

Question Answering Using First Order Logic

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Abstract

Question Answering is a paradigm of Artificial Intelligence which uses Knowledge Bases to find answers. Our Q/A system uses a Knowledge Base custom made by us, which consists of First Order Logic Axioms for the Supermarket domain (Groceries and Meat). These axioms are used to then query for answers to questions asked by the user.

Keywords: First Order Logic, Knowledge Representation, Artificial Intelligence

1. Introduction

Construction of a system capable of mimicking human-like reasoning capabilities has been a area of research for scientists for over a decade. Since real-time data that we get is usually of unstructured form, it makes the job much more difficult. Hence, the first step is to build a system capable of taking unstructured data as input, which in itself is a humongous challenge. This is quite an active area of research nowadays. Another approach towards solving this problem would be converting unstructured textual data to a reasonable structured form and then using that data in our systems. Several efforts had been made towards building structured form of the collected data. One of the most popular forms are creation of Knowledge Base which contains enough information to facilitate reasoning.



2. Assumptions

Our domain Supermarket is restricted to just Groceries and Meat. In other words, we assume that our Supermarket only sells Groceries and Meat. We further limit our Groceries to Fruits, Vegetables, Dairy Product and Others(which con-

sists of Miscellaneous other food items). For the full list of what items fall under each subcategory, please refer to Appendix A and B.

We also make several real world assumptions to ensure that our system is capable of answering questions with good enough accuracy. The assumptions are as follows:

1. A person can either be a customer or staff at a time, not both.
2. All supermarkets in our universe mimic each other.
3. Product or items are same as each other.
4. Any person who buys Product will receive a receipt.
5. Any person who wishes to return the Product must bring their receipt.
6. All our Dairy Product contain Milk.
7. Conversely, if any product contains milk, then we classify it as a Dairy Product.
8. Oil, Water, Milk and Energy Drink are the only Liquids in our system.
9. Everything else is deemed as a solid.
10. We put Eggs under Meat to simplify categorization of Vegetarians from Non-Vegetarians.
11. Our universe doesn't have Eggetarians.
12. We only sell sweet yogurt and salty butter in our supermarket.
13. We also assume that Fruits and Vegetables can

be Fresh, Frozen or Canned.

14. We consider any product that contains sugar as sweet in taste.

15. We consider any product that contains salt as salty in taste.

16. We also deem only Sweet, Salty, Sour and Tangy as Tastes.

17. Similarly, we only deem Round, Oval or Elliptical as Shapes.

18. We only consider Red, Blue, Green, Yellow, Black, White, Purple, Pink and Orange as colors.

19. We assume that Frozen Product can never be Canned or Fresh and vice versa.

20. We also deem all vegetables as not fit to be eaten raw.

21. We deem all fruits fit to be eaten raw or after cooking.

22. We also assume that Bread is often eaten with butter and Cereal is eaten with Milk.

23. Further, we only accept Cash, Debit and Credit as payment methods.

24. All Solids are measured in Pounds.

25. All Liquids are measured in Ounces.

26. Only an Adult can buy products from the Supermarket.

27. If the Supermarket is open, then there will be atleast Staff in the Supermarket.

3. Methodology

We build our English axioms based on the above pre-decided rules of our Supermarket universe. The full list of the axioms can be found in Appendix C. We make approximately 120 axioms to make our supermarket deem as close to reality as possible. We then convert these axioms into First Order Logic. The full list of First Order Logic axioms can be found in Appendix D. We lastly convert these FOL Axioms into CNF Form. The full list of these can be found in Appendix E. We use Prover9 to build our question answering system. Prover9 uses Resolution Refutation on the axioms listed in Appendix E and gives a proof as a answer.

An example of how we give input to Prover9 and the proof it generates is as shown below.

Assumption:

Tomatoes(Roma).

Question:

ENGLISH: *Are Roma Tomatoes Red?*

GOAL: *Red(Roma).*

```
===== PROOF =====
% ----- Comments from original proof -----
% Proof 1 at 0.24 (+ 0.01) seconds.
% Length of proof is 10.
% Level of proof is 4.
% Maximum clause weight is 7.
% Given clauses 0.

144 -Vegetables(x) | Groceries(x). [assumption].
145 -Groceries(x) | Product(x). [assumption].
160 -Tomatoes(x) | Vegetables(x). [assumption].
182 -Vegetables(x) | Product(x). [resolve(144,b,145,a)].
269 Tomatoes(Roma). [assumption].
285 Product(x) | -Tomatoes(x). [resolve(182,a,160,b)].
301 -Product(x) | -Product(y) | x != y. [assumption].
318 Product(Roma). [resolve(285,b,269,a)].
320 -Product(x). [factor(301,a,b),xx(b)].
321 $F. [resolve(320,a,318,a)].

===== end of proof =====
```

Please do note that the assumption mentioned here is in addition to all the CNF axioms that we provide in Appendix E.

4. Results

To test durability and efficiency of our system, we decided to test a variety of inter and intra category questions to our system. For inter category check, we checked if any two Product within the same category were correctly identified by the system or not. In other words, we checked if one product which is chicken and another product which is pork, were identified as two different Product by our system.

Given below are the assumptions and the goal that we provide to Prover9 (apart from axioms in Appendix E).

Assumption:

Chicken(C).

Pork(P).

Question:

ENGLISH: *Are chicken and pork the same Product?*

GOAL: *C != P.*

These assumptions and goals generate the following proof using Prover9's resolution refutation.

```

===== PROOF =====
% ----- Comments from original proof -----
% Proof 1 at 0.25 (+ 0.01) seconds.
% Length of proof is 8.
% Level of proof is 3.
% Maximum clause weight is 7.
% Given clauses 0.

43 -Meat(x) | Product(x). [assumption].
44 -Chicken(x) | Meat(x). [assumption].
263 -Chicken(x) | Product(x). [resolve(44,b,43,a)].
264 Chicken(C). [assumption].
301 -Product(x) | -Product(y) | x != y. [assumption].
387 Product(C). [resolve(263,a,264,a)].
421 -Product(x). [factor(301,a,b),xx(b)].
422 $F. [resolve(421,a,387,a)].

===== end of proof =====

```

Next, we tested whether our system was capable of differentiating between Product belonging to two different categories. We checked if Yogurt belonging to the Category "DairyProduct" and Watermelon belonging to the category "Vegetables" was correctly differentiated by our system was not.

Assumption:

Yogurt(Y).
Watermelon(W).

Question:

ENGLISH: *Is Yogurt the same as Watermelon?*

GOAL: $Y \neq W$.

