Annotation Guideline for RecipeRef: A Corpus for Modeling Anaphora Resolution of the Procedural Text of Recipes

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1 Overview

In recipes, ingredients usually undergo changes (e.g. *chopping, baking, boiling*, etc.) and interact with other ingredients (e.g. *mixing, stirring*, etc.). Various expressions are used to describe the processed ingredients, making it hard to determine how ingredients are used. To fully understand recipes, resolving referring relations among ingredients is essential. Moreover, processed ingredients might be involved in state changes, either physical (e.g. *diced, peeled*, etc.) or chemical (e.g. *baked, cooked*, etc.). These subtle state changes form an important part in recipe processing, but also bring challenges in identifying ingredients. For instance, as shown in Figure 1, the expression *the biscuits* in lines 4 and 5 refer to the same ingredient *biscuits*, where the one on line 5 is baked and the other is not. Coreference, the most commonly used referring relation that links expressions representing the same entity, is not sufficient to capture these subtle state changes. To resolve that, we hence propose this novel annotation framework to annotate anaphora phenomena in recipes. Specifically, we aim to identify ingredient expressions, as discussed in Section 2, and relate them with corresponding anaphora relations, as defined in Section 3.

You will be presented with one text "snippet" at a time in the format shown in Figure 1. In this excerpt, you need to consider what types of referring relations occur in the snippet and identify the expressions describing ingredients (which we call "mentions") that are involved in these referring relationships. Once identified, these expressions are represented by highlighting, and mention labels such as "Entity". You will then need to identify relationships between these expressions, where one expression refers to the other, and link them together with a line indicating how they are connected (the link type). One thing worth mentioning is that an expression can only link to previous expression/s, which means the arrow/direction of the relation is strictly from right to left. Detailed annotation instructions can be found in Section 5.

One noteworthy point is that recipes will largely be presented in lowercase. As the recipes

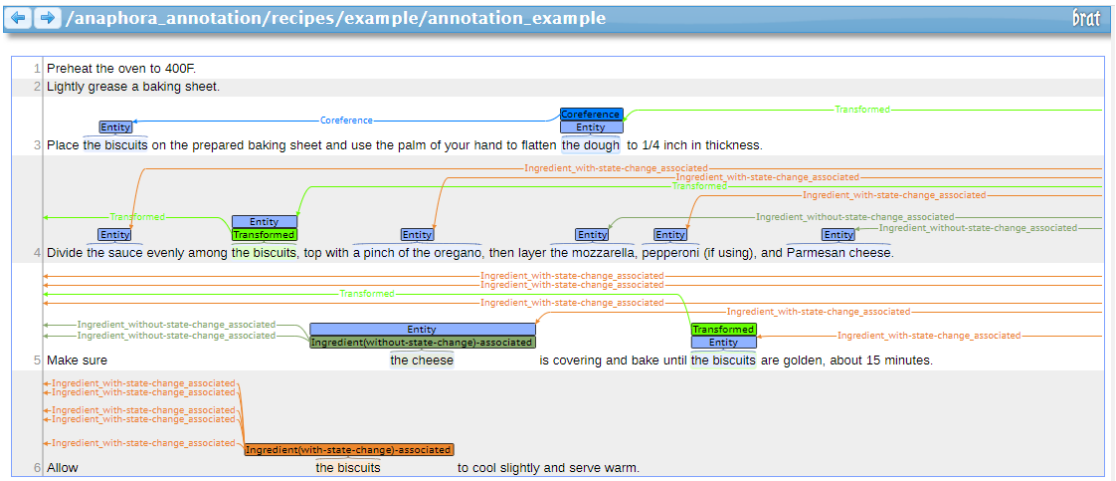


Figure 1: Example of annotated snippet in recipes.

have been sourced externally, you may encounter recipe sentences that are disfluent or duplicated. In either of these cases, please report to the annotation mediator for further instruction.

2 Mention Types

The key component in understanding recipes is to understand the ingredients. In this annotation guideline, we focus on tackling anaphora relations among ingredients. Only expressions that represent ingredients and are involved in anaphora relations (as defined in Section 3) will be annotated. Candidate mentions that are considered for referring links are discussed in the following section and examples are provided in Table 1. Specifically, verbs (e.g. *chopping*, *baking*, *stirring*, etc.) will not be annotated in this corpus.

2.1 Ingredient Terms

In recipes, ingredient terms are essential as they indicate what ingredients are used, in the form of individual words or phrases. As shown in examples (1) - (3), expressions that are bolded are ingredient terms and considered to be candidate mentions.

(1) Melt ⌈**candy**⌋$_1$, ⌈**butter**⌋$_2$ and ⌈**cream**⌋$_3$ in microwave at medium, stirring frequently. Add ⌈**marshmallows**⌋$_4$ and ⌈**nuts**⌋$_5$...

(2) Arrange ⌈**endive leaves**⌋$_1$ on a serving platter. Top with ⌈**candied nuts**⌋$_2$ and ⌈**blue cheese**⌋$_3$. In a small bowl or jar, combine ⌈**vinegar**⌋$_4$, ⌈**oil**⌋$_5$ and ⌈**mustard**⌋$_6$. Whisk or shake jar to combine...

(3) Season ⌈**chopped chicken**⌋$_1$ with ⌈**salt**⌋$_2$, ⌈**roasted red peppers**⌋$_3$, ⌈**garlic powder**⌋$_4$ and cook until no longer pink. Set it aside in a bowl...

Types	**Examples of Mentions**
Ingredient Terms	*candy*
	butter
	cream
	endive leaves
	blue cheese
	garlic powder
	candied nuts
	chopped chicken
	roasted red peppers
Referring Expressions	*it*
	them
	their
	the ingredients
	the meat mixture
	rotini mixture
	rings
	the slices
	very thin 3 inch rounds
	1
	four

Table 1: Mentions that are related to ingredients

2.2 Referring Expressions

To avoid redundancy in repeating terms or complex ingredient combinations, referring expressions are often used in recipes, in the form of anaphors. In this task, we consider referring expressions to be pronouns and generic phrases.

In recipes, pronouns usually refer to ingredient/s mentioned earlier. As demonstrated in examples (4) - (6), pronouns in bold stand for ingredients and are considered to be candidate mentions.

(4) Place the garbanzo beans, tahini, lemon juice, salt and garlic in a blender or food processor. Blend until smooth. Transfer mixture to a serving bowl. Drizzle olive oil over ⌈**it**⌋$_1$. Sprinkle with paprika and parsley.

(5) ...Cut into 1 slices and shape into round cakes, coat with a little more flour and then dip ⌈**them**⌋$_1$ into the beaten egg and then coat ⌈**them**⌋$_2$ with the breadcrumbs. Place ⌈**them**⌋$_3$ on a plate and allow to chill for 30 minutes for firm up a little...

