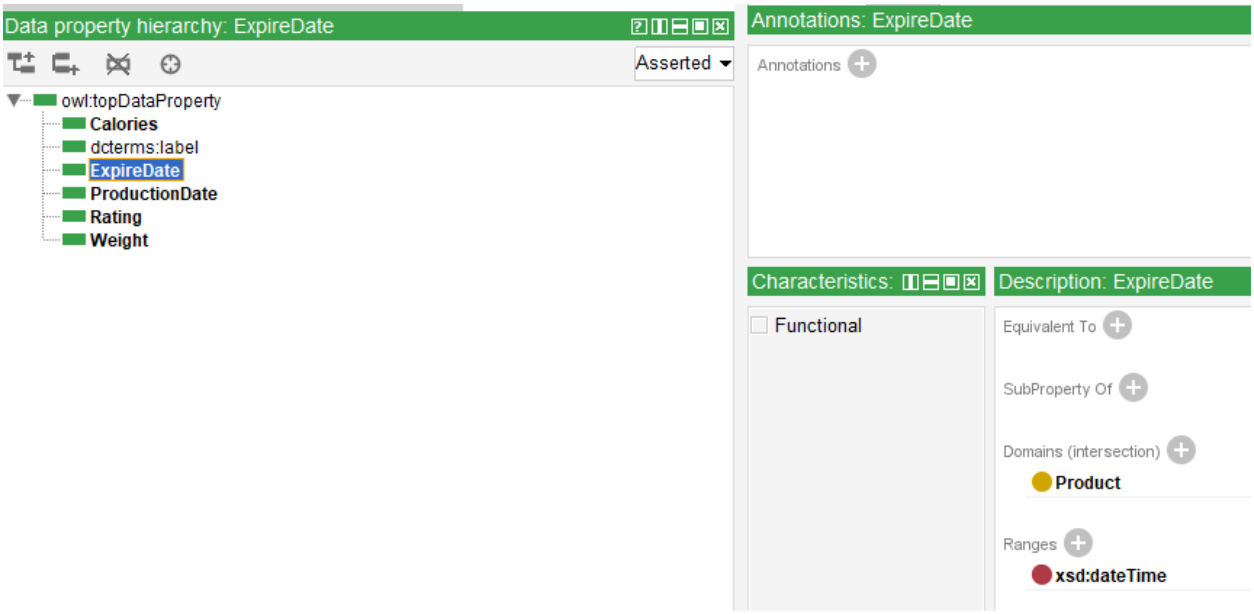


Figure 8Data property Expire date

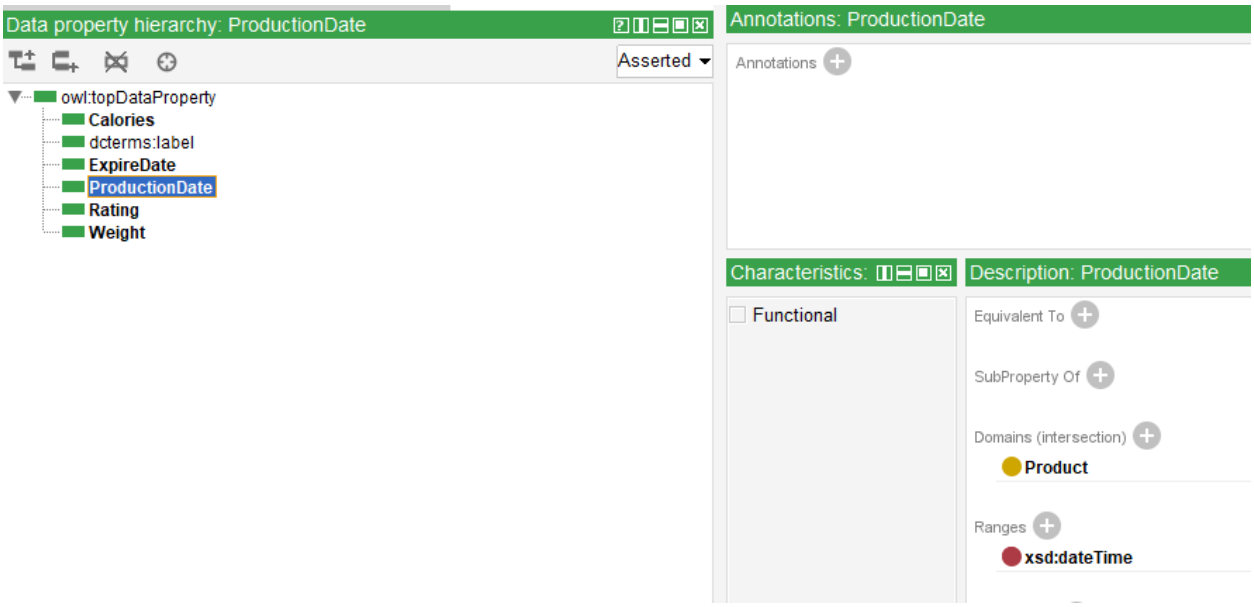


Figure 9Data property production date

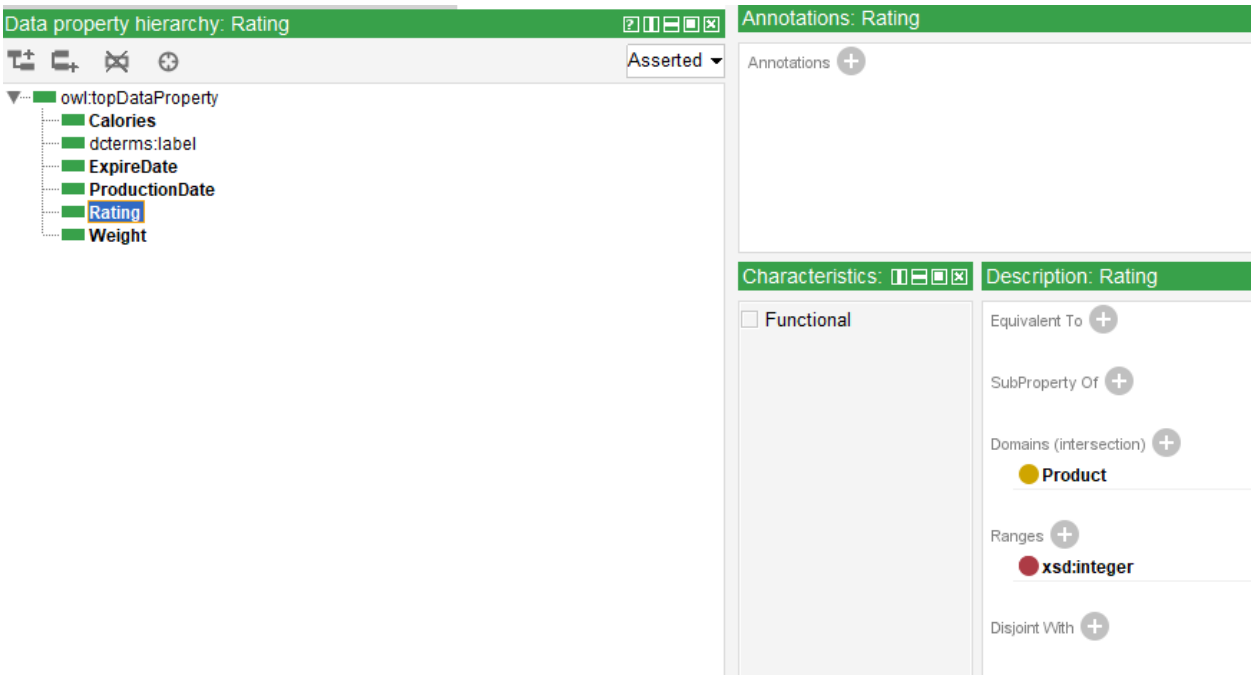


Figure 10Data property Rating

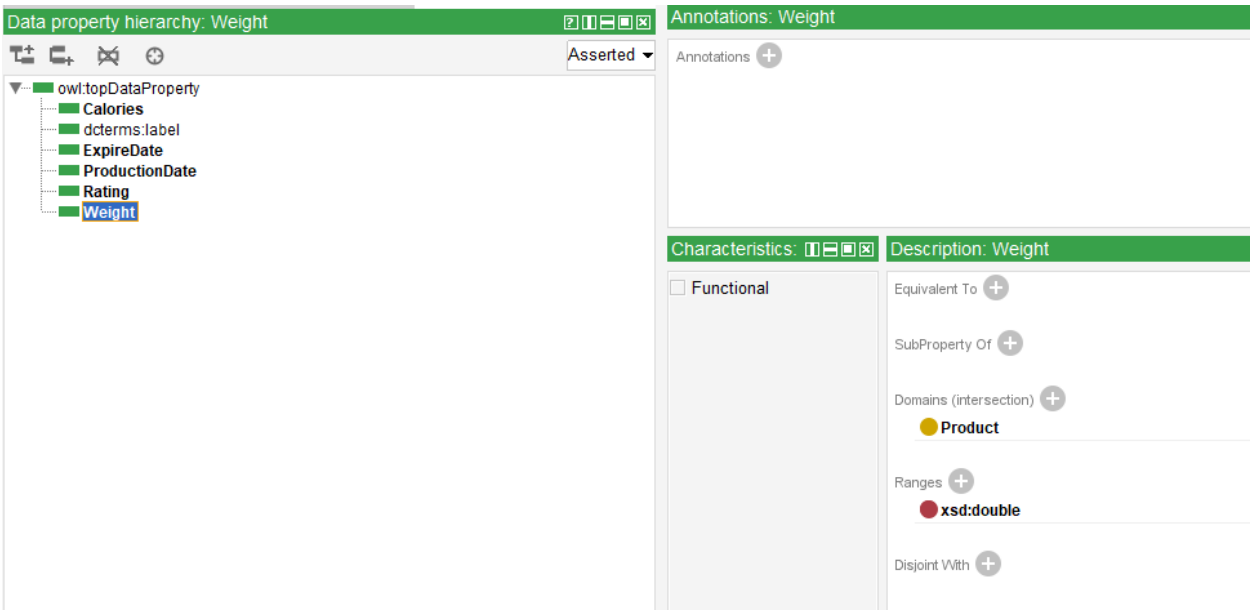


Figure 11Data property Weight

3.3. Define Instances

To demonstrate the ontology's integration with external data sources, we also performed multiple SPARQL queries to retrieve instances from DBpedia. This query helps populate the ontology with real-world products, ensuring that customers searching for those products can find relevant results.

select ?instance

where {?instance dbo:wikiPageWikiLink <http://dbpedia.org/resource/Category:Personal_hygiene_products>. }

This SPARQL query is designed to retrieve all resources from a dataset that are linked to the dbpedia category Personal_hygiene_products through the dbo:wikiPageWikiLink property.

the results include all the istances related to personal hygiene products (products , hand sanitizer , soaps , related companies...etc.)