These assumptions and goals above generate the following proof using Prover9's resolution refutation.

```

===== PROOF =====
% ----- Comments from original proof -----
% Proof 2 at 0.11 (+ 0.01) seconds.
% Length of proof is 7.
% Level of proof is 3.
% Maximum clause weight is 7.
% Given clauses 74.

120 -DairyProduct(x) | Product(x). [assumption].
122 -Yogurt(x) | DairyProduct(x). [assumption].
138 Yogurt(Y). [assumption].
148 -Yogurt(x) | Product(x). [resolve(122,b,120,a)].
199 -Product(x) | -Product(y) | x != y. [assumption].
280 Product(Y). [resolve(148,a,138,a)].
306 $F. [hyper(199,a,280,a,b,280,a,c,xx)].

===== end of proof =====

```

The next step was to test for durability. We tested whether our system could identify indirectly implied relations correctly. We gave the system assumptions stating that chocolate contains sugar. We asked to prove whether it means chocolate is sweet or not.

Assumption:

Chocolate(Cadbury).

Sugar(S).

Contains(Cadbury, S).

Question:

ENGLISH: *Is chocolate sweet?*

GOAL: *IsSweet(Cadbury).*

These assumptions and goals above generate the following proof using Prover9's resolution refutation.

```

===== PROOF =====
% ----- Comments from original proof -----
% Proof 2 at 0.24 (+ 0.01) seconds.
% Length of proof is 8.
% Level of proof is 3.
% Maximum clause weight is 7.
% Given clauses 4.

263 Sugar(S). [assumption].
266 -Sugar(x) | IsSweet(x). [assumption].
279 -IsSweet(x) | Tastes(x). [assumption].
280 -Tastes(x) | -Tastes(y) | x != y. [assumption].
292 IsSweet(S). [resolve(263,a,266,a)].
303 -Tastes(x). [xx_res(280,c),merge(b)].
304 -IsSweet(x). [back_unit_del(279),unit_del(b,303)].
305 $F. [resolve(304,a,292,a)].

===== end of proof =====

```

We further checked if our system understood the concept of Vegetarians v/s Non Vegetarians or not. We gave the system assumptions stating that Ana bought pork. We asked the system whether it meant she was Vegetarian or not.

Assumption:

Person(Ana).

Pork(P).

Buys(Ana, P).

Question:

ENGLISH: *Ana buys pork. Is she Vegetarian?*

GOAL: *-Vegetarian (Ana).*

These assumptions and goals above generate the following proof using Prover9's resolution refutation.

```

===== PROOF =====
% ----- Comments from original proof -----
% Proof 1 at 0.26 (+ 0.02) seconds.
% Length of proof is 14.
% Level of proof is 5.
% Maximum clause weight is 0.
% Given clauses 0.

1 -Vegetarian(Ana) # label(non_clause) # label(goal). [goal].
15 -Person(x) | -Meat(y) | -Buys(x,y) | Non_Vegetarian(x). [assumption].
18 Person(Ana). [assumption].
26 Vegetarian(Ana). [deny(1)].
27 -Vegetarian(x) | -Non_Vegetarian(x). [assumption].
55 -Pork(x) | Meat(x). [assumption].
65 -Meat(x) | -Buys(Ana,x) | Non_Vegetarian(Ana). [resolve(18,a,15,a)].
272 Pork(P). [assumption].
276 -Buys(Ana,x) | Non_Vegetarian(Ana) | -Pork(x). [resolve(65,a,55,b)].
292 Buys(Ana,P). [assumption].
302 -Buys(Ana,P) | Non_Vegetarian(Ana). [resolve(276,c,272,a)].
304 -Non_Vegetarian(Ana). [resolve(26,a,27,a)].
310 Non_Vegetarian(Ana). [resolve(302,a,292,a)].
328 $F. [resolve(310,a,304,a)].

===== end of proof =====
===== PROOF =====

```

One another test that we performed tested if our system was capable of understanding intuition well. We gave our system data about John buying products at the Supermarket. We asked the system whether his money decreased or not.

Assumption:

Person(John).

Product(P).

Buys(John, P).

Money(z).

Question:

ENGLISH: *Does John's Money decreases?*

GOAL: *IsDecreased(z).*

These assumptions and goals generate the following proof using Prover9's resolution refutation.

```

===== PROOF =====
% ----- Comments from original proof -----
% Proof 1 at 0.37 (+ 0.02) seconds.
% Length of proof is 10.
% Level of proof is 4.
% Maximum clause weight is 0.
% Given clauses 0.

1 IsDecreased(M) # label(non_clause) # label(goal). [goal].
14 -Person(x) | -Product(y) | -Buys(x,y) | IsDecreased(z). [assumption].
19 Person(John). [assumption].
53 Product(T1). [assumption].
59 -Product(x) | -Buys(John,x) | IsDecreased(y). [resolve(19,a,14,a)].
350 Buys(John,T1). [assumption].
357 -Buys(John,T1) | IsDecreased(x). [resolve(59,a,53,a)].
441 -IsDecreased(M). [deny(1)].
443 IsDecreased(x). [resolve(357,a,350,a)].
449 $F. [resolve(443,a,441,a)].

===== end of proof =====

```

We did several other tests such as the ones mentioned and our system passed quite a lot of them, if not all.

5. Conclusion

Thus, we can say that we though our system gives good results, it is still not a complete system. We need to infuse it with more human-like reasoning and knowledge to make it capable of adapting and understanding real word scenarios. We also believe that merely using a Knowledge Base in the traditional sense might not be enough to capture all aspects of the real world. It might be quite interesting to see more creative ways to build artificially intelligent systems capable of giving human-like performance in real-time.

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References

- ¹ Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*. Prentice Hall Press, 2009.
- ² Kurt Bollacker, Colin Evans, Praveen Paritosh, Tim Sturge, and Jamie Taylor, *Freebase: a collaboratively created graph database for structuring human knowledge*. CM SIGMOD international conference on Management, 2008.

6. Appendix A**General Objects**

SuperMarket(x)
 IsOpen(x)
 Person(x), People(x)
 Staff(x)
 Customer(x)
 IsProbable(x)
 IsVisiting _ Supermarket(x)
 AtTime(x)
 Adult(x)
 Product(x), Items(x)
 Kids(x), IsChild(x)
 Debit(x)
 Credit(x)
 Cash(x)
 Is _ Accpetable _ payment(x)
 Receipt(x)
 Money(x)
 IsIncreased(x)
 IsDecreased(x)
 ParkingLot(x)
 HasCar(x)
 Vegetarians(x)
 Non _ Vegetarians(x)
 Liquid(x)
 Solid(x)
 Pounds(x)
 Ounces(x)
 Groceries(x)
 Color(x)
 Red(x), Blue(x), Green(x), Black(x), Grey(x),
 Yellow(x), Pink(x), White(x), Orange(x),
 Brown(x), Purple(x)
 Round(x)
 IsSweet(x)
 IsSalty(x)
 Frozen(x)
 Canned(X)
 Fresh(x)
 Oval(x)
 IsTangy(x)
 IsSour(x)
 Others(x)
 Sugar(x)
 Salt(x)
 Food(x)
 Leafy _ Vegetables(x)
 Tastes(x)