(6) Combine the flour and sugar in a bowl, mix well with a whisk. crack in eggs, then add oil, beer, and vanilla and whisk till smooth thick batter forms. Stir in the milk a little at a time. Let the batter rest for 30 minutes in the fridge, then fry the pancakes thin like crepes. While batter is resting, toss strawberries with vinegar and sugar; Let sit at room temp till juicy. Serve fresh pancakes with a scoop of berries and ⌈**their**⌋$_1$ juice.

Generic phrases are non-pronominal noun phrases that are used to represent ingredient terms mentioned earlier in the recipe, but which cannot be grounded to specific ingredients out of context. As shown in examples (7) - (8), expressions in bold are generic phrases and considered to be candidate mentions.

(7) Place all ⌈**the ingredients**⌋$_1$ in a sauce pan and bring to boil and cook uncovered for 20 minutes over medium heat. Cool ⌈**the meat mixture**⌋$_2$ and pour in pastry lined pan. Cover with the top crust...

(8) ...Mix rotini, diced red onion, roasted red peppers, mozzarella cheese, artichoke hearts, salami, green olives, black olives, pepperoncini peppers, italian seasoning, garlic powder, seasoned salt, and black pepper in a large bowl. Whisk italian style dressing and mayonnaise together in a small bowl; Pour over ⌈**rotini mixture**⌋$_1$ and toss to coat...

In recipe corpus, shape and numerical expression can also be used to describe ingredients. As shown in example (9), ⌈**rings**⌋$_1$, ⌈**the slices**⌋$_2$ and ⌈**rings**⌋$_3$ are the shape expression of the ingredient *endive heads* and they semantically represent the *endive heads*. Thus, they are considered as candidate mentions. A similar example can be seen in example (10) for ⌈**very thin 3 inch rounds**⌋$_1$.

(9) In a medium bowl, whisk together the dijon mustard, red wine vinegar and lemon juice. Whisk in olive oil slowly until you have an almost creamy consistency. Taste and season

with salt and pepper. Set aside. Cut endive heads crosswise into ⌈**rings**⌋$_1$. Remove the hard end of the stems and discard. Rinse in a colander, shaking to separate ⌈**the slices**⌋$_2$ into ⌈**rings**⌋$_3$.

(10) Preheat oven to 350 degrees f. Grease a cookie sheet thoroughly. Whip the egg whites on low speed until light and foamy. Blend in the sugar and continue to beat until soft peaks form. Pour in the melted butter, flour, salt, and extracts; mix until well combined. Drop a tablespoon of the batter onto the prepared cookie sheet. Using the back of a spoon, spread the batter evenly into ⌈**very thin 3 inch rounds**⌋$_1$...

However, one thing worth noticing is that when the shape expression is used to describe the property, it is not considered as an ingredient. As shown in example (11), **2cm thick** is used to describe the state of the process of *rolling dough*, thus it is not considered as an ingredient. A similar example is demonstrated in (12), **half** is used to described the process *cut*. Thus, it is not annotated as an ingredient. As a comparison, if it is "cut them in halves", "halves" will be considered as an ingredient expression.

(11) Make a well in centre of mixture. add buttermilk. Using a flat bladed knife, stir until a sticky dough forms. Turn out onto a lightly floured surface. Knead gently until just smooth. Using a lightly floured rolling pin, gently roll dough out until **2cm thick**. Using a 7cm round cutter, cut out scones. Press leftover dough together.

(12) Make the puff pastry crescents, lay out the puff pastry dough. Cut out 16 crescent shapes from the dough. Brush with egg whites and bake in a 375 preheated oven for 15 minutes, until golden. Make the stuffed chicken, arrange the chicken breasts on a cutting board and cut them in **half**.

Numerical expression can be used as a substitution of the referred ingredient. In this case, we consider the numerical expression as a candidate mention as well if it presents an ingredient. As shown in examples (13) and (14), ⌈**1**⌋$_1$ and ⌈**four**⌋$_1$ are considered as candidate mentions.

(13) Preheat oven to 350^{o}f. butter and flour 8 inch square metal cake pan. Line bottom of pan with parchment paper. Butter and flour parchment paper. Stir chopped chocolate in top of double boiler set over simmering water until chocolate is melted and smooth. Remove from over water. Using electric mixer, beat butter in medium bowl until smooth. Gradually add sugar and beat until well blended. Beat in eggs ⌈**1**⌋$_1$ at a time, blending well after each addition.

(14) Take a slice of bread and layer on it a slice of mozzarella, basil, and salt and pepper to taste. Top with another slice of bread and press together firmly to make a sandwich. Repeat with the rest of the bread and ingredients to make ⌈**four**⌋$_1$, and set aside.

3 Relation Types

In anaphora relations, referring mentions which cannot be interpreted on their own, or indirect mentions, are called *anaphors* and the mentions anaphors refer back to are called *antecedents*. *Anaphors* are linked to *antecedents* via corresponding anaphora relations.

In the following examples, anaphora relations will be presented using the notation:

AnaphoraRelationship (*antecedent*, *anaphor*)

where the referring direction of the connecting link is from the *anaphor* to its corresponding *antecedent*. And for illustration and discussion purposes, not all annotated anaphora relationships are presented in the following examples

Following the discussion in Section 1, ingredients might undergo some subtle state changes (e.g. *heat*, *mix*, etc.). These changes potentially signify a change in an entity. To capture anaphora phenomena in recipes, we classify anaphora relations into four fine-grained types, i.e. COREFERENCE, TRANSFORMED, INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED and INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED. The classification is shown in Fig 2. Detailed definitions of anaphora relations are provided below.

Specifically, state changes are categorized into two types: physical and chemical changes. We consider the following definition for those two subtypes.

- Physical changes occur when objects or substances undergo a change that does not change their chemical composition. This contrasts with the concept of chemical change in which the composition of a substance changes or one or more substances combine or break up to form new substances. In general, a physical change can be reversible or irreversible using physical means. In recipes, physical changes include *knead, chop, peel, etc.*

- Chemical changes occur when a substance combines with another to form a new substance, called chemical synthesis or, alternatively, chemical decomposition into two or more different substances. These processes are called chemical reactions and, in general, are not reversible except by further chemical reactions. In recipes, chemical changes include *bake, simmer, boil, etc.*

3.1 Coreference

It is defined as expressions/mentions that refer one-to-one to the same entity in the real world. In recipes, this relates expressions that are without physical/chemical change. As shown in Example (15), ⌈**the biscuits**⌋$_1$ and ⌈**the dough**⌋$_2$ are coreferent as they refer to the same entity without any physical/chemical changes. A similar example can be seen in (16), where ⌈**coated beef**⌋$_1$ and ⌈**meat**⌋$_2$ are coreferent.