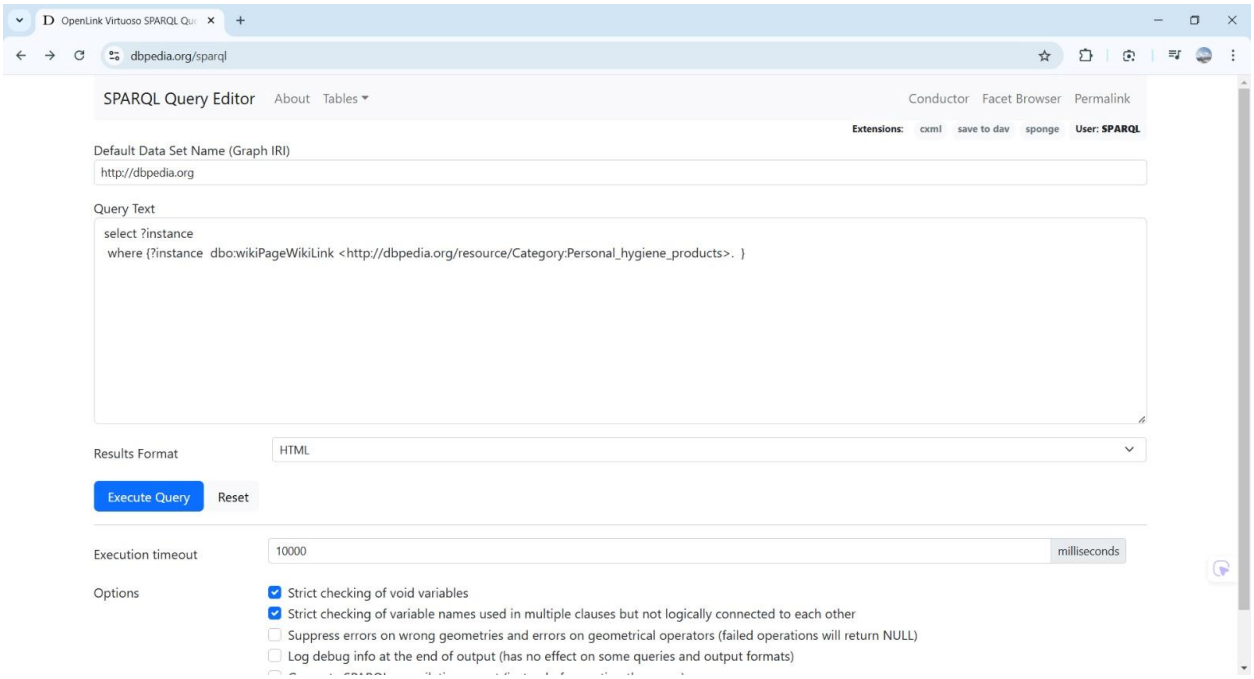


Figure 12personal hygiene query

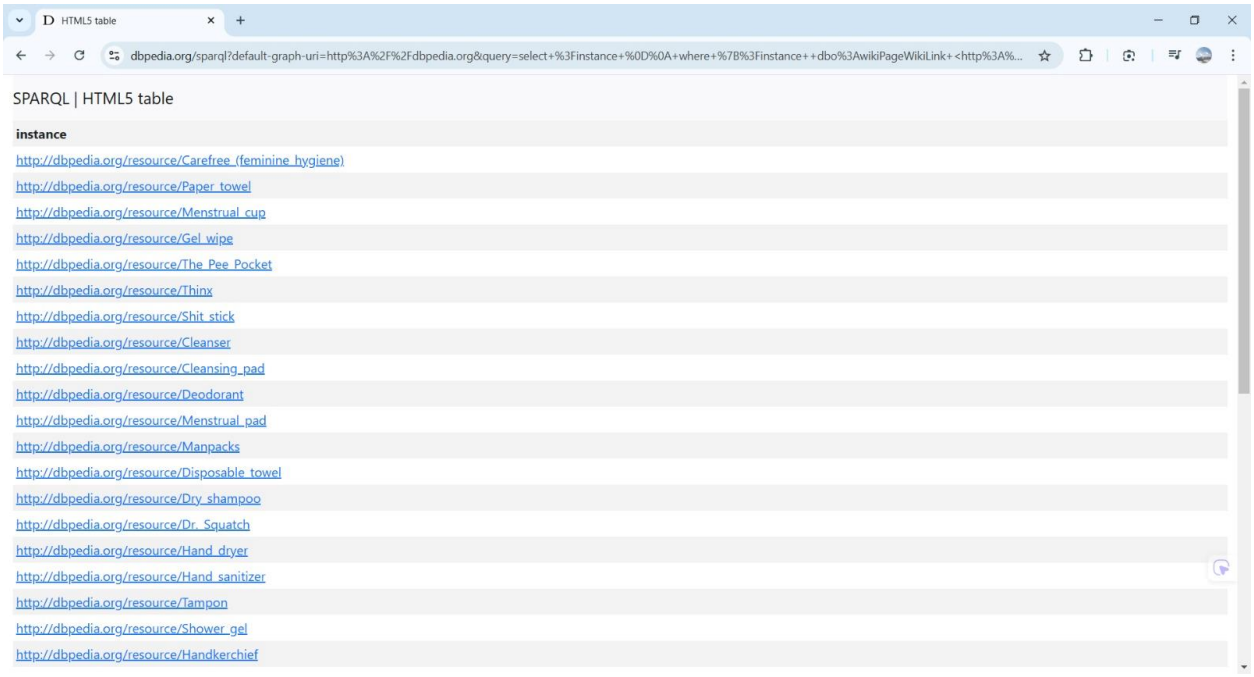


Figure 13personal hygiene result

select ?instance

where {?instance
dbo:wikiPageWikiLink<http://dbpedia.org/resource/Category:Pet_foods>.}

This sparql query retrieves all entities that are linked to the dbpedia resource Pet_foods through the dbo:wikiPageWikiLink property.

the results include all the istances related to pet food (tools , products , kinds of pet food , related pet stors...etc.)

