Conditional Probability

DSC 40A

You are an avocado researcher and are studying the color and hardness properties of some avocados to check their quality. You look at 100 avocados and find that 75 are green and 40 are soft. 10 are neither green nor soft.

If we choose a random avocado from the set of 100, what is the probability that the avocado is soft given that it is green?

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We can't solve this problem directly because we need to find more information about the conditional probabilities. For example, we could solve P(Green) easily because there are 75 green avocados out of 100 total which makes it

$$P(\text{Green}) = \frac{75}{100}$$

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We need to use a different method to solve the conditional probability problem like using a Venn diagram.

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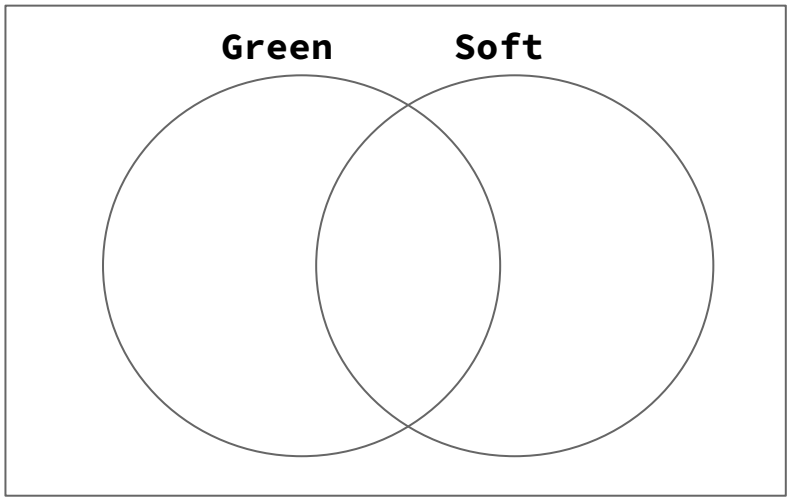
First we can fill in a Venn diagram of the number of avocados that are green, soft, both, and neither.

Let events G be for green avocados and S be for soft avocados.



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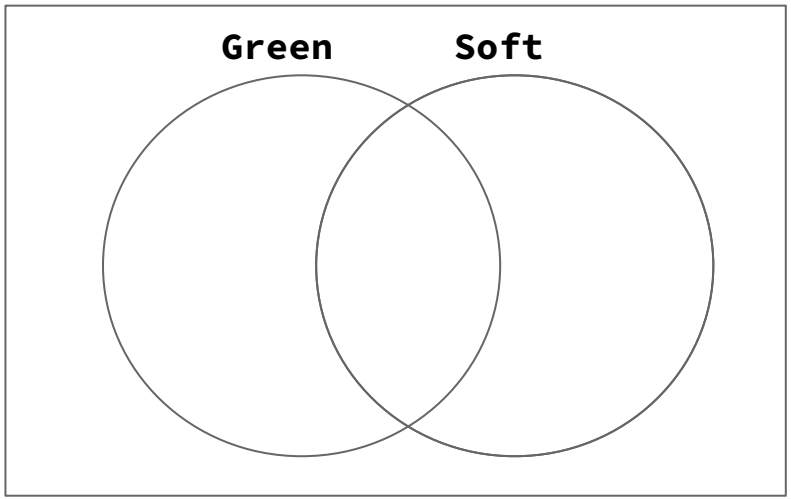

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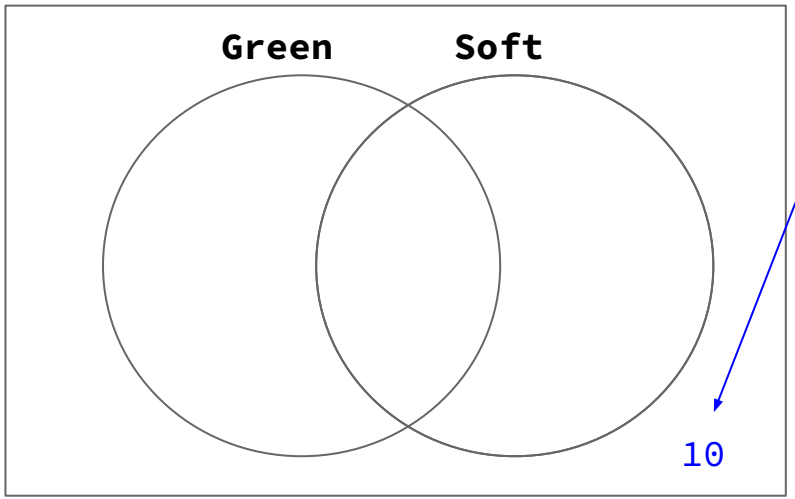