Shapes(x)
 EatenRaw(x)
 EatenAfterCooking(x)

General Relations

Sees(x,y)
 In(x,y)
 Meets(x,y)
 Contains(x,y)
 Knows(x,y)
 Buys(x,y)
 Eats(x,y)
 Can _ accompany(x,y)
 Pays _ using(x,y)
 Returns(x,y)
 Parked(x,y)
 In(x,y), Contains(x,y)
 MeasuredIn(x,y)
 Sells(x,y)
 Made(x,y)
 Has(x,y)
 HasShape(x,y)
 HasTaste(x)
 Is(x,y)
 EqualTo(x,y)
 EatenWith(x,y)
 BoughtWith(x,y)
 IsAvailable(x,y)
 Receives(x, y)

7. Appendix B

Dairy Product

Butter
Milk
Cheese
Yogurt

Others

Cereal
Bread
Rice
Oil
Sugar
Chocolate
Energy Drink
Water
Icecream
Popsicle

Vegetables

Potatoes
Onions
Jalapenos
Bell Pepper
Cabbage
Cauliflower
Okra
Green Onions
Ginger
Tomatoes
Broccoli
Lemon
Spinach
Kale
Fenugreek

Fruits

Apples
Oranges
Grapes
Strawberries
Blackberries
Blueberries
Raspberry
Kiwi
Watermelon
Cherry
Banana
Mangoes

Pear

Meat

Eggs
Chicken
Beef
Sausage
Pork
Bacon
Turkey
Fish - Salmon, Tuna

Spices

Green _ Cardamom
Cloves
Pepper
Salt
Garlic
Italian Seasoning
Cumin
Mustard Seeds
Paprika
Basil
Oregano

8. Appendix C: English Axioms

1. Person in the supermarket are either staff or customer.
2. If the supermarket is open, then there are people in the supermarket.()
3. If a person buys Product then they eat them.
4. If a person buys Product then they are adults.
5. Adults cannot be kids.
6. Kids cannot be adults.
7. A person can be either an Adult or a kid
8. Acceptable Payment Method include Credit, Debit or Cash.
9. Items are Product.
10. If a person returns a product, then they must have a receipt.
11. If a person returns a product then their money increases.
12. If a person buys a product, then their money decreases.
13. Supermarket contains a parking lot.
14. If a person buys meat, then they are non-vegetarians.
15. If a person does not buy meat, then they are vegetarians.
16. A vegetarian cannot be a Non-vegetarian
17. A person can either be a vegetarian or a non-vegetarian.
18. Any product can either be liquid or solid.
19. Liquid Product are either milk or water or energy drink or oil.
20. Liquid Product are not solid.
21. Solid Product are any product that is not liquid.
22. Solids are measured in pounds.
23. Liquids are measured in ounces.
24. Meat are Solids.
25. Fruits are Solids.
26. Vegetables are Solids.
27. Groceries are available in the supermarket.
28. Meat is available in the supermarket.
29. None of the Product sold in the supermarket are made in the supermarket.
30. Color are Red, Blue, Green, Black, Yellow, Pink, White, Orange, Purple.
31. Product attributes are color, taste, shape.
32. Butter is a Dairy Product
33. DairyProduct are Product.
34. Milk is a Dairy Product
35. Cheese is a Dairy Product
36. Yogurt is a Dairy Product
37. If a product contains milk, then it is a Dairy Product.
38. Dairy product, contains milk.
39. Butter contains milk.
40. Cheese contains milk.
41. Yogurt contains milk.
42. Yogurt is sweetened.
43. Butter can be salted or unsalted.
44. Cheese is salted.
45. Milk can be sweetened or unsweetened
46. If the product is milk, then it is white in color and liquid.
47. If the product is butter, then it is yellow in color and solid.
48. If the product is yogurt then it is white in color and solid.
49. If the product is cheese, then it is yellow or white in color and solid.

50. Dairy Product are part of Groceries.
51. Vegetables can be Frozen Vegetables or Canned Vegetables or Fresh Vegetables.
52. Fruits can be Frozen or Canned or Fresh Fruits.
53. Frozen items cannot be Fresh Items or Canned Items.
54. Fresh Items cannot be Canned Items or Frozen Items.
55. Canned items cannot be Frozen items or Fresh Items.
56. Vegetables are part of Groceries.
57. Fruits are part of Groceries.
58. Potatoes or Onions or Jalapenos or Bell Pepper or Cabbage or Okra or Green Onions or Ginger or Tomatoes or Broccoli or Mushrooms or Lemon or Spinach or Kale or Fenugreek is vegetables
59. Potatoes are oval or round in shape.
60. Potatoes can be red, brown, yellow or white.
61. Tomatoes are round in shape.
62. Tomatoes are red or green in color
63. Jalapenos are green, red, yellow or orange in color.
64. Bell Pepper are green, red, yellow or orange in color.
65. Cabbages are green or purple in color.
66. Green Onions are Onions
67. Onions can be white or purple.
68. Broccoli is green in color.
69. Lemon is yellow or green in color and round in shape.
70. Leafy vegetables are also vegetables.
71. Leafy Vegetables include Kale, Spinach and fenugreek.
72. Kale, Spinach and fenugreek are green in color.
73. Apples or Oranges or Grapes or Strawberries or Blackberry or Blueberry or Raspberry or Kiwi or Watermelon or Cherry or Banana or Mangoes or Pear are Fruits.
74. Apples are red in color and sweet and sour in taste.
75. Strawberries and Raspberry are red in color and sweet in taste.
76. Grapes are round in shape and come in black, red and green colors and sweet in taste.
77. Oranges, Pears and Mangoes are yellow or orange in color and sweet or tangy in taste.
78. Banana is yellow in color and sweet in taste.
79. Blueberry and black berry are black in color and sweet in taste.
80. Kiwi is green in color and tangy in taste.
81. Cherry is red in color and sweet in taste.
82. Blueberry, strawberry, raspberry, blackberry are berries.
83. Berries are sweet in taste.
84. Watermelon are green in color and sweet in taste and round in shape.
85. Fruits cannot be Vegetables.
86. Fruits cannot be Dairy Product.
87. Vegetable cannot be Dairy Product
88. Eggs or Chicken or Beef or Turkey or Sausage or Pork or Bacon or Fish is Meat.
89. Meat can be Frozen, Canned or Fresh.
90. Meat cannot Dairy Product.
91. Meat cannot be Fruits.
92. Eggs are white or brown in color and oval in shape.
93. Meat cannot be Vegetables.
94. Green Cardamom or Cloves or Pepper or Salt or Garlic or Italian Seasoning or Cumin Seeds or Mustard Seeds or Paprika or Smoked Paprika or Basil or Oregano are Spices
95. Spices are groceries.