(15) Preheat the oven to 400F. Lightly grease a baking sheet. Place ⌈**the biscuits**⌋$_1$ on the prepared baking sheet and use the palm of your hand to flatten ⌈**the dough**⌋$_2$ to 1/4 inch in thickness...

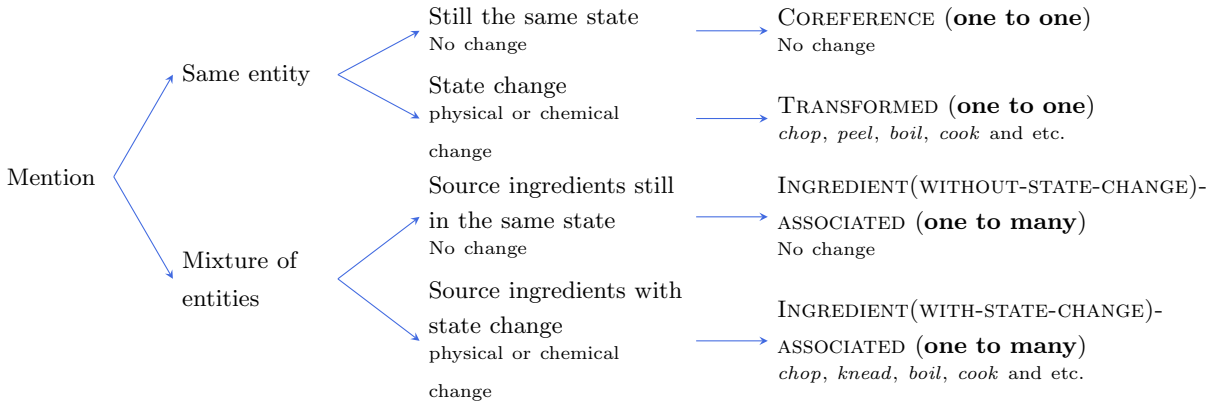


Figure 2: The classification of anaphora relations in recipes.

- Coreference (⌈**the biscuits**⌋$_1$, ⌈**the dough**⌋$_2$)

(16) In a medium bowl, mix flour, curry powder, chili powder, red pepper flakes and red pepper. Add beef; toss to coat. In a large nonstick skillet, heat oil over medium high heat. Add ⌈**coated beef**⌋$_1$ to skillet and brown all sides of ⌈**meat**⌋$_2$, turning constantly, for about 5 minutes.

- Coreference (⌈**coated beef**⌋$_1$, ⌈**meat**⌋$_2$)

3.2 Transformed

It is defined as a one-to-one anaphoric link for a set of ingredients that is meaning-wise the same but has undergone physical/chemical changes (e.g. *peel*, *chop*, *boil*, *cook* and etc.). For instance, in example (17), ⌈**the dough**⌋$_1$ and ⌈**the biscuits**⌋$_2$ have a Transformed relation as *the biscuits* has undergone a physical change, i.e. *flatten*. Similarly, in example (18), ⌈**remaining chocolate**⌋$_1$ and ⌈**chopped chocolate**⌋$_2$ refers to the same *chocolate*. However, ⌈**chopped chocolate**⌋$_2$ has gone through a physical change, i.e. *chop*. In this case, Transformed is applied.

(17) ...Use the palm of your hand to flatten ⌈**the dough**⌋$_1$ to 1/4 inch in thickness. Divide the sauce evenly among ⌈**the biscuits**⌋$_2$, top with a pinch of the oregano...

- Transformed (⌈**the dough**⌋$_1$, ⌈**the biscuits**⌋$_2$)

(18) Heat oven to 325°f. Reserve 2 oz. chocolate. Coarsely chop ⌈**remaining chocolate**⌋$_1$. Microwave ⌈**chopped chocolate**⌋$_2$ in small microwaveable bowl on high 2 min...

- Transformed (⌈**remaining chocolate**⌋$_1$, ⌈**chopped chocolate**⌋$_2$)

3.3 Ingredient(without-state-change)-associated

It is defined as a one-to-many relationship between processed food and its source ingredients, where the source ingredients have not undergone a state change (i.e. physical/chemical changes). For example, in (19), ⌈**the cheese**⌋$_3$ has INGREDIENT (WITHOUT-STATE-CHANGE)-ASSOCIATED links to its source ingredients, i.e. ⌈**the mozzarella**⌋$_1$ and ⌈**Parmesan cheese**⌋$_2$, as the mention ⌈**the cheese**⌋$_3$ refers to the previous ingredients without any state changes. A similar example is provided in (20), where ⌈**the gremolata**⌋$_3$ refers to ⌈**the lemon zest**⌋$_1$ and ⌈**the remaining chopped parsley**⌋$_2$ without any state changes.

(19) ...Divide the sauce evenly among the biscuits, top with a pinch of the oregano, then layer ⌈**the mozzarella**⌋$_1$, pepperoni (if using), and ⌈**Parmesan cheese**⌋$_2$. Make sure ⌈**the cheese**⌋$_3$ is covering...

- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**the mozzarella**⌋$_1$, ⌈**the cheese**⌋$_3$)
- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**Parmesan cheese**⌋$_2$, ⌈**the cheese**⌋$_3$)

(20) ...Prepare a gremolata by stirring together ⌈**the lemon zest**⌋$_1$ and ⌈**the remaining chopped parsley**⌋$_2$. Serve the osso buco garnished with sauce and ⌈**the gremolata**⌋$_3$.

- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**the lemon zest**⌋$_1$, ⌈**the gremolata**⌋$_3$)
- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**the remaining chopped parsley**⌋$_2$, ⌈**the gremolata**⌋$_3$)

3.4 Ingredient(with-state-change)-associated

It is defined as a one-to-many relationship between processed food and its source ingredients which have undergone state changes. As seen in example (21), ⌈**the biscuits**⌋$_6$ comes from the previous ingredients (i.e. ⌈**the sauce**⌋$_1$, ⌈**a pinch of the oregano**⌋$_2$, ⌈**pepperoni**⌋$_3$, ⌈**the cheese**⌋$_4$ and ⌈**the biscuits**⌋$_5$) which have undergone a chemical change, i.e. *bake*. Thus, they are linked with INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED relation. A similar example can be seen in (22), where ⌈**butter/chocolate mixture**⌋$_3$ is obtained by melting ⌈**chocolate**⌋$_1$ and ⌈**butter**⌋$_2$.