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$$|G^C \cap S^C| = 10$$

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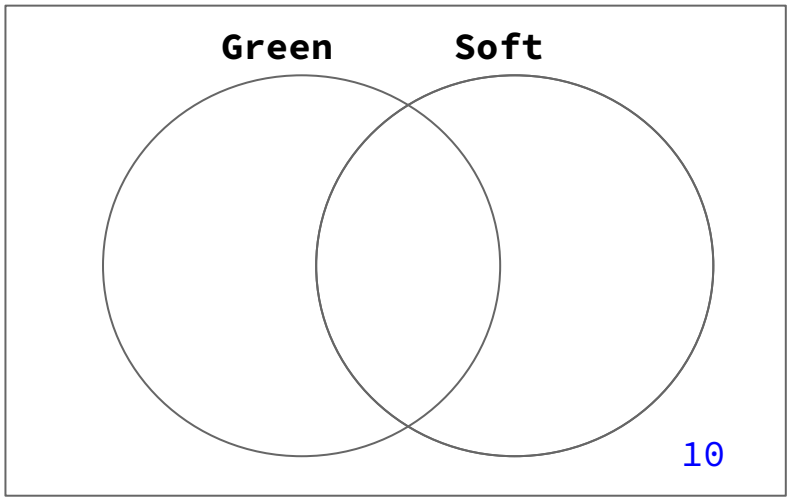

10 avocados are neither green nor soft.

Since there are 100 avocados total, we need to sort out the other 90 which are either green or soft. First we need to find the number that are green and soft.

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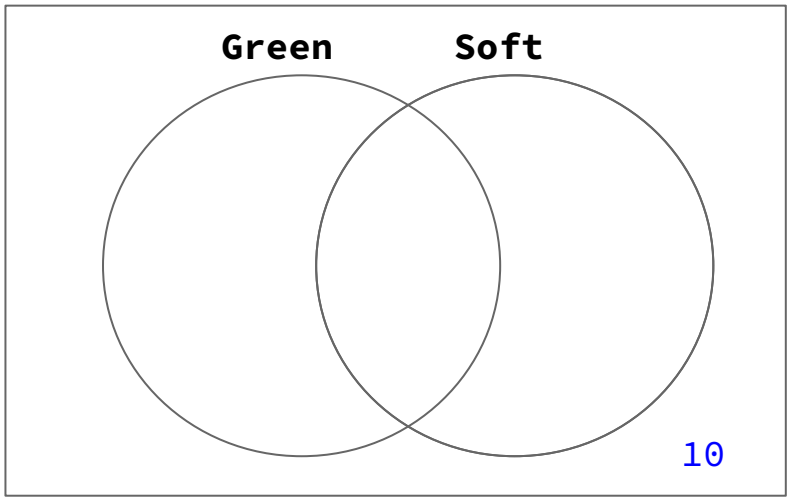

We need to find how many are green and soft. We can use the addition rule:

$$|G \cup S| = |G| + |S| - |G \cap S|$$

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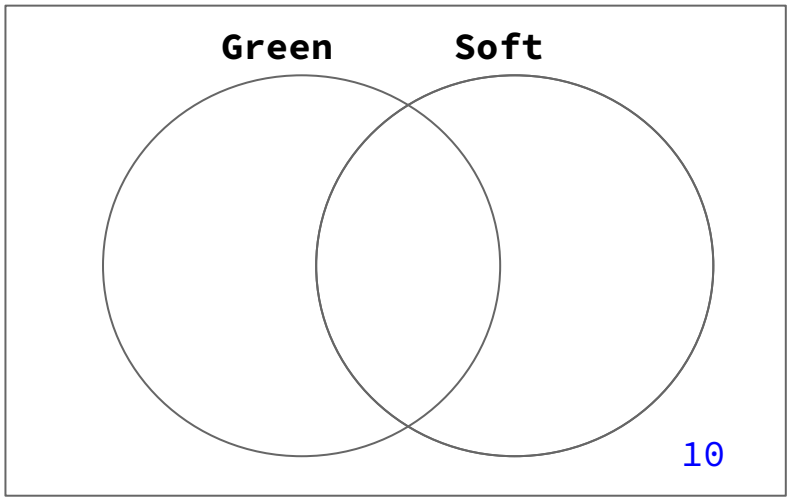