96. Spices cannot be fruits, vegetables, meat or dairy Product.
97. If a product is sweet then it has sugar in it.
98. If a product is salty then it has salt in it.
99. Icecream and Popsicle are frozen foods.
100. Other items in supermarket include Cereal, Bread, rice, Oil, Sugar, chocolate, energy drink, bottled water.
101. Other items are groceries.
102. Milk and cereal are eaten together.
103. Bread and butter are eaten together
104. Sugar can be both white and brown in color.
105. Sugar is sweet in taste.
106. Chocolate contains sugar.
107. Energy Drink is a liquid and it is sweet in taste.
108. Sweet, sour, tangy, salty are tastes.
109. Round, Oval, Elliptical are Shapes.
110. If it's a vegetable then it can't be eaten raw.
111. If it's a fruit, then it can be eaten raw or after cooking.
112. Dairy Product can be eaten raw or cooked.
113. Meat can only be eaten raw not cooked.
114. Other items may or may not be eaten raw or after cooking.
115. No two Product are the same.
116. Salmon and Tuna are fishes.
117. No two colors are the same.
118. No two taste are the same.
119. No staff can be the same as customer.
120. No two shapes are the same.
121. Groceries are Product.
122. Ice cream and Popsicle are others.
123. Meat is Product.
124. Money is Cash, Debit or Credit.
125. Groceries are Product.
126. Only Adults can buy products.

9. Appendix D :First Order Logic Axioms

- $\forall x \text{Person}(x) \wedge \forall y \text{Supermarket}(y) \wedge \text{In}(x, y) \Rightarrow \text{Staff}(x) \vee \text{Customer}(x)$
- $\forall x \text{Supermarket}(x) \wedge \text{IsOpen}(x) \Rightarrow \exists y \text{Person}(y) \wedge \text{In}(y, x)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Product}(y) \wedge \text{Buys}(x, y) \Rightarrow \text{Eats}(x, y)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Product}(y) \wedge \text{Buys}(x, y) \Rightarrow \text{Adult}(x)$
- $\forall x \text{Adult}(x) \Rightarrow \text{Kids}(x)$
- $\forall x \text{Kids}(x) \Rightarrow \text{Adult}(x)$
- $\forall x \text{Person}(x) \Rightarrow \text{Adult}(x) \vee \text{Kids}(x)$
- $\forall x \text{IsAcceptablePayment}(x) \Rightarrow \text{Cash}(x) \vee \text{Debit}(x) \vee \text{Credit}(x)$
- $\forall x \text{Items}(x) \Rightarrow \text{Product}(x)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Product}(y) \wedge \text{Buys}(x, y) \Rightarrow \exists z \text{Receipt}(z) \wedge \text{Has}(x, z)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Product}(y) \wedge \text{Returns}(x, y) \Rightarrow \exists z \text{Receipt}(z) \wedge \text{Has}(x, z)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Product}(y) \wedge \text{Returns}(x, y) \Rightarrow \exists z \text{Money}(z) \wedge \text{Has}(x, z) \wedge \text{IsIncreased}(z)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Product}(y) \wedge \text{Buys}(x, y) \Rightarrow \exists z \text{Money}(z) \wedge \text{Has}(x, z) \wedge \text{IsDecreased}(z)$
- $\forall x \text{Supermarket}(x) \Rightarrow \exists y \text{ParkingLot}(y) \wedge \text{Contains}(x, y)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Meat}(y) \wedge \text{Buys}(x, y) \Rightarrow \text{NonVegetarian}(x)$
- $\forall x \forall y \text{Person}(x) \wedge \text{Meat}(y) \wedge \text{Buys}(x, y) \Rightarrow \text{Vegetarian}(x)$
- $\forall x \text{Vegetarian}(x) \Rightarrow \text{NonVegetarian}(x)$
- $\forall x \text{Person}(x) \Rightarrow \text{Vegetarian}(x) \vee \text{NonVegetarian}(x)$
- $\forall x \text{Product}(x) \Rightarrow \text{Liquid}(x) \vee \text{Solid}(x)$
- $\forall x \text{Milk}(x) \Rightarrow \text{Liquid}(x)$
- $\forall x \text{Oil}(x) \Rightarrow \text{Liquid}(x)$
- $\forall x \text{Water}(x) \Rightarrow \text{Liquid}(x)$
- $\forall x \text{EnergyDrink}(x) \Rightarrow \text{Liquid}(x)$
- $\forall x \text{Liquid}(x) \Rightarrow \text{Solid}(x)$
- $\forall x \text{Solid}(x) \Rightarrow \text{Liquid}(x)$
- $\forall x \forall y \text{Solid}(x) \wedge \text{Pounds}(y) \Rightarrow \text{MeasuredIn}(x, y)$
- $\forall x \forall y \text{Liquid}(x) \wedge \text{Ounces}(y) \Rightarrow \text{MeasuredIn}(x, y)$
- $\forall x \forall y \text{Groceries}(x) \wedge \text{Supermarket}(y) \Rightarrow \text{IsAvailable}(x, y)$
- $\forall x \forall y \text{Meat}(x) \wedge \text{Supermarket}(y) \Rightarrow \text{IsAvailable}(x, y)$
- $\forall x \forall y \text{Supermarket}(x) \wedge \text{Product}(y) \wedge \text{Sells}(x, y) \Rightarrow \text{Made}(y, x)$
- $\forall x \text{Red}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Blue}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Green}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Black}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Yellow}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Pink}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{White}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Orange}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Purple}(x) \Rightarrow \text{Color}(x)$
- $\forall x \text{Butter}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{DairyProduct}(x) \Rightarrow \text{Product}(x)$
- $\forall x \text{Milk}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{Cheese}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{Yogurt}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \forall y \text{Product}(x) \wedge \text{Milk}(y) \wedge \text{Contains}(x, y) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{DairyProduct}(x) \Rightarrow \exists y \text{Milk}(y) \wedge \text{Contains}(x, y)$
- $\forall x \forall y \text{Butter}(x) \wedge \text{Milk}(y) \Rightarrow \text{Contains}(x, y)$
- $\forall x \forall y \text{Cheese}(x) \wedge \text{Milk}(y) \Rightarrow \text{Contains}(x, y)$
- $\forall x \forall y \text{Yogurt}(x) \wedge \text{Milk}(y) \Rightarrow \text{Contains}(x, y)$
- $\forall x \text{Yogurt}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Butter}(x) \Rightarrow \text{IsSalted}(x) \vee \text{IsSalted}(x)$
- $\forall x \text{Cheese}(x) \Rightarrow \text{IsSalted}(x)$
- $\forall x \text{Milk}(x) \Rightarrow \text{IsSweet}(x) \vee \text{IsSweet}(x) \forall x$
- $\forall y \text{Product}(x) \wedge \text{Milk}(y) \wedge \text{Is}(x, y) \Rightarrow \text{White}(x) \forall x$
- $\forall y \text{Product}(x) \wedge \text{Milk}(y) \wedge \text{Is}(x, y) \Rightarrow \text{Liquid}(x) \forall x$
- $\forall y \text{Product}(x) \wedge \text{Butter}(y) \wedge \text{Is}(x, y) \Rightarrow \text{Yellow}(x) \forall x$