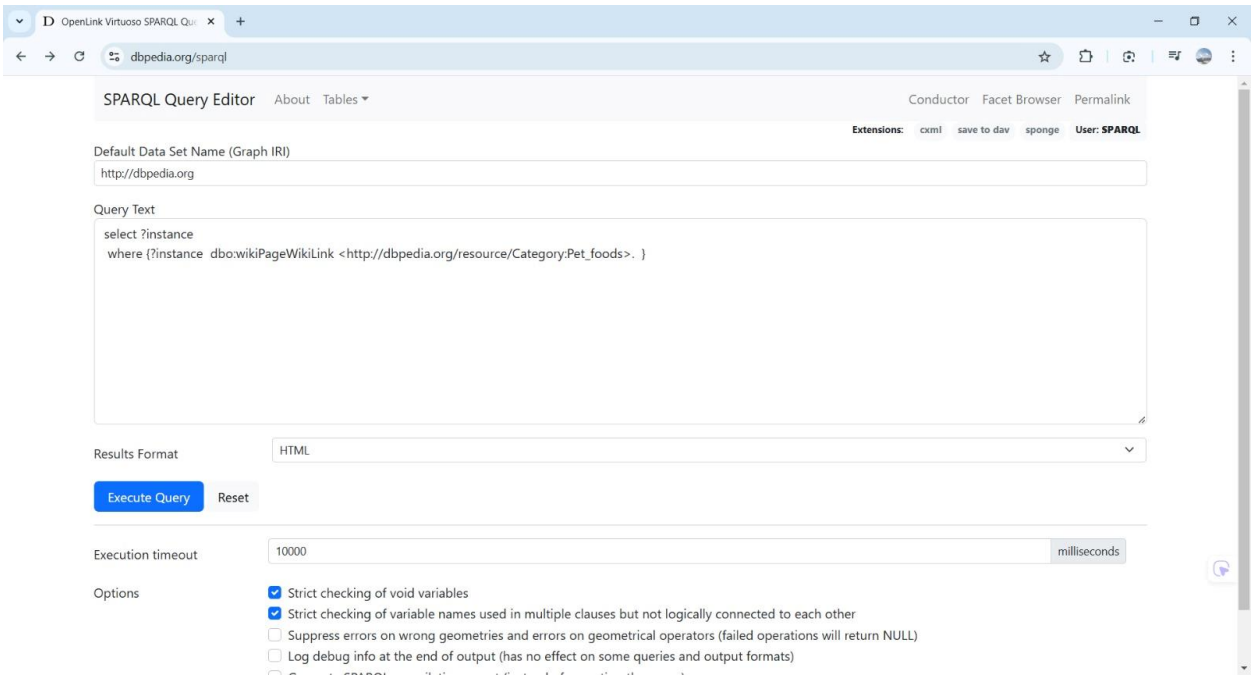


Figure 14pet food query

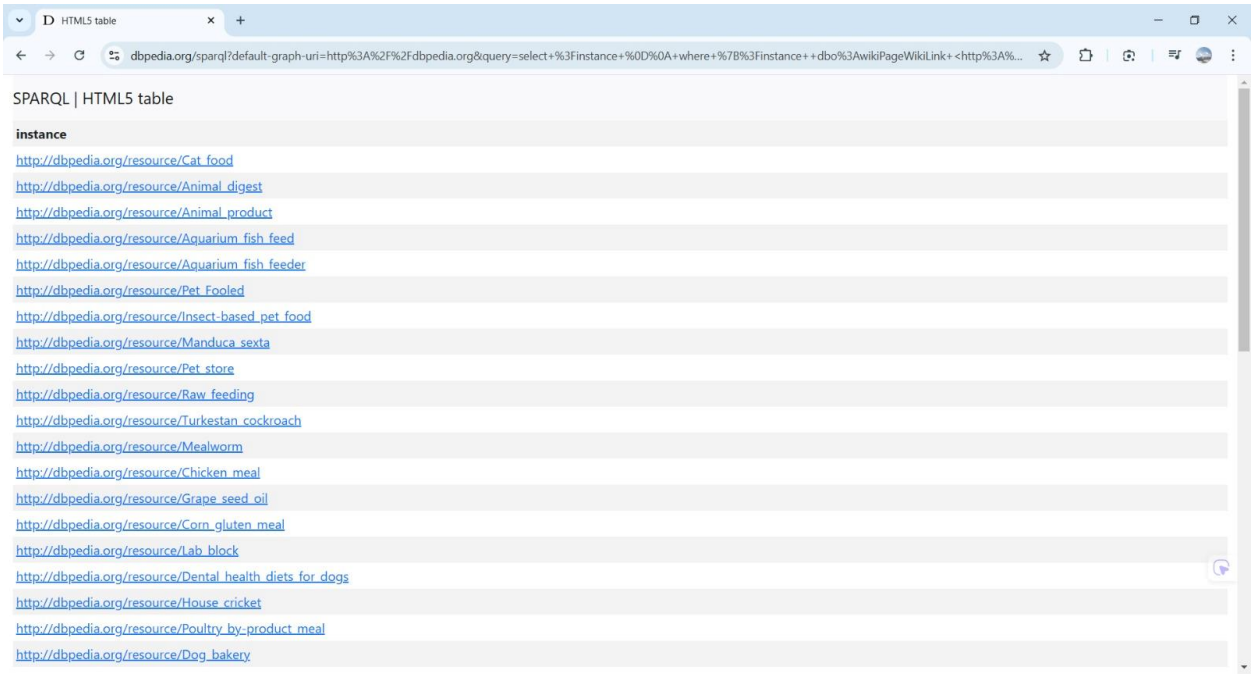


Figure 15pet food result

select ?instance

where {?instance dbo:wikiPageWikiLink <http://dbpedia.org/resource/Hair_care>. }

This sparql query retrieves all instances from a dataset that are linked to the dbpedia resource for Hair care through the dbo:wikiPageWikiLink property.

the results include all the instances related to Hair care (tools , products , shampoos ...etc.)