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$$|G \cup S| = |G| + |S| - |G \cap S|$$
$$90 = 75 + 40 - |G \cap S|$$
$$|G \cap S| = 25$$

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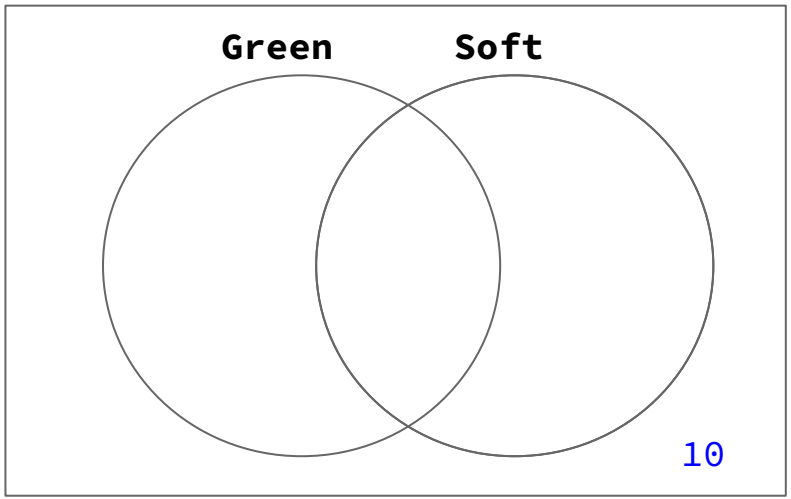

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25 avocados are both green and soft.

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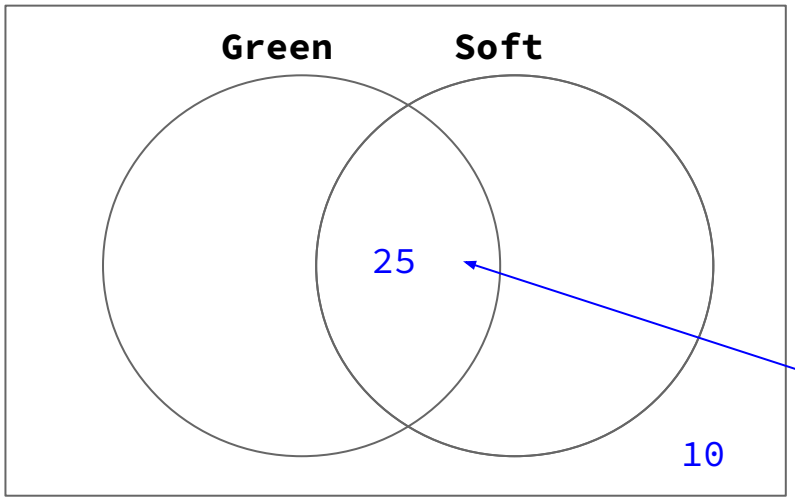

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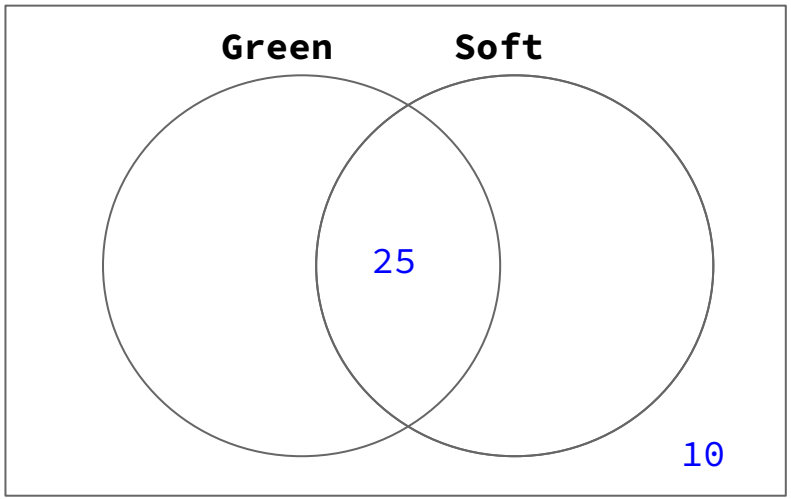