- $\forall y Product(x) \wedge Butter(y) \wedge Is(x, y) \Rightarrow Solid(x) \forall x$
- $\forall y Product(x) \wedge Yogurt(y) \wedge Is(x, y) \Rightarrow White(x) \forall x$
- $\forall y Product(x) \wedge Yogurt(y) \wedge Is(x, y) \Rightarrow Solid(x) \forall x$
- $\forall y Product(x) \wedge Cheese(y) \wedge Is(x, y) \Rightarrow Yellow(x) \vee White(x) \forall x$
- $\forall y Product(x) \wedge Cheese(y) \wedge Is(x, y) \Rightarrow Solid(x) \forall x DairyProduct(x) \Rightarrow Groceries(x)$
- $\forall x Vegetables(x) \Rightarrow Frozen(x) \vee Canned(x) \vee Fresh(x)$
- $\forall x Fruits(x) \Rightarrow Frozen(x) \vee Canned(x) \vee Fresh(x)$
- $\forall x Frozen(x) \Rightarrow Canned(x)$
- $\forall x Frozen(x) \Rightarrow Fresh(x)$
- $\forall x Fresh(x) \Rightarrow Canned(x)$
- $\forall x Fresh(x) \Rightarrow Frozen(x)$
- $\forall x Canned(x) \Rightarrow Fresh(x)$
- $\forall x Canned(x) \Rightarrow Frozen(x)$
- $\forall x Vegetables(x) \Rightarrow Groceries(x)$
- $\forall x Fruits(x) \Rightarrow Groceries(x)$
- $\forall x Potatoes(x) \Rightarrow Vegetables(x)$
- $\forall x Onions(x) \Rightarrow Vegetables(x)$
- $\forall x Jalapenos(x) \Rightarrow Vegetables(x)$
- $\forall x Bell_peppers(x) \Rightarrow Vegetables(x)$
- $\forall x Cabbages(x) \Rightarrow Vegetables(x)$
- $\forall x Okra(x) \Rightarrow Vegetables(x)$
- $\forall x GreenOnions(x) \Rightarrow Vegetables(x)$
- $\forall x Ginger(x) \Rightarrow Vegetables(x)$
- $\forall x Tomatoes(x) \Rightarrow Vegetables(x)$
- $\forall x Broccoli(x) \Rightarrow Vegetables(x)$
- $\forall x Mushrooms(x) \Rightarrow Vegetables(x)$
- $\forall x Lemons(x) \Rightarrow Vegetables(x)$
- $\forall x Spinach(x) \Rightarrow Vegetables(x)$
- $\forall x Kale(x) \Rightarrow Vegetables(x)$
- $\forall x Fenugreek(x) \Rightarrow Vegetables(x)$
- $\forall x Potatoes(x) \Rightarrow Oval(x) \vee Round(x)$
- $\forall x Potatoes(x) \Rightarrow Red(x) \vee Brown(x) \vee Yellow(x) \vee White(x)$
- $\forall x Tomatoes(x) \Rightarrow Round(x)$
- $\forall x Tomatoes(x) \Rightarrow Red(x) \vee Green(x)$
- $\forall x Jalapenos(x) \Rightarrow Green(x) \vee Red(x) \vee Yellow(x) \vee Orange(x)$
- $\forall x Bell_peppers(x) \Rightarrow Green(x) \vee Red(x) \vee Yellow(x) \vee Orange(x)$
- $\forall x Cabbages(x) \Rightarrow Green(x) \vee Purple(x)$
- $\forall x GreenOnions(x) \Rightarrow Onions(x)$
- $\forall x Onions(x) \Rightarrow White(x) \vee Purple(x)$
- $\forall x Broccoli(x) \Rightarrow Green(x)$
- $\forall x Lemon(x) \Rightarrow Yellow(x) \vee Green(x)$
- $\forall x Lemon(x) \Rightarrow Round(x)$
- $\forall x LeafyVegetables(x) \Rightarrow Vegetables(x)$
- $\forall x Spinach(x) \Rightarrow LeafyVegetables(x)$
- $\forall x Kale(x) \Rightarrow LeafyVegetables(x)$
- $\forall x Fenugreek(x) \Rightarrow LeafyVegetables(x)$
- $\forall x Spinach(x) \Rightarrow Green(x)$
- $\forall x Kale(x) \Rightarrow Green(x)$
- $\forall x Fenugreek(x) \Rightarrow Green(x)$
- $\forall x Apples(x) \Rightarrow Fruits(x)$
- $\forall x Oranges(x) \Rightarrow Fruits(x)$
- $\forall x Grapes(x) \Rightarrow Fruits(x)$
- $\forall x Strawberries(x) \Rightarrow Fruits(x)$
- $\forall x Blackberries(x) \Rightarrow Fruits(x)$
- $\forall x Blueberries(x) \Rightarrow Fruits(x)$
- $\forall x Raspberry(x) \Rightarrow Fruits(x)$
- $\forall x Kiwi(x) \Rightarrow Fruits(x)$
- $\forall x Watermelon(x) \Rightarrow Fruits(x)$
- $\forall x Cherry(x) \Rightarrow Fruits(x)$
- $\forall x Banana(x) \Rightarrow Fruits(x)$
- $\forall x Mangoes(x) \Rightarrow Fruits(x)$
- $\forall x Pear(x) \Rightarrow Fruits(x)$
- $\forall x Apples(x) \Rightarrow Red(x)$
- $\forall x Apples(x) \Rightarrow IsSweet(x) \vee IsSour(x)$
- $\forall x Strawberries(x) \Rightarrow Red(x)$
- $\forall x Strawberries(x) \Rightarrow IsSweet(x)$
- $\forall x Raspberry(x) \Rightarrow Red(x)$
- $\forall x Raspberry(x) \Rightarrow IsSweet(x)$