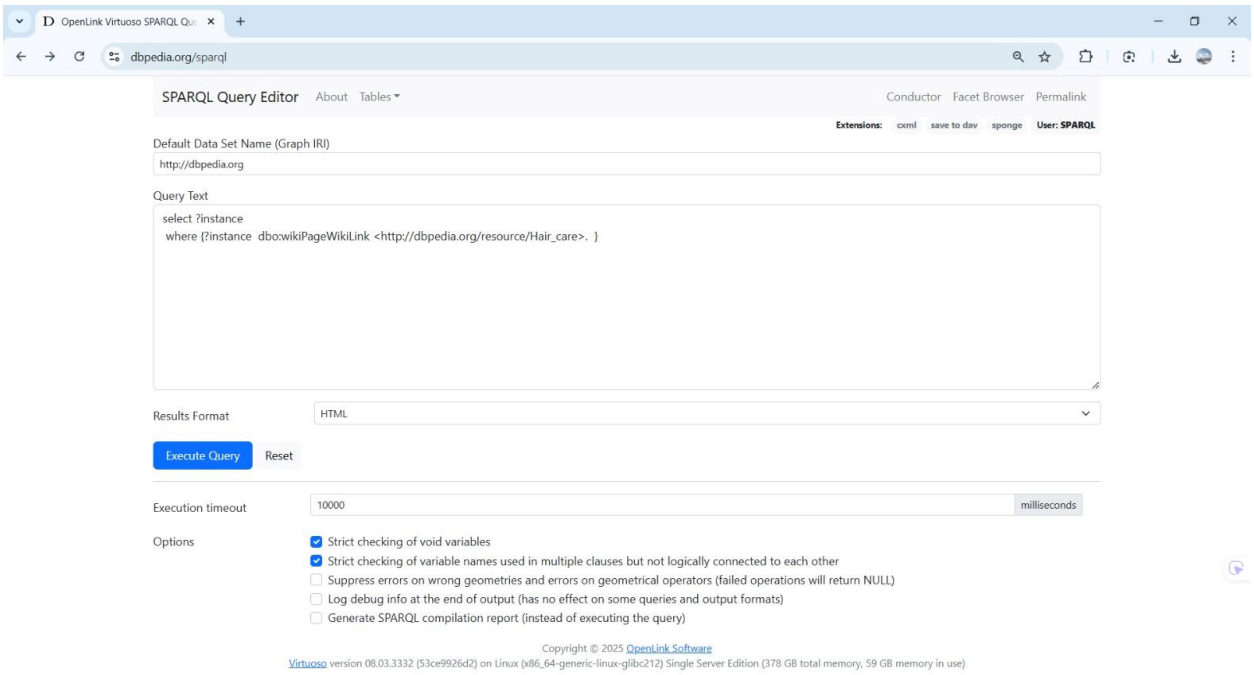


Figure 16 hair care query

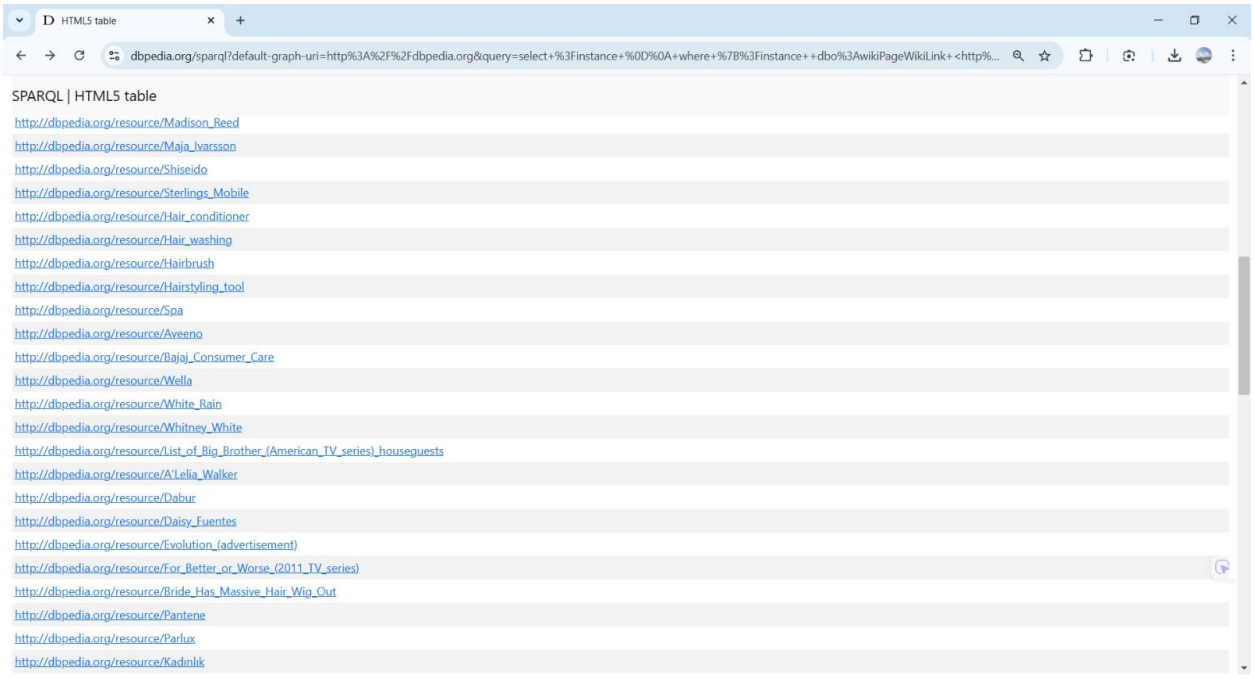


Figure 17 hair care query result

The following SPARQL query is designed to retrieve a comprehensive list of all individuals that are explicitly categorized as belonging to the Food class within the DBpedia ontology