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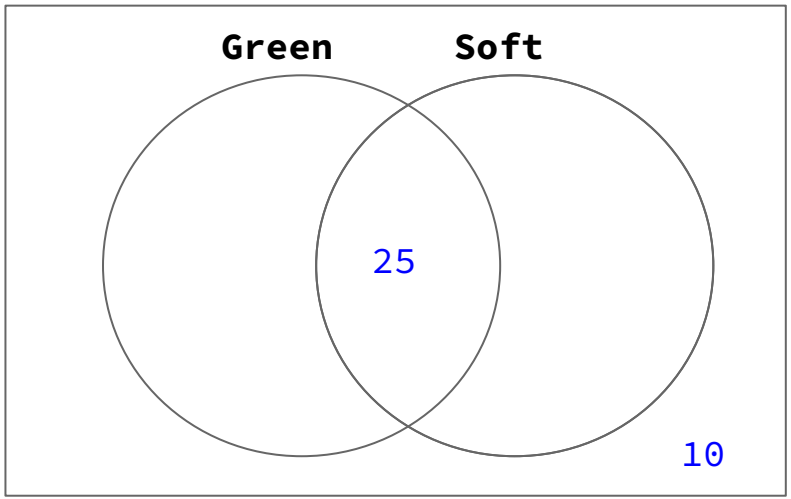

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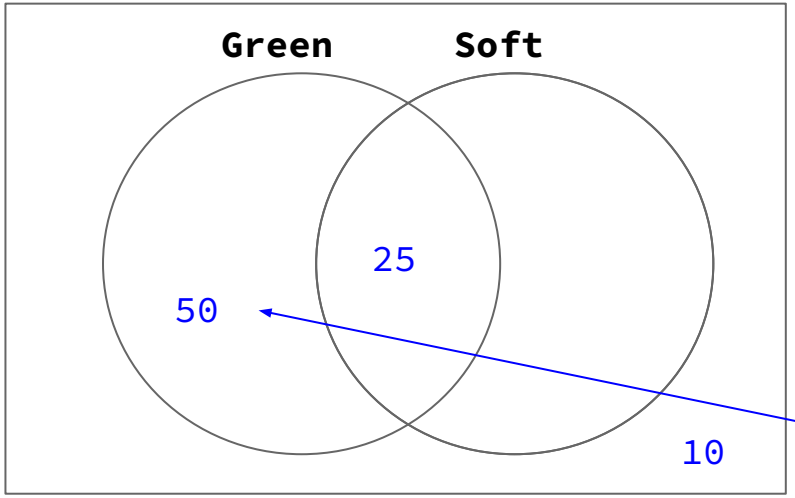

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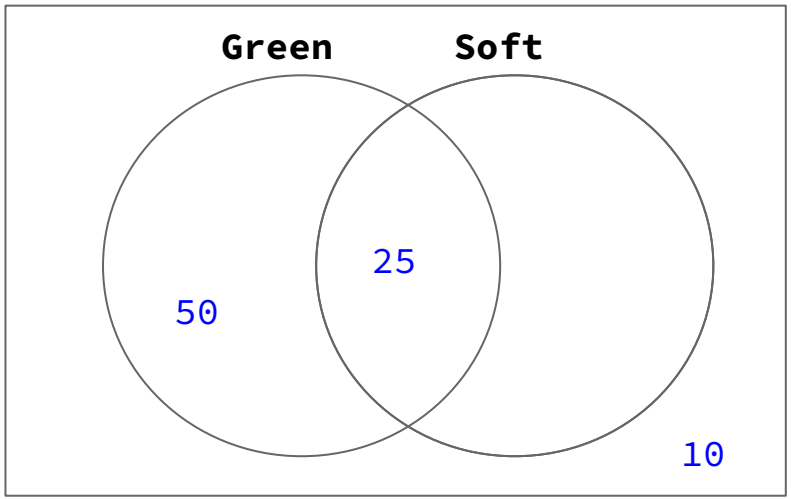