- $\forall x \text{Grapes}(x) \Rightarrow \text{Round}(x)$
- $\forall x \text{Grapes}(x) \Rightarrow \text{Red}(x) \vee \text{Green}(x) \vee \text{Black}(x)$
- $\forall x \text{Grapes}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Oranges}(x) \Rightarrow \text{Yellow}(x) \vee \text{Orange}(x)$
- $\forall x \text{Oranges}(x) \Rightarrow \text{IsSweet}(x) \vee \text{IsTangy}(x)$
- $\forall x \text{Mangoes}(x) \Rightarrow \text{Yellow}(x) \vee \text{Orange}(x)$
- $\forall x \text{Mangoes}(x) \Rightarrow \text{IsSweet}(x) \vee \text{IsTangy}(x)$
- $\forall x \text{Pear}(x) \Rightarrow \text{Yellow}(x) \vee \text{Orange}(x)$
- $\forall x \text{Pear}(x) \Rightarrow \text{IsSweet}(x) \vee \text{IsTangy}(x)$
- $\forall x \text{Banana}(x) \Rightarrow \text{Yellow}(x)$
- $\forall x \text{Banana}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Blackberries}(x) \Rightarrow \text{Black}(x)$
- $\forall x \text{Blackberries}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Blueberries}(x) \Rightarrow \text{Black}(x)$
- $\forall x \text{Blueberries}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Kiwi}(x) \Rightarrow \text{Green}(x)$
- $\forall x \text{Kiwi}(x) \Rightarrow \text{IsTangy}(x)$
- $\forall x \text{Cherry}(x) \Rightarrow \text{Red}(x)$
- $\forall x \text{Cherry}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Blueberries}(x) \Rightarrow \text{Berries}(x)$
- $\forall x \text{Raspberry}(x) \Rightarrow \text{Berries}(x)$
- $\forall x \text{Strawberries}(x) \Rightarrow \text{Berries}(x)$
- $\forall x \text{Berries}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Watermelon}(x) \Rightarrow \text{Green}(x)$
- $\forall x \text{Watermelon}(x) \Rightarrow \text{IsSweet}(x)$
- $\forall x \text{Watermelon}(x) \Rightarrow \text{Round}(x)$
- $\forall x \text{Fruits}(x) \Rightarrow \text{Vegetables}(x)$
- $\forall x \text{Fruits}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{Vegetables}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{Eggs}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \text{Chicken}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \text{Beef}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \text{Turkey} \Rightarrow \text{Meat}(x)$
- $\forall x \text{Sausage}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \text{Pork}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \text{Bacon}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \text{Fish}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \text{Meat}(x) \Rightarrow \text{Frozen}(x) \vee \text{Canned}(x) \vee \text{Fresh}(x)$
- $\forall x \text{Meat}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{Meat}(x) \Rightarrow \text{Fruits}(x)$
- $\forall x \text{Eggs}(x) \Rightarrow \text{Brown}(x) \vee \text{White}(x)$
- $\forall x \text{Eggs}(x) \Rightarrow \text{Oval}(x)$
- $\forall x \text{Meat}(x) \Rightarrow \text{Vegetables}(x)$
- $\forall x \text{GreenCardamom}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Cloves}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Pepper}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Salt}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Garlic}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{ItalianSeasoning}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{CuminSeeds}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{MustardSeeds}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Paprika}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{SmokedPaprika}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Basil}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Oregano}(x) \Rightarrow \text{Spices}(x)$
- $\forall x \text{Spices}(x) \Rightarrow \text{Groceries}(x)$
- $\forall x \text{Spices}(x) \Rightarrow \text{DairyProduct}(x)$
- $\forall x \text{Spices}(x) \Rightarrow \text{Fruits}(x)$
- $\forall x \text{Spices}(x) \Rightarrow \text{Vegetables}(x)$
- $\forall x \text{Spices}(x) \Rightarrow \text{Meat}(x)$
- $\forall x \forall y \text{Product}(x) \wedge \text{IsSweet}(x) \wedge \text{Sugar}(y) \Rightarrow \text{Contains}(x, y)$
- $\forall x \forall y \text{Product}(x) \wedge \text{IsSalty}(x) \wedge \text{Salt}(y) \Rightarrow \text{Contains}(x, y)$
- $\forall x \text{Icecream}(x) \Rightarrow \text{Frozen}(x)$
- $\forall x \text{Popsicle}(x) \Rightarrow \text{Frozen}(x)$
- $\forall x \text{Cereal}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{Bread}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{Rice}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{Oil}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{Sugar}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{Chocolate}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{EnergyDrink}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{Water}(x) \Rightarrow \text{Others}(x)$
- $\forall x \text{Others}(x) \Rightarrow \text{Groceries}(x)$

- $\forall x \forall y Cereal(x) \wedge Milk(y) \Rightarrow EatenWith(x, y)$
- $\forall x \forall y Bread(x) \wedge Butter(y) \Rightarrow EatenWith(x, y)$
- $\forall x Sugar(x) \Rightarrow White(x) \vee Brown(x)$
- $\forall x Sugar(x) \Rightarrow IsSweet(x)$
- $\forall x \forall y Chocolate(x) \wedge Sugar(y) \Rightarrow Contains(x, y)$
- $\forall x EnergyDrink(x) \Rightarrow Liquid(x)$
- $\forall x EnergyDrink(x) \Rightarrow IsSweet(x)$
- $\forall x IsSweet(x) \Rightarrow Tastes(x)$
- $\forall x IsSour(x) \Rightarrow Tastes(x)$
- $\forall x IsTangy(x) \Rightarrow Tastes(x)$
- $\forall x IsSalty(x) \Rightarrow Tastes(x)$
- $\forall x Round(x) \Rightarrow Shapes(x)$
- $\forall x Oval(x) \Rightarrow Shapes(x)$
- $\forall x Elliptical(x) \Rightarrow Shapes(x)$
- $\forall x Vegetables(x) \Rightarrow EatenAfterCooking(x)$
- $\forall x Vegetables(x) \Rightarrow EatenRaw(x)$
- $\forall x Fruits(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x DairyProduct(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Meat(x) \Rightarrow EatenAfterCooking(x)$
- $\forall x Meat(x) \Rightarrow EatenRaw(x)$
- $\forall x Cereal(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Bread(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Rice(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Oil(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Sugar(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Chocolate(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x EnergyDrink(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Water(x) \Rightarrow EatenRaw(x) \vee EatenAfterCooking(x)$
- $\forall x Tuna(x) \Rightarrow Fish(x)$
- $\forall x \forall y Color(x) \wedge Color(y) \Rightarrow (x \neq y)$
- $\forall x \forall y Tastes(x) \wedge Tastes(y) \Rightarrow (x \neq y)$
- $\forall x Staff(x) \Rightarrow \neg Customer(x)$
- $\forall x Customer(x) \Rightarrow \neg Staff(x)$
- $\forall x \forall y Shapes(x) \wedge Shapes(y) \Rightarrow (x \neq y)$
- $\forall x Groceries(x) \Rightarrow Product(x)$
- $\forall x Icecream(x) \Rightarrow Others(x)$
- $\forall x Popsicle(x) \Rightarrow Others(x)$