(21) ...Divide ⌈**the sauce**⌋$_1$ evenly among the biscuits, top with ⌈**a pinch of the oregano**⌋$_2$, then layer the mozzarella, ⌈**pepperoni**⌋$_3$ (if using), and Parmesan cheese. Make sure ⌈**the cheese**⌋$_4$ is covering and bake until ⌈**the biscuits**⌋$_5$ are golden, about 15 minutes. Allow ⌈**the biscuits**⌋$_6$ to cool slightly and serve warm.

- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**the sauce**⌋$_1$, ⌈**the biscuits**⌋$_6$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**a pinch of the oregano**⌋$_2$, ⌈**the biscuits**⌋$_6$)

- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**pepperoni**⌋$_3$, ⌈**the biscuits**⌋$_6$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**the cheese**⌋$_4$, ⌈**the biscuits**⌋$_6$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**the biscuits**⌋$_5$, ⌈**the biscuits**⌋$_6$)

(22) Melt ⌈**chocolate**⌋$_1$ and ⌈**butter**⌋$_2$ in a small pan over low heat. Beat eggs with a whisk until light and foamy. Gradually beat in sugar, flour, and vanilla to eggs. Add ⌈**butter/chocolate mixture**⌋$_3$. pour into a well buttered 9 inch pie pan.

- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**chocolate**⌋$_1$, ⌈**butter/chocolate mixture**⌋$_3$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**butter**⌋$_2$, ⌈**butter/chocolate mixture**⌋$_3$)

4 Remarks on Anaphora Relation

As discussed above, resolving anaphora phenomena in recipes is challenging as it needs to correctly identify the states of ingredients and the actions applied to them. In this section, we detail remarks of annotating different anaphora phenomena based on the anaphora types we define.

4.1 Largest Logical Span of Mentions

One thing worth mentioning is that there might be overlapping candidate mentions available for the same anaphora relation. For instance, in example (23), either *the diced onion* in line 1 or its nested mention *onion* can be annotated, and are meaning-wise the same for the TRANSFORMED relation with ⌈**the onion**⌋$_3$. To eliminate ambiguity, the largest logical span of mentions should be annotated when there are overlapping candidate mentions that could be linked in the same anaphora relation. Thus, in this TRANSFORMED relation with ⌈**the onion**⌋$_3$, only ⌈**the diced onion**⌋$_2$ will be annotated as it is the largest logical span. A similar example can be seen in (24). The nested mention *water* in ⌈**warm water**⌋$_3$ is not annotated for the INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED relation with ⌈**mixture**⌋$_4$ as ⌈**warm water**⌋$_3$ is the largest logical span.

(23) Fry ⌈**the diced onion**⌋$_1$ in the oil over medium heat until golden and translucent. Remove ⌈**the onion**⌋$_2$, set aside and fry the steak for 3-5 minutes each side...

- TRANSFORMED (⌈**the diced onion**⌋$_1$, ⌈**the onion**⌋$_2$)

(24) Dissolve ⌈**yeast**⌋$_1$ and ⌈**sugar**⌋$_2$ in ⌈**warm water**⌋$_3$. Let stand 5 to 6 minutes, until ⌈**mixture**⌋$_4$ is foamy...

- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**yeast**⌋$_1$, ⌈**mixture**⌋$_4$)
- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**sugar**⌋$_2$, ⌈**mixture**⌋$_4$)
- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**warm water**⌋$_3$, ⌈**mixture**⌋$_4$)

4.2 State Identification of Mentions

As anaphora relations are based on state changes, it is important to identify the state of mentions. In this annotation, we consider the original state of mentions/ingredients as the default when listed as an ingredient. As shown in example (25), ⌈**the butter**⌋$_1$ is not melted yet, i.e. it is in its original state of "not-melted". However, ⌈**butter**⌋$_2$ has undergone the melting process. Thus, a TRANSFORMED relation holds between them. Another example is in (26) with *the soup*, where ⌈**the soup**⌋$_1$ is not blenderized but ⌈**the soup**⌋$_2$ is.

(25) Melt ⌈**the butter**⌋$_1$ in a large saucepan over medium heat. Fry the onion in ⌈**butter**⌋$_2$ until soft, about 5 minutes...

- TRANSFORMED (⌈**the butter**⌋$_1$, ⌈**butter**⌋$_2$)

(26) Use an immersion hand blender to puree ⌈**the soup**⌋$_1$, or transfer to a blender or food processor in batches, and puree until smooth. Return to the pot. Season ⌈**the soup**⌋$_2$ with cayenne pepper, allspice, nutmeg, ginger, salt and pepper, then stir in the sherry, cream and milk

- TRANSFORMED (⌈**the soup**⌋$_1$, ⌈**the soup**⌋$_2$)

One construction worthy of particular mention is the preposition *until*, e.g. as seen in example (27) for *the onion*. ⌈**the onion**⌋$_2$ is cooked, which is different from the state of ⌈**onion**⌋$_1$, i.e. not cooked. The word *until* indicates that ⌈**the onion**⌋$_2$ has reached the end state of cooking process, i.e. softened and translucent, which is also cooked. In this case, ⌈**onion**⌋$_1$ and ⌈**the onion**⌋$_2$ are linked as TRANSFORMED. As comparison, in example (28), ⌈**the onion**⌋$_2$ is mentioned before the word *until*. In this case, ⌈**the onion**⌋$_2$ is in the original state, i.e. not cook, as it has not gone through any state changes. It is linked with ⌈**onion**⌋$_1$ as COREFERENCE. A similar example with the preposition *until* can also be seen in (29) for *pork*.

(27) Heat the butter and vegetable oil in a large frying pan over medium heat. Stir in the chicken, ⌈**onion**⌋$_1$ and garlic. Cook and stir until ⌈**the onion**⌋$_2$ has softened and turned translucent, about 10 minutes.

- TRANSFORMED (⌈**onion**⌋$_1$, ⌈**the onion**⌋$_2$)

(28) Heat the butter and vegetable oil in a large frying pan over medium heat. Stir in the chicken, ⌈**onion**⌋$_1$ and garlic. Cook and stir ⌈**the onion**⌋$_2$ until softened and turned translucent, about 10 minutes.

- COREFERENCE (⌈**onion**⌋$_1$, ⌈**the onion**⌋$_2$)

(29) Heat the cooking oil in a wok or a large, deep frying pan over medium-high heat. Add ⌈**the pork**⌋$_1$, onions, and crushed chilli flakes to the oil; Cook until ⌈**the pork**⌋$_2$ is browned completely. Stir in 3 tablespoons sweet chilli sauce, cabbage, celery, carrots and peppers;

- TRANSFORMED (⌈**the pork**⌋$_1$, ⌈**the pork**⌋$_2$)

Although we consider the original state for mentions to be the default, this can be overridden by an explicit mention of an alternative state. As provided in example (30), ⌈**almonds**⌋$_1$ is unbaked and ⌈**the toasted almonds**⌋$_2$ indicates clearly that the state is "toasted". Thus, these two are linked as TRANSFORMED.