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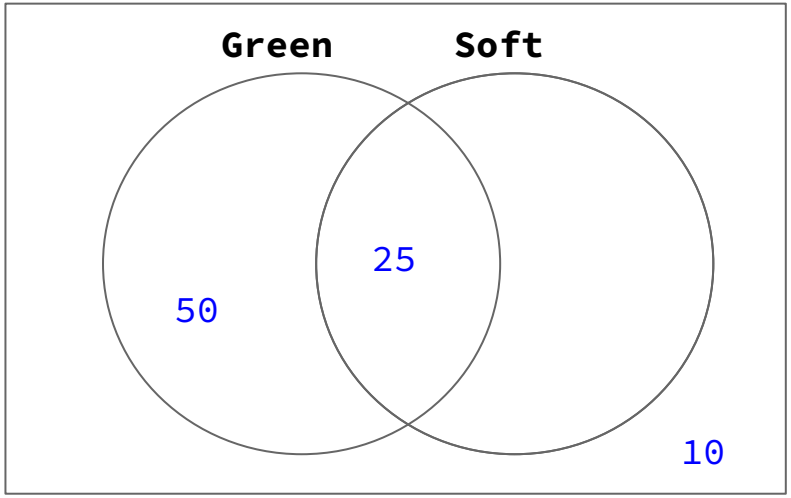

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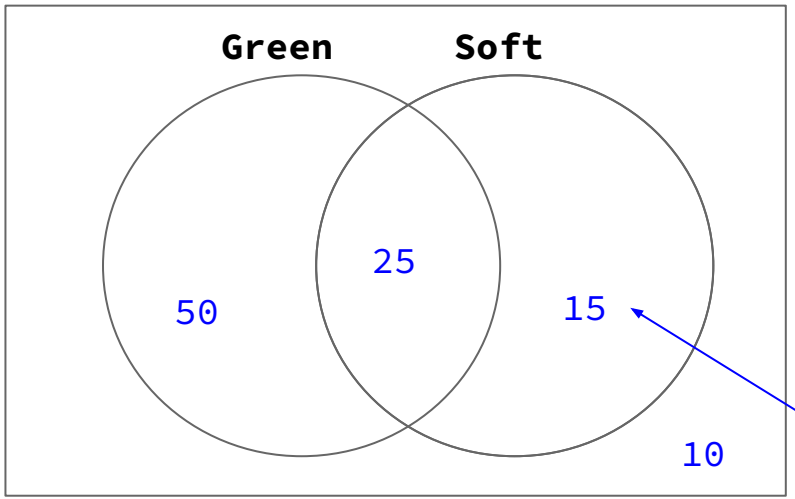

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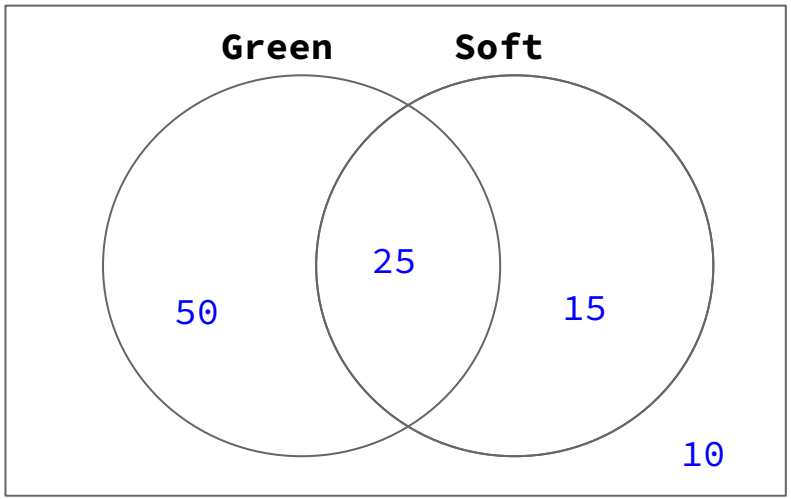