10. Appendix E: CNF Axioms

-Person (x) | -Supermarket(x) | -In(x,y) | Staff(x) | Customer(x)´

-Staff(x) | -Customer(x)´

-Customer(x) | -Staff(x)´

-Person(x) | -Product(y) | -Buys(x,y) | Adult(x)´

-Person(x) | -Money(y) | Has(x,y)´

-Money(x) | Cash(x) | Debit(x) | Credit(x)´

-Supermarket(x) | -IsOpen(x) | Person(f(x))´

-Supermarket(x) | -IsOpen(x) | In(f(x),x)´

-Person(x) | -Product(y) | -Buys(x,y) | Eats(x,y)´

-Person(x) | -Product(y) | -Buys(x,y) | Adult(x)´

-Adult(x) | -Kids(x)´

-Kids(x) | -Adults(x)´

-Person(x) | Adult(x) | Kids(x)´

-IsAcceptablePayment(x) | Cash(x) | Debit(x) | Credit(x)´

-Items(x) | Product(x)´

-Person(x) | -Product(y) | -Returns(x,y) | Receipt(f(x))´

-Person(x) | -Product(y) | -Returns(x,y) | Has(x,f(x))´

-Person(x) | -Product(y) | -Returns(x,y) | Money(f(x))´

-Person(x) | -Product(y) | -Returns(x,y) | Has(x,f(x))´

-Person(x) | -Product(y) | -Returns(x,y) | IsIncreased(f(x))´

-Person(x) | -Product(y) | -Buys(x,y) | Money(f(x))´

-Person(x) | -Product(y) | -Buys (x,y) | Has(x,f(x))´

-Person(x) | -Product(y) | -Buys (x,y) | IsDecreased(f(x))´

-Supermarket(x) | Parking _ Lot(f(x))´

-Supermarket(x) | Contains(x,f(x))´

-Product(x) | -Product(y) | (x != y)´

-Person(x) | -Meat(y) | -Buys(x,y) | Non _ Vegetarian (x)´

-Person(x) | -Meat(y) | Buys(x,y) | Vegetarian (x)´

- Vegetarian(x) | - Non _ Vegetarian(x)´

-Person(x) | Vegetarian(x) | Non _ Vegetarian(x)´

-Product(x) | Liquid(x) | Solid(x)´

-Milk(x) | Liquid(x)´

-Oil(x) | Liquid(x)´

-Water(x) | Liquid(x)´

-Energy _ Drink(x) | Liquid(x)´

-Liquid(x) | -Solid(x)´

-Solid(x) | -Liquid(x)´

- Solid(x) | -Pounds(y) | MeasuredIn(x,y)'
- Liquid(x) | -Ounces(y) | MeasuredIn(x,y)'
- Groceries(x) | -Supermarket(y) | IsAvailable(x,y)'
- Meat(x) | -Supermarket(y) | IsAvailable(x,y)'
- Meat(x) | Solid(x)'
- Meat(x) | Product(x)'
- Supermarket(x) | -Product(y) | -Sells(x,y) | -Made(y,x)'
- Red(x) | Color(x)'
- Blue(x) | Color(x)'
- Green(x) | Color(x)'
- Black(x) | Color(x)'
- Yellow(x) | Color(x)'
- Pink(x) | Color(x)'
- White(x) | Color(x)'
- Orange(x) | Color(x)'
- Purple(x) | Color(x)'
- Color(x) | -Color(y) | (x != y)'
- Butter(x) | DairyProduct(x)'
- DairyProduct (x) | Product(x)'
- Milk (x) | DairyProduct(x)'
- Cheese(x) | DairyProduct(x)'
- Yogurt(x) | DairyProduct(x)'
- Product(x) | -Milk(y) | -Contains(x,y) | DairyProduct(x)'
- DairyProduct(x) | Milk(f(x))'
- DairyProduct(x) | Contains(x, f(x))'
- Butter(x) | -Milk (y) | Contains(x,y)'
- Cheese(x) | -Milk (y) | Contains(x,y)'
- Yogurt(x) | -Milk (y) | Contains(x,y)'
- Yogurt(x) | IsSweet(x)'
- Butter(x) | IsSalted(x) | -IsSalted(x)'
- Cheese(x) | IsSalted(x)'
- Milk(x) | IsSweet(x) | -IsSweet(x)'
- Product(x) | -Milk(y) | -Is(x,y) | White(x)'
- Product(x) | -Milk(y) | -Is(x,y) | Liquid(x)'
- Product(x) | -Butter(y) | -Is(x,y) | Yellow(x)'
- Product(x) | -Butter(y) | -Is(x,y) | Solid(x)'
- Product(x) | -Yogurt(y) | -Is(x,y) | White(x)'
- Product(x) | -Yogurt(y) | -Is(x,y) | Solid(x)'
- Product(x) | -Cheese(y) | -Is(x,y) | Yellow(x) | White(x)'
- Product(x) | -Cheese(y) | -Is(x,y) | Solid(x)'
- DairyProduct(x) | Groceries(x)'

- Groceries(x) | Product(x)´
- Vegetables(x) | Frozen (x) | Canned(x) | Fresh (x)´
- Fruits(x) | Frozen (x) | Canned(x) | Fresh (x)´
- Frozen(x) | - Canned (x)´
- Frozen(x) | -Fresh(x)´
- Fresh (x) | - Canned (x)´
- Fresh (x) | - Frozen (x)´
- Canned (x) | - Fresh (x)´
- Canned (x) | - Frozen (x)´
- Vegetables(x) | Groceries(x)´
- Fruits(x) | Groceries(x)´
- Potatoes(x) | Vegetables(x)´
- Onions(x) | Vegetables(x)´
- Jalapenos(x) | Vegetables(x)´
- Bell _ pepper(x) | Vegetables(x)´
- Cabbages(x) | Vegetables(x)´
- Okra(x) | Vegetables(x)´
- Green _ Onions(x) | Vegetables(x)´
- Ginger(x) | Vegetables(x)´
- Tomatoes(x) | Vegetables(x)´
- Broccoli(x) | Vegetables(x)´
- Mushrooms (x) | Vegetables(x)´
- Lemons(x) | Vegetables(x)´
- Spinach(x) | Vegetables(x)´
- Kale(x) | Vegetables(x)´
- Fenugreek (x) | Vegetables(x)´
- Potatoes(x) | Oval(x) | Round(x)´
- Potatoes(x) | Red(x) | Brown(x) | Yellow(x) | White(x)´
- Tomatoes(x) | Round(x)´
- Tomatoes(x) | Red(x) | Green(x)´
- Jalapenos(x) | Green(x) | Red(x) | Yellow(x) | Orange(x)´
- Bell _ peppers(x) | Green(x) | Red(x) | Yellow(x) | Orange(x)´
- Cabbages(x) | Green(x) | Purple(x)´
- Green _ Onions(x) | Onions(x)´
- Onions(x) | White(x) | Purple(x)´
- Broccoli (x) | Green(x)´
- Lemon(x) | Yellow(x) | Green(x)´
- Lemon(x) | Round(x)´
- Leafy _ Vegetables(x) | Vegetables(x)´
- Spinach (x) | Leafy _ Vegetables(x)´
- Kale (x) | Leafy _ Vegetables(x)´
- Fenugreek (x) | Leafy _ Vegetables(x)´