(30) Preheat oven to 190 C / Gas mark 5. Arrange ⌈**almonds**⌋$_1$ in a single layer on a baking tray. Bake 5 minutes, stirring occasionally, until fragrant and lightly toasted. In a medium bowl, toss the red wine vinegar mixture with the spinach and mangos. Top with ⌈**the toasted almonds**⌋$_2$ to serve.

- TRANSFORMED (⌈**almonds**⌋$_1$, ⌈**the toasted almonds**⌋$_2$)

Also, when there is an ambiguity in deciding if the state of ingredient/s has changed, we consider there is no state change happening to the ingredient/s by default. For instance, in example (31), ⌈**all the ingredients**⌋$_1$ is mixed together. However, it is vague to decide if the *mix* process changes the state of ingredients in ⌈**all the ingredients**⌋$_1$ without further information. In this case, we consider there is no state change when applying the *mix* process. ⌈**all the ingredients**⌋$_1$ and ⌈**the mixture**⌋$_2$ are therefore linked as COREFERENCE. A similar example can be seen in (32). Simple combination of ⌈**the first six ingredients**⌋$_1$ does not provide enough information about whether the state of ingredients in ⌈**the first six ingredients**⌋$_1$ has changed. ⌈**the first six ingredients**⌋$_1$ and ⌈**hot cake**⌋$_2$ are linked as TRANSFORMED is due to the *beat* and *bake* processes, which explicitly indicate changing the state of ⌈**the first six ingredients**⌋$_1$.

(31) Preheat the oven to 200 degrees centigrade. Mix ⌈**all the ingredients**⌋$_1$ together in a large bowl until well combined. Lightly grease an oven dish and shape ⌈**the mixture**⌋$_2$ into meatballs. Either medium size or half that size for bite size for a toddler.

- COREFERENCE (⌈**all the ingredients**⌋$_1$, ⌈**the mixture**⌋$_2$)

(32) Combine ⌈**the first six ingredients**⌋$_1$ together and beat with mixer for 2 minutes. Spread in jelly roll pan and bake at 350 for 15 20 minutes. Spread peanut butter on ⌈**hot cake**⌋$_2$ and refrigerate for 2 hours...

- TRANSFORMED (⌈**the first six ingredients**⌋$_1$, ⌈**hot cake**⌋$_2$)

4.3 The Closest Antecedent for Anaphora Relation

In these annotation guidelines, an important point to note is that anaphoric expressions refer to the closest previous corresponding antecedent/s. As shown in example (33), the expression ⌈**the noodles**⌋$_2$ is, in this context, the antecedent of ⌈**the noodles**⌋$_3$ under the TRANSFORMED relation. However, ⌈**the Chinese noodles**⌋$_1$ is not considered to be the antecedent of ⌈**the noodles**⌋$_3$ since ⌈**the noodles**⌋$_2$ is the closet corresponding antecedent.

(33) Fill a large pot with lightly salted water and bring to a rolling boil over high heat. Once the water is boiling, stir in ⌈**the Chinese noodles**⌋$_1$, and return to the boil. Cook ⌈**the noodles**⌋$_2$ uncovered, stirring occasionally, until cooked through, but still firm to the bite, about 5 minutes. Drain well. Whisk together the 3 tablespoons soy sauce, 180ml sweet chilli sauce, 1/2 teaspoon garlic granules, the ground ginger and the sesame oil in a large bowl; add ⌈**the noodles**⌋$_3$ and toss to coat; set aside.

- COREFERENCE (⌈**the Chinese noodles**⌋$_1$, ⌈**the noodles**⌋$_2$)
- TRANSFORMED (⌈**the noodles**⌋$_2$, ⌈**the noodles**⌋$_3$)

4.4 Remarks on Coreference and Transformed Relation

As categorised in Fig 2, regardless of the state change, COREFERENCE and TRANSFORMED relations are one-to-one. We consider these two relations simultaneously when annotating the antecedent/s for the anaphors. As shown in example (34), ⌈**dough**⌋$_1$, ⌈**loaves**⌋$_2$ and ⌈**dough**⌋$_3$ refer to the same *dough* in different states. The TRANSFORMED relation between ⌈**dough**⌋$_1$ and ⌈**loaves**⌋$_2$ and COREFERENCE relation between ⌈**loaves**⌋$_2$ and ⌈**dough**⌋$_3$ are sufficient to capture the implied information that these three expressions refer to the same entity. In line with the remark in Section 4.3, where anaphor links to its closest antecedent/s, it therefore is no need for explicit annotation of the TRANSFORMED relation between ⌈**dough**⌋$_1$ and ⌈**dough**⌋$_3$.

(34) ...Punch ⌈**dough**⌋$_1$ down. Knead for a few minutes, and divide in half. Shape into ⌈**loaves**⌋$_2$, and place into two well oiled 23x13cm (9x5 in) loaf tins. Allow ⌈**dough**⌋$_3$ to rise for 30 minutes, or until risen 2.5cm (1 in) above tins. Bake in a preheated 180 C / Gas 4 oven for 30 minutes...

- TRANSFORMED (⌈**dough**⌋$_1$, ⌈**loaves**⌋$_2$)
- COREFERENCE (⌈**loaves**⌋$_2$, ⌈**dough**⌋$_3$)

4.5 Identifying the Semantic Meaning of Ingredient Terms

As we state in Section 2, generic phrases are used to represent the ingredients. It is easy to tell if the generic phrases are referring to the exact ingredient (e.g. *it*) or a combination of ingredients (e.g. *the mixture*). However, for an ingredient term, sometimes it can represent a mixture, as seen in examples (38) - (40).

To clarify this ambiguity, we put a further explanation for identifying the semantic meaning of ingredient terms: during the cooking process, if the ingredient term is used for describing the changed state, then it represents the "exact" ingredient. And in other cases, the ingredient term refers to the mixture.

As shown in example (35), when it talks about the ⌈**chicken**⌋$_2$, it focus on the state of "exact" *chicken*, although some state changes will also happen for the other ingredients (i.e. *onion, 1/2 salsa, hot peppers, cream cheese* and *cumin*). In this case, ⌈**chicken**⌋$_2$ is linked with TRANSFORMED relation to⌈**chicken**⌋$_1$. Similar examples can be seen in (36) and (37).

(35) Preheat oven 350 degreees. Melt butter or heat oil in large frying pan. Saute ⌈**chicken**⌋$_1$, onion, 1/2 salsa, hot peppers, cream cheese, and cumin. When ⌈**chicken**⌋$_2$ is cooked add 1/2 shredded cheese. Spray pan with pam and line with foil. Spoon mixture into tortillas, roll up and fold ends inches. Place in pan seam side down. Top with remaining salsa and cheese. Bake 15 min uncovered.