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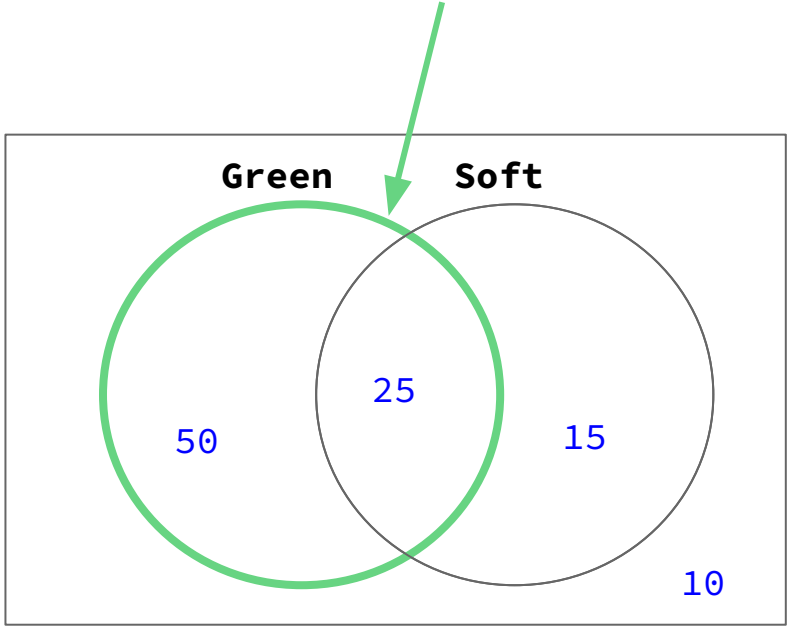

In this section we can see that 25 avocados are soft. In total there are 75 avocados.

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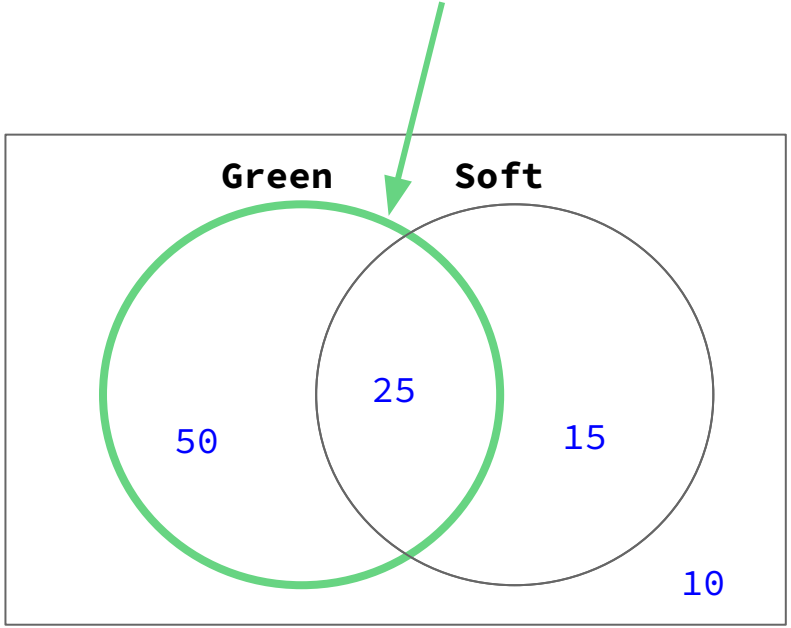

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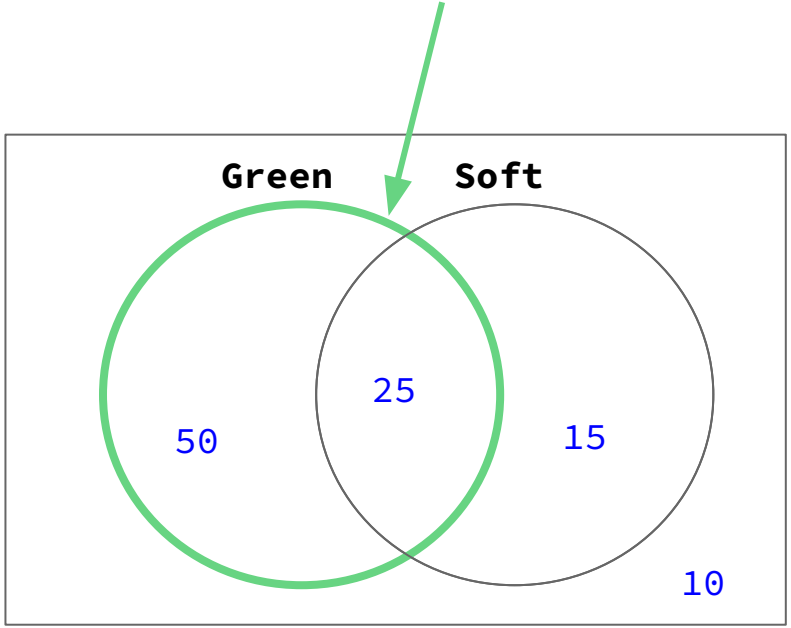

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We have found the probability that the avocado is soft given it is green.