- | | |
|----------------------------------|--|
| -Spinach (x) Green(x)· | -Raspberry(x) Sweet(x)· |
| -Kale (x) Green(x)· | -Grapes(x) Round(x)· |
| -Fenugreek (x) Green(x)· | -Grapes(x) Red(x) Green(x) Black(x)· |
| -Apples(x) Fruits(x)· | -Grapes(x) Sweet(x)· |
| -Oranges(x) Fruits(x)· | -Oranges(x) Yellow(x) Orange(x)· |
| -Grapes(x) Fruits(x)· | -Oranges(x) IsSweet(x) IsTangy(x)· |
| -Strawberries(x) Fruits(x)· | -Mangoes(x) Yellow(x) Orange(x)· |
| -Blackberries(x) Fruits(x)· | -Mangoes(x) IsSweet(x) IsTangy(x)· |
| -Blueberries(x) Fruits(x)· | -Pear(x) Yellow(x) Orange(x)· |
| -Raspberry(x) Fruits(x)· | -Pear(x) IsSweet(x) IsTangy(x)· |
| -Kiwi(x) Fruits(x)· | -Banana(x) Yellow(x)· |
| -Watermelon(x) Fruits(x)· | -Banana(x) Sweet(x)· |
| -Cherry(x) Fruits(x)· | -Blackberries(x) Black(x)· |
| -Banana(x) Fruits(x)· | -Blackberries(x) IsSweet(x)· |
| -Mangoes(x) Fruits(x)· | -Blueberries(x) Black(x)· |
| -Pear(x) Fruits(x)· | -Blueberries(x) IsSweet(x)· |
| -Apples(x) Red(x)· | -Kiwi(x) Green(x)· |
| -Apples(x) Sweet(x) Sour(x)· | -Kiwi(x) IsTangy(x)· |
| -Strawberries(x) Red(x)· | -Cherry(x) Red(x)· |
| -Strawberries(x) Sweet(x)· | -Cherry(x) IsSweet(x)· |
| -Raspberry(x) Red(x)· | -Blueberries(x) Berries(x)· |

-Raspberry(x) Berries(x)´	-Meat(x) -Fruits(x)´
-Strawberries(x) Berries(x)´	-Eggs(x) Brown(x) White(x)´
-Berries(x) IsSweet(x)´	-Eggs(x) Oval(x)´
-Watermelon (x) Green(x)´	-Meat(x) -Vegetables(x)´
-Watermelon (x) IsSweet(x)´	-Groceries(x) Product(x)´
-Watermelon (x) Round(x)´	-Meat(x) Product(x)´
-Fruits(x) -Vegetables(x)´	-Green _ Cardamom(x) Spices(x)´
-Fruits(x) -DairyProduct(x)´	-Cloves(x) Spices(x)´
-Vegetables(x) -DairyProduct(x)´	-Pepper(x) Spices(x)´
-Eggs(x) Meat(x)´	-Salt(x) Spices(x)´
-Chicken(x) Meat(x)´	-Garlic(x) Spices(x)´
-Beef(x) Meat(x)´	-Italian _ Seasoning (x) Spices(x)´
-Turkey Meat(x)´	-Cumin _ Seeds (x) Spices(x)´
-Sausage(x) Meat(x)´	-Mustard _ Seeds (x) Spices(x)´
-Pork(x) Meat(x)´	-Paprika(x) Spices(x)´
-Bacon(x) Meat(x)´	-Smoked _ Paprika(x) Spices(x)´
-Fish(x) Meat(x)´	-Basil(x) Spices(x)´
-Salmon(x) Fish(x)´	-Oregano(x) Spices(x)´
-Tuna(x) Fish(x)´	-Spices(x) Groceries(x)´
-Meat(x) Frozen(x) Canned(x) Fresh(x)´	-Spices(x) -DairyProduct(x)´
-Meat(x) -DairyProduct(x)´	-Spices(x) -Fruits(x)´

-Spices(x) -Vegetables(x)'	-Chocolate(x) -Sugar(y) Contains(x,y)'
-Spices(x) -Meat(x)'	-Energy _ Drink(x) Liquid(x)'
-Product(x) -IsSweet(x) -Sugar(y) Contains(x,y)'	-Energy _ Drink(x) IsSweet(x)'
-Product(x) -IsSalty(x) -Salt(y) Contains(x,y)'	-IsSweet(x) Tastes(x)'
-Icecream(x) Frozen(x)'	-IsSour(x) Tastes(x)'
-Popsicle(x) Frozen(x)'	-IsTangy(x) Tastes(x)'
-Cereal(x) Others(x)'	-IsSalty(x) Tastes(x)'
-Icecream(x) Others(x)'	-Tastes(x) -Tastes (y) (x != y)'
-Popsicle(x) Others(x)'	-Round(x) Shapes(x)'
-Bread(x) Others(x)'	-Oval(x) Shapes(x)'
-Rice(x) Others(x)'	-Elliptical(x) Shapes(x)'
-Oil(x) Others(x)'	-Shapes(x) -Shapes(y) (x != y)'
-Sugar(x) Others(x)'	-Vegetables(x) EatenAfterCooking(x)'
-Chocolate(x) Others(x)'	-Vegetables(x) -EatenRaw(x)'
-Energy _ Drink (x) Others(x)'	-Fruits(x) EatenRaw(x) EatenAfterCooking(x)'
-Water(x) Others(x)'	-DairyProduct(x) EatenRaw(x) EatenAfterCooking(x)'
-Others(x) Groceries(x)'	-Meat(x) EatenAfterCooking(x)'
-Cereal(x) -Milk(y) EatenWith(x,y)'	-Meat(x) -EatenRaw(x)'
-Bread(x) -Butter(y) EatenWith(x,y)'	-Cereal(x) EatenRaw(x) EatenAfterCooking(x)'
-Sugar(x) White(x) Brown(x)'	-Bread(x) EatenRaw(x) EatenAfterCooking(x)'
-Sugar(x) IsSweet(x)'	-Rice(x) -EatenRaw(x) EatenAfterCooking(x)'

EatenAfterCooking(x)·

-Oil(x) | -EatenRaw(x) | EatenAfterCooking(x)·

-Sugar(x) | EatenRaw(x) | EatenAfterCooking(x)·

-Chocolate(x) | EatenRaw(x) |

-Energy _ Drink (x) | EatenRaw(x) |

-EatenAfterCooking(x)·

-Water(x) | EatenRaw(x) | EatenAfterCooking(x)·