- TRANSFORMED (⌈**chicken**⌋$_1$, ⌈**chicken**⌋$_2$)

(36) Rub an non stick saucepan with cut garlic halves. Combine ⌈**cheeses**⌋$_1$ and flour until ⌈**cheese**⌋$_2$ is melted and well blended. Add white wine stirring constantly to keep from sticking, until just beginning to boil and looks creamy.

- TRANSFORMED (⌈**cheese**⌋$_1$, ⌈**cheese**⌋$_2$)

(37) Discard all but 1 tablespoon grease. Add ⌈**the onions**⌋$_1$ and leeks and season with salt and pepper; cook, covered, over medium low heat, stirring occasionally, until ⌈**onions**⌋$_2$ are tender.

- TRANSFORMED (⌈**the onions**⌋$_1$, ⌈**onions**⌋$_2$)

However, in example (38), when *press* ⌈**the potatoes**⌋$_3$, it is the process that applies to the mixture of ⌈**the grated potatoes**⌋$_1$ and ⌈**salt**⌋$_2$. Thus, the ingredient term ⌈**the potatoes**⌋$_3$ semantically represent a mixture instead of just ⌈**the grated potatoes**⌋$_1$. ⌈**the potatoes**⌋$_3$ therefore links to the previous resources (⌈**the grated potatoes**⌋$_1$ and ⌈**salt**⌋$_2$) with INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED relation. Similar examples can be seen in (39) and (40).

(38) Place the potatoes in a large pot. Cover the potatoes with water. Bring the water to a boil over medium high heat. Cook the potatoes until tender enough to pierce with a fork, about 15 minutes; drain and refrigerate potatoes overnight. Peel and grate the potatoes into a large bowl. Melt the butter in a skillet over medium heat; Add ⌈**the grated potatoes**⌋$_1$; Season with ⌈**salt**⌋$_2$. Press ⌈**the potatoes**⌋$_3$ into a round loaf using a spatula.

- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**the grated potatoes**⌋$_1$, ⌈**potatoes**⌋$_3$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**salt**⌋$_2$, ⌈**potatoes**⌋$_3$)

(39) Mix shrimp with ginger, egg, salt, sherry and cornstarch. Shape into small flat cakes. deep fry cakes. Drain and place in wok. Add stock, bring to a boil, and simmer for 5 minutes. Remove ⌈**cakes**⌋$_1$ from stock and place on ⌈**a bed of spinach**⌋$_2$. Add cornstarch mixture to boiling stock. Allow mixture to thicken and pour over ⌈**shrimp cakes**⌋$_3$.

- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**cakes**⌋$_1$, ⌈**shrimp cakes**⌋$_3$)
- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**a bed of spinach**⌋$_2$, ⌈**shrimp cakes**⌋$_3$)

(40) Combine vinegar, thyme, rosemary and 2 tablespoons oil in a jug. Place beef in a glass or ceramic baking dish. Using a small sharp knife, cut twelve 2cm long x 3cm deep slits over beef. Insert ⌈**garlic slices**⌋$_1$ in ⌈**slits**⌋$_2$. pour over ⌈**vinegar mixture**⌋$_3$. Turn to coat. Cover with plastic wrap. Refrigerate for 3 to 4 hours, if time permits. Preheat barbecue on high with hood closed. Lightly grease a disposable foil baking tray. Place ⌈**potatoes**⌋$_4$ in a large bowl. Add ⌈**remaining oil**⌋$_5$. Season with ⌈**salt**⌋$_6$ and ⌈**pepper**⌋$_7$. Toss to coat. Place ⌈**beef**⌋$_8$ and ⌈**potatoes**⌋$_9$ in prepared tray...

- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**garlic slices**⌋$_1$, ⌈**beef**⌋$_8$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**slits**⌋$_2$, ⌈**beef**⌋$_8$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**vinegar mixture**⌋$_3$, ⌈**beef**⌋$_8$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**potatoes**⌋$_4$, ⌈**potatoes**⌋$_9$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**remaining oil**⌋$_5$, ⌈**potatoes**⌋$_9$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**salt**⌋$_6$, ⌈**potatoes**⌋$_9$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**pepper**⌋$_7$, ⌈**potatoes**⌋$_9$)

4.6 Ingredient and By-product

In recipe annotations, we also consider the anaphora relation between ingredient and its by-product, linking from the expression that appears later to the expression that appears earlier, regardless of which expression is the ingredient or its by-product.

As show in example (41), ⌈**sinew**⌋$_1$ and ⌈**membrane**⌋$_2$ are part of ⌈**the chicken breast**⌋$_3$, they are linked as INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED. A similar example can be seen in (42), where ⌈**chicken**⌋$_1$ and ⌈**skin**⌋$_2$ are linked as INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED as ⌈**skin**⌋$_2$ is part of ⌈**chicken**⌋$_1$ and ⌈**chicken**⌋$_1$ is broiled/grilled.

(41) Remove ⌈**sinew**⌋$_1$ and ⌈**membrane**⌋$_2$ from ⌈**the chicken breast**⌋$_3$, chop or mince very finely to almost a paste...

- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**sinew**⌋$_1$, ⌈**the chicken breast**⌋$_3$)
- INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**membrane**⌋$_2$, ⌈**the chicken breast**⌋$_3$)

(42) Preheat broiler or barbeque. Broil or grill ⌈**chicken**⌋$_1$, for 4 minutes. Turn and broil/grill 4 minutes longer until ⌈**skin**⌋$_2$ is crispy...

- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**chicken**⌋$_1$, ⌈**skin**⌋$_2$)

However, when the ingredient and by-product appear repeatedly, it will cause redundancy in the annotation. As shown in examples (43), if the ingredient *chicken* and its by-product *skin* appear repeatedly, there will be redundant INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED links between them, demonstrating with strikethrough.

To handle this issue, we put a restriction as the by-product/ part of the product and its sourced product/s are only linked once when they first appear. In this case, in examples (43) and (44), the anaphora relations with strikethrough will not be annotated and it eliminates the redundancy in annotation.

(43) Cook ⌈**the chicken**⌋$_1$ through till ⌈**the skin**⌋$_2$ is crispy and ⌈**chicken**⌋$_3$ is cook through, discard ⌈**the skin**⌋$_4$...