Query Text

```
select * where {

?s rdf:type <http://dbpedia.org/ontology/Food>



} LIMIT 100
```

Results Format: HTML

Execute Query | Reset

Figure 18Food query

SPARQL | HTML5 table

s
http://dbpedia.org/resource/Cadbury_Clusters
http://dbpedia.org/resource/Cadbury_Creme_Egg
http://dbpedia.org/resource/Cadbury_Fingers
http://dbpedia.org/resource/Caesar_salad
http://dbpedia.org/resource/Caffè_mocha
http://dbpedia.org/resource/Café_de_Paris_sauce
http://dbpedia.org/resource/Café_de_olla
http://dbpedia.org/resource/Calas_(food)
http://dbpedia.org/resource/Caldo_gallego
http://dbpedia.org/resource/California_roll
http://dbpedia.org/resource/Camaron_rebosado
http://dbpedia.org/resource/Campa_Cola
http://dbpedia.org/resource/Campari
http://dbpedia.org/resource/Canal+_Gol_(Poland)

Figure 19 food query result

SPARQL | HTML5 table

http://dbpedia.org/resource/Canestrelli
http://dbpedia.org/resource/Cannabis_(drug)
http://dbpedia.org/resource/Caozaiguo
http://dbpedia.org/resource/Capellini
http://dbpedia.org/resource/Captain_America's_shield
http://dbpedia.org/resource/Carabao_Energy_Drink
http://dbpedia.org/resource/Caramel_apple
http://dbpedia.org/resource/Caramilk
http://dbpedia.org/resource/Caravane_cheese
http://dbpedia.org/resource/Cart_noodle
http://dbpedia.org/resource/Castella
http://dbpedia.org/resource/Cat_food
http://dbpedia.org/resource/Ambrosia_(fruit_salad)
http://dbpedia.org/resource/Ambula_(food)
http://dbpedia.org/resource/American_chop_suey

Figure 20food query Result

We constructed a SPARQL query for skin care products to extract relevant instances. You can find the results below
Query explanation

Prefix:

- **dbo:**: Refers to the DBpedia ontology for structured data (e.g., classes and properties like dbo:abstract).
- **dbr:**: Refers to DBpedia resources (e.g., specific entities like dbr:Skincare).
- **rdfs:**: Refers to RDF Schema, used for labeling resources (e.g., rdfs:label).

Where clause

- ?instance dbo:wikiPageWikiLink dbr:Skincare: Finds resources linked to "Skincare."
- rdfs:label ?label: Gets the resource's name.
- dbo:abstract ?description: Gets the resource's description.

Output

The query returns resources related to "Skincare," their names (?label), and their descriptions

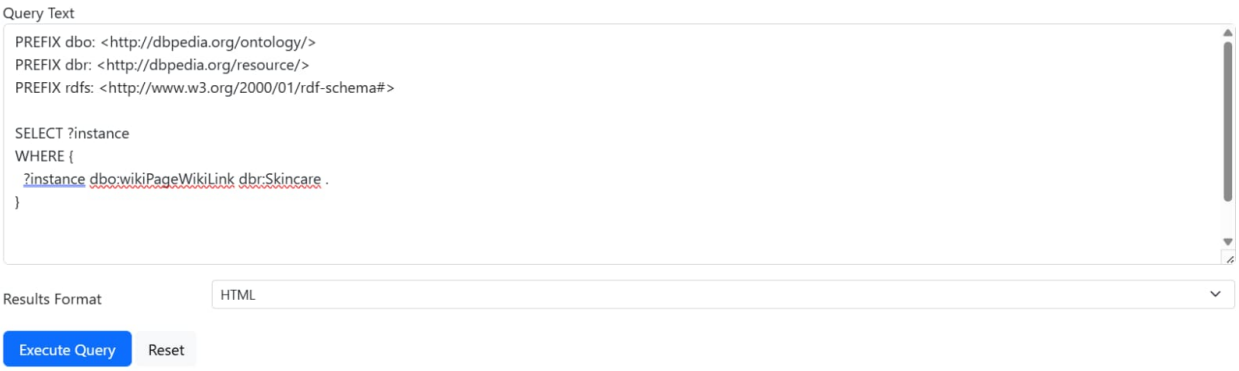


Figure 21skin care query

SPARQL | HTML5 table

instance
http://dbpedia.org/resource/Epilogic
http://dbpedia.org/resource/Bayankala_(skincare)
http://dbpedia.org/resource/Decamethylcyclopentasiloxane
http://dbpedia.org/resource/Alguronic_acid
http://dbpedia.org/resource/List_of_retailers_in_New_Zealand
http://dbpedia.org/resource/Premier_Dead_Sea
http://dbpedia.org/resource/Cosmetics
http://dbpedia.org/resource/Creme_21
http://dbpedia.org/resource/Salicylic_acid
http://dbpedia.org/resource/Clarins
http://dbpedia.org/resource/Elizabeth_Arden
http://dbpedia.org/resource/Bourjois
http://dbpedia.org/resource/Conditioner_(chemistry)
http://dbpedia.org/resource/Cristtee
http://dbpedia.org/resource/Eqology
http://dbpedia.org/resource/Silk_amino_acid
http://dbpedia.org/resource/SimplySiti
http://dbpedia.org/resource/Zydus_Wellness
http://dbpedia.org/resource/Bajaj_Nomarks
http://dbpedia.org/resource/Dr._Hauschka