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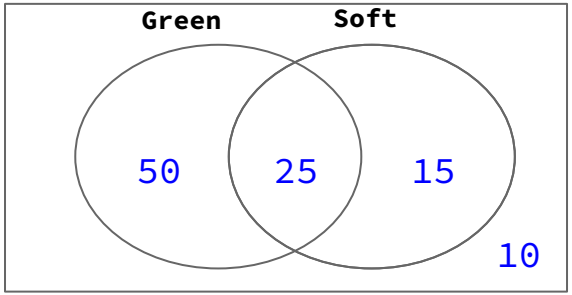
We can also use a tree in this situation.



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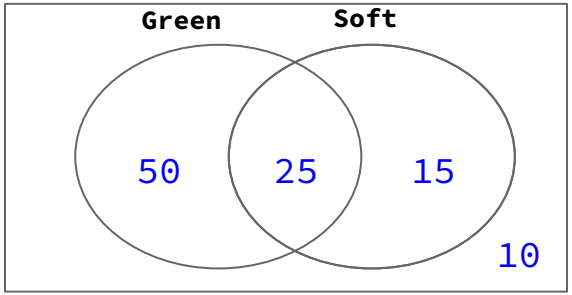
75 avocados are green so 25 are not. The probabilities of green and not green are:



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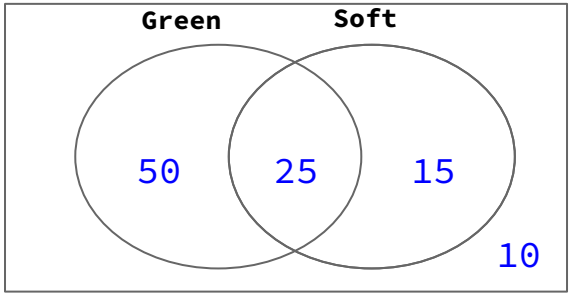

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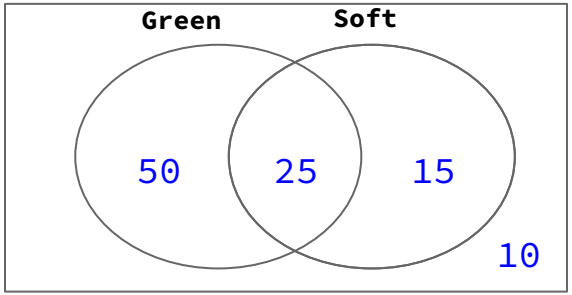

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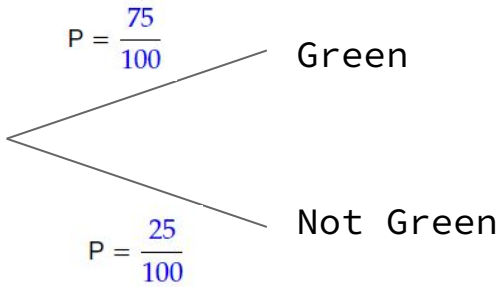
We draw the tree like this:



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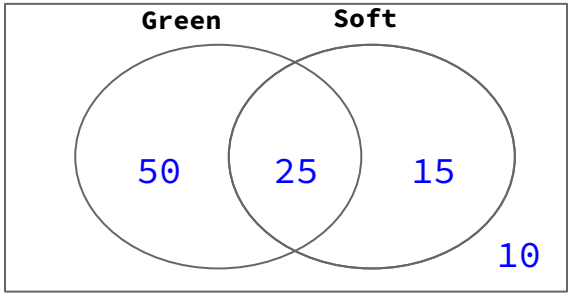
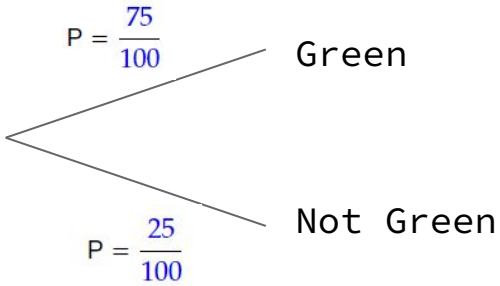
Of the 75 green avocados we see that 25 are soft and 50 are not in the Venn diagram.





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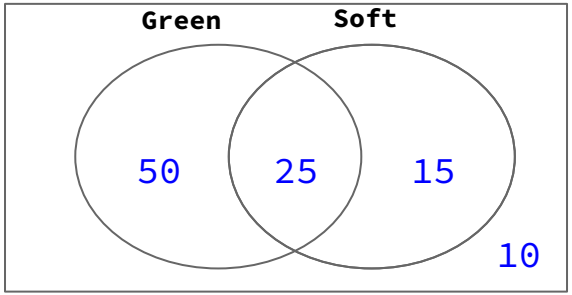
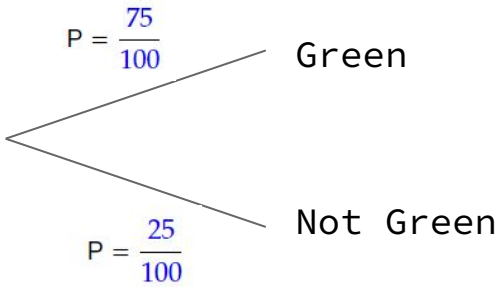


Of the 75 green avocados we see that 25 are soft and 50 are not in the Venn diagram.

$$P(S|G) = \frac{25}{75} \quad P(S^C|G) = \frac{50}{75}$$



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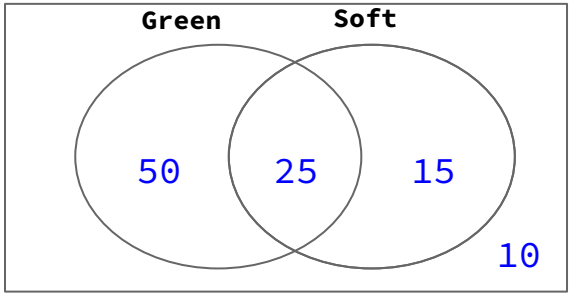

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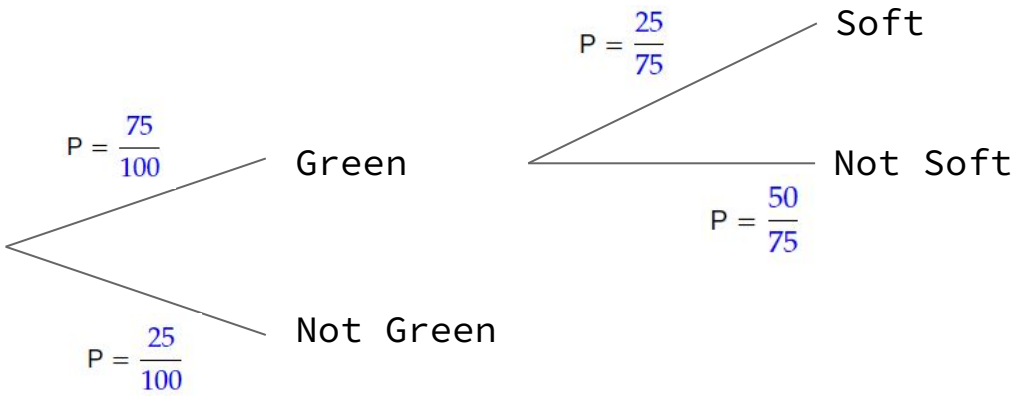

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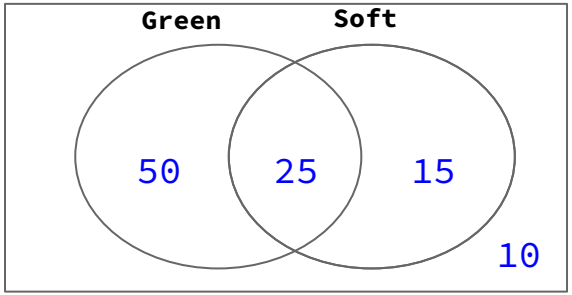