- TRANSFORMED (⌈**the chicken**⌋$_1$, ⌈**chicken**⌋$_3$)
- COREFERENCE (⌈**the skin**⌋$_2$, ⌈**the skin**⌋$_4$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**the chicken**⌋$_1$, ⌈**the skin**⌋$_2$)
- ~~INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**the skin**⌋$_2$, ⌈**chicken**⌋$_3$)~~
- ~~INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**chicken**⌋$_3$, ⌈**the skin**⌋$_4$)~~

(44) Mix the flour and ⌈**butter**⌋$_1$, beat ⌈**the mixture**⌋$_2$ until ⌈**the butter**⌋$_3$ is soft and ⌈**the mixture**⌋$_4$ forms a dough...

- TRANSFORMED (⌈**butter**⌋$_1$, ⌈**the butter**⌋$_3$)
- COREFERENCE (⌈**the mixture**⌋$_2$, ⌈**the mixture**⌋$_4$)
- INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**butter**⌋$_1$, ⌈**the mixture**⌋$_2$)
- ~~INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED (⌈**the mixture**⌋$_2$, ⌈**the butter**⌋$_3$)~~
- ~~INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED (⌈**the butter**⌋$_3$, ⌈**the mixture**⌋$_4$)~~

4.7 Quantify Information Related

For the expression that comes with quantity information, we include the quantity description in the mention annotation while we don't consider the quantity information in the relation annotation.

As shown in example (45), we include quantity information for ingredient terms ⌈**a little of the chicken mixture**⌋$_1$, ⌈**all the chicken**⌋$_2$ and ⌈**lots of chicken bits/balls pea size**⌋$_3$ for mention annotation. However, they are coreferent as they are the same *chicken* using in the cooking process. In other words, not considering the quantity information when linking those ingredient terms.

(45) Remove sinew and membrane from the chicken breast, chop or mince very finely to almost a paste. Mix with $\frac{1}{2}$ a tablespoon of the cornflour, milk, add the egg white and blend well. Skin the tomatoes, cut them in small cubes about the size of the peas. Bring the stock to the boil; add the peas and the tomatoes, when it boils again remove from the stove. With one chopstick pick up ⌈**a little of the chicken mixture**⌋$_1$ and drop that in the stock, go on until ⌈**all the chicken**⌋$_2$ is used up and you have ⌈**lots of chicken bits/balls pea size**⌋$_3$...

- COREFERENCE (⌈**a little of the chicken mixture**⌋$_1$, ⌈**all the chicken**⌋$_2$)
- COREFERENCE (⌈**all the chicken**⌋$_2$, ⌈**lots of chicken bits/balls pea size**⌋$_3$)

However, one thing worth pointing out is that, although this annotation guideline links the ingredients regardless their quantity information, the annotation still relies on the semantic meaning of the expression, especially for the expression that includes "remaining". As shown in example (46), ⌈**one quarter of the egg white**⌋$_2$ and ⌈**the remaining egg white**⌋$_3$ are both coreferent to ⌈**the egg whites**⌋$_1$, as they come from ⌈**the egg whites**⌋$_1$. But there is no coreferent link between them. The explanation of its hierarchy structure can be seen in Fig 3. ⌈**one quarter of the egg white**⌋$_2$ and ⌈**the remaining egg white**⌋$_3$ are not exactly the same *egg white* used in the cooking process, i.e. different portions of ⌈**the egg whites**⌋$_1$. More examples are provided in (47) and (48), where there is no COREFERENCE link between ⌈**half the milk**⌋$_1$ and ⌈**the remaining milk**⌋$_2$ and between ⌈**each slice of bread**⌋$_2$ and ⌈**remaining bread**⌋$_3$.

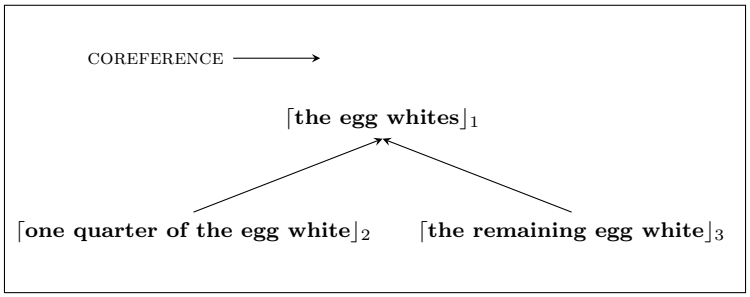


Figure 3: Hierarchy structure of *egg whites* in example (46). ⌈**one quarter of the egg white**⌋$_2$ and ⌈**the remaining egg white**⌋$_3$ are coreferent with ⌈**the egg whites**⌋$_1$. However, ⌈**one quarter of the egg white**⌋$_2$ and ⌈**the remaining egg white**⌋$_3$ are not coreferent as they refer to the individual *egg whites* used in the recipe.

(46) Use an electric beater to beat ⌈**the egg whites**⌋$_1$ in a clean, dry bowl until firm peaks form. Add ⌈**one quarter of the egg white**⌋$_2$ to the cheddar mixture and use a large metal spoon to fold until just combined. Add ⌈**the remaining egg white**⌋$_3$ and fold until just combined.

- TRANSFORMED (⌈**the egg whites**⌋$_1$, ⌈**one quarter of the egg white**⌋$_2$)
- TRANSFORMED (⌈**the egg whites**⌋$_1$, ⌈**the remaining egg white**⌋$_3$)

(47) Preheat oven to 200°c. Brush a 5l capacity ovenproof souffle dish with melted butter to lightly grease. Lightly dust with breadcrumbs. Place a baking tray in the oven. Melt the butter in a medium saucepan over medium heat until foaming. Add the flour and cook, stirring, for 2 minutes or until mixture bubbles and begins to come away from the side of

the pan. Remove from heat. Gradually pour in **half the milk**, whisking constantly with a balloon whisk until mixture is smooth. Gradually add **the remaining milk**, whisking until smooth and combined.

(48) ...Top the burger with cheese in the last 2 minutes of burger cooking time. Remove burgers and ⌈**bread**⌋$_1$; spread ⌈**each slice of bread**⌋$_2$ with russian dressing and top with 1/4 cup of sauerkraut. Cover with ⌈**remaining bread**⌋$_3$.

- Coreference (⌈**bread**⌋$_1$, ⌈**each slice of bread**⌋$_2$)
- Coreference (⌈**bread**⌋$_1$, ⌈**remaining bread**⌋$_3$)

4.8 Equipment Related

In this annotation guideline, we are not annotating the equipment for the recipe corpus as we aim for capturing anaphora relationship among ingredients. However, if the equipment semantically represents the ingredient, we treat and annotate the equipment as an ingredient. As shown in example (49), ⌈**skewers**⌋$_2$ here semantically represents the ingredient *chicken*. In this case, ⌈**skewers**⌋$_2$ is annotated for the anaphora relations with ⌈**chicken pieces**⌋$_1$ and ⌈**chicken**⌋$_3$.