Figure 22skin care query result

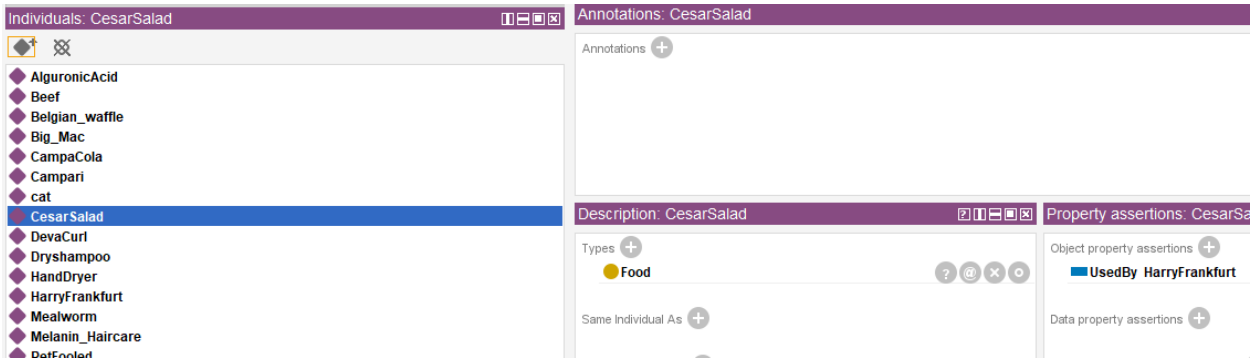


Figure 23Instances

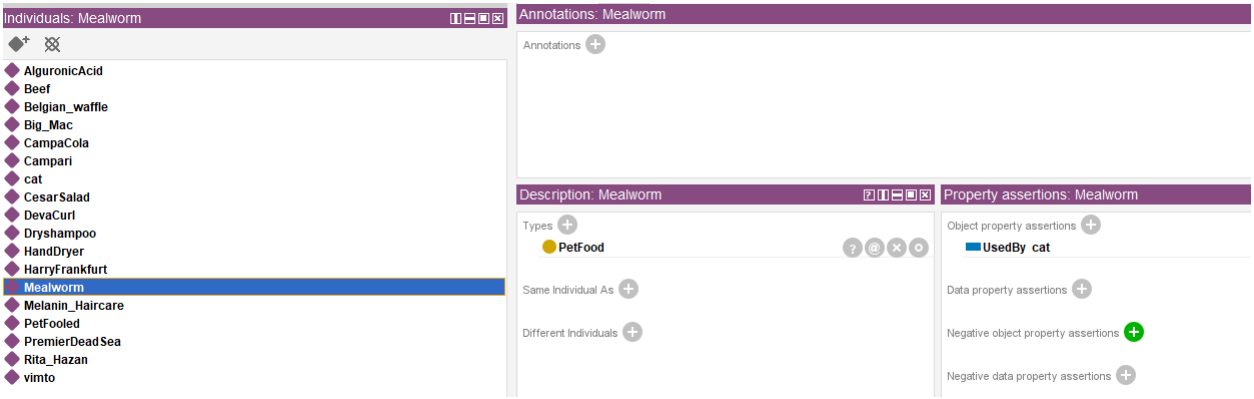


Figure 24instance

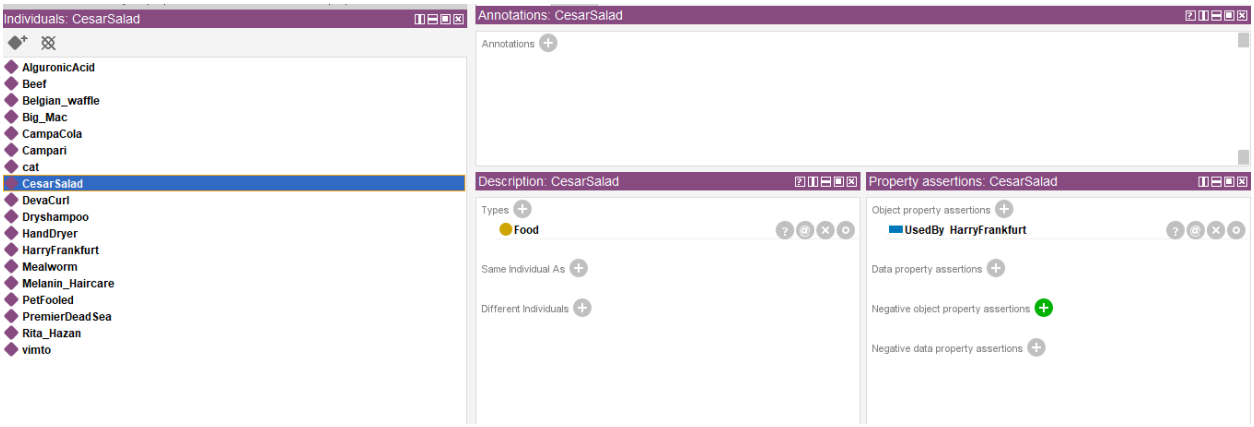


Figure 25 instance

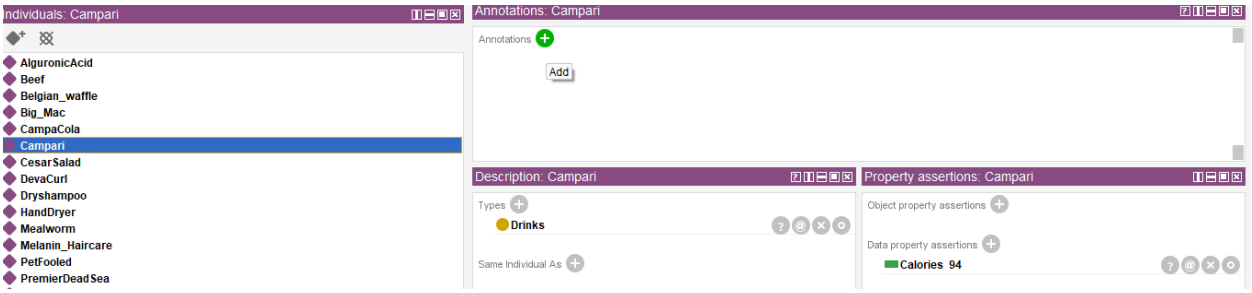


Figure 26instance

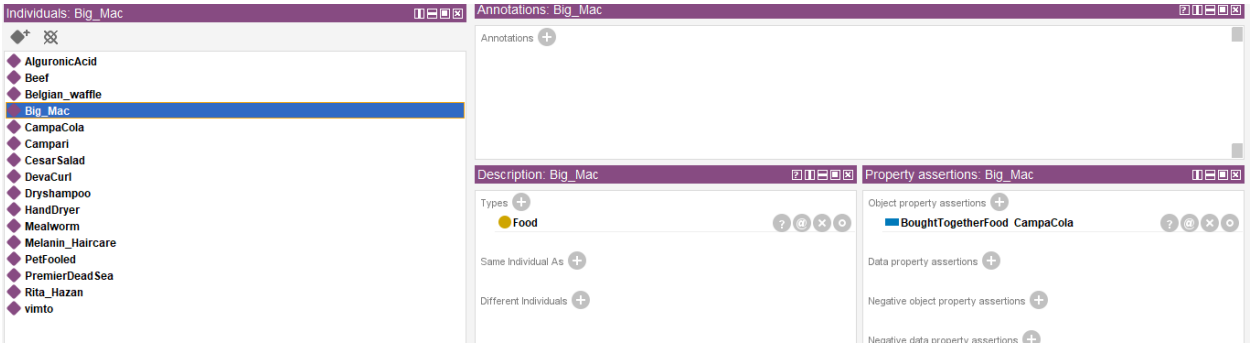


Figure 27instance

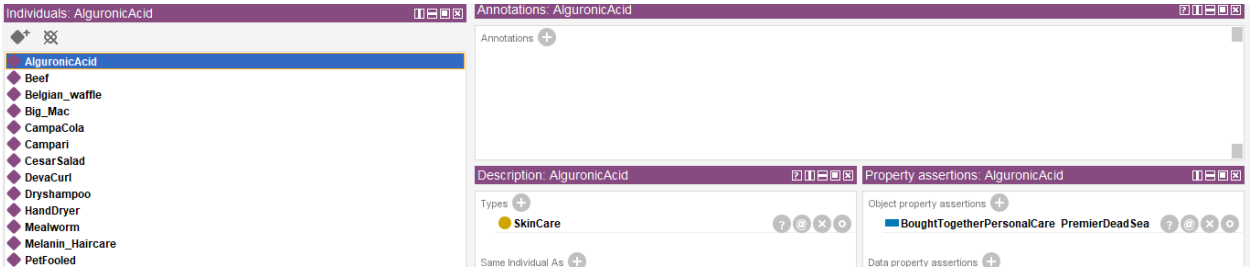


Figure 28instance

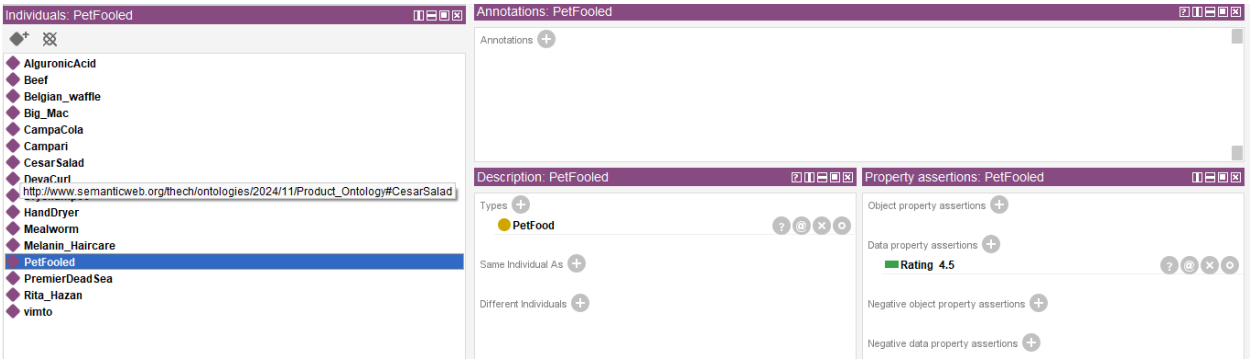


Figure 29 Instance

4.Conclusion

In conclusion, a product ontology provides a comprehensive and structured framework for organizing supermarket products, their attributes, and relationships. By leveraging knowledge sources like FoodOn, GPC Browser, and DBpedia, our goal was to construct an ontology that aligns with industry standards and is populated with real-world data. The ontology's ability to support personalized recommendations, efficient inventory management, and targeted marketing makes it a valuable tool for supermarkets and their customers.

5.Work breakdown:

Our Group broke the work load into tasks that were divided between members.

Determining the class hierarchy was done in 2 group meetings in which all group members participated

Define instances: Queries: Dana, Shahed, Leen

Adding them to protégé: Dana

Define object properties and data properties:

Defining them: Group

Define classes: Group work

Adding them to protégé: Jana

Define concept glossary and relationship glossary:
Concept Glossary: Dana
Relationship : Eithar

The conceptualization approach: Shahed

Ontology knowledge sources: Jana Godieh

Ontology Scope: Jana Godieh

Ontology Scenario: Leen Masarweh