(49) To make chicken, in a large bowl, whisk together first seven ingredient. Add chicken breasts and toss to coat. Cover bowl and marinate for 1 hour and up to preheat outdoor grill, stovetop grill, or non stick skillet. Skewer ⌈**chicken pieces**⌋$_1$ onto 4 metal or wooden skewers. Grill or cook ⌈**skewers**⌋$_2$ in a hot skillet for 5 to 7 minutes, until ⌈**chicken**⌋$_3$ is cooked through, turning frequently.

- Coreference (⌈**chicken pieces**⌋$_1$, ⌈**skewers**⌋$_2$)
- Transformed (⌈**skewers**⌋$_2$, ⌈**chicken**⌋$_3$)

5 Annotation Instruction

You will be provided with recipes without any annotations, as shown in Figure 4. Your annotation task involves labelling each expression which is part of a referring relationship and linking them with a relation of the appropriate type, depending on the relevant referring relationship.

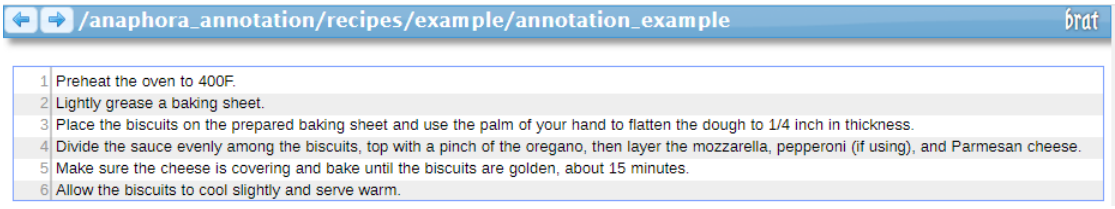


Figure 4: Example of recipe

To annotate the anaphora phenomena, i.e. COREFERENCE, TRANSFORMED, INGREDIENT(WITHOUT-STATE-CHANGE)-ASSOCIATED and INGREDIENT(WITH-STATE-CHANGE)-ASSOCIATED as defined in Section 3, you should follow the following steps. Firstly, you need to consider the types of referring relationships in the corpus and label the mentions that are involved in these referring relationships. Furthermore, the labelled mentions are to be linked based on the referring relationships by which they are related.

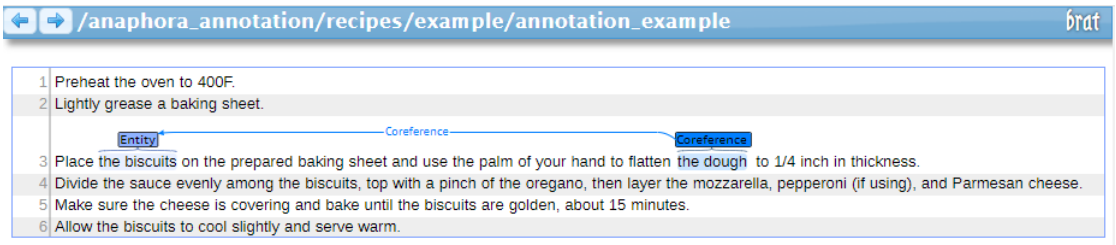
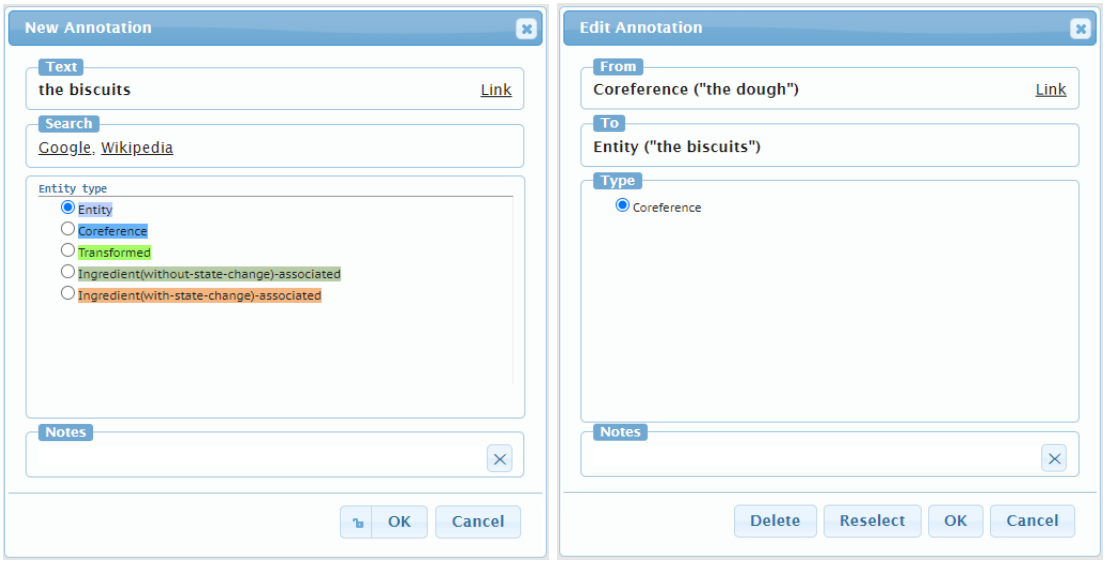


Figure 5: Annotated example of COREFERENCE referring relationship in recipe



(a) Mention labels (b) Annotating "Coreference" referring link

Figure 6: Annotation for mentions and referring links

Take the COREFERENCE referring relationship as an example. Figure 5 demonstrates how to annotate it in the recipe illustrated in Figure 4. First, you need to identify whether there is a COREFERENCE relationship in the sentence. Second, the expressions *the biscuits* and *the dough* should be labeled for COREFERENCE. The label of mentions, as shown in Figure 6(a), are annotated based on the referring relationships they are involved in. Specifically, the mentions serving as *antecedent* are labeled as "Entity". E.g. *the biscuits* in line 3 is the *antecedent* which is labeled as "Entity" in this COREFERENCE referring relationship. The mentions playing the

role of *anaphor* are annotated based on the referring relationships that they are involved in. E.g. *the dough* is the *anaphor* for the COREFERENCE referring relationship and it is, therefore, labeled as "Coreference". Lastly, based on the labels, you will link these mentions, from *anaphor* to *antecedent*. To simplify the annotation task, the referring relationships only can be linked between the corresponding mention label (*anaphor*) and "Entity" (*antecedent*). For instance, as shown in Figure 6(b), the COREFERENCE referring relationship only can be linked between "Coreference" and "Entity" labels and cannot be annotated between other type of labels and "Entity".

Figure 1 shows the annotation of anaphora phenomena in the snippet illustrated in Figure 4.

Acknowledgements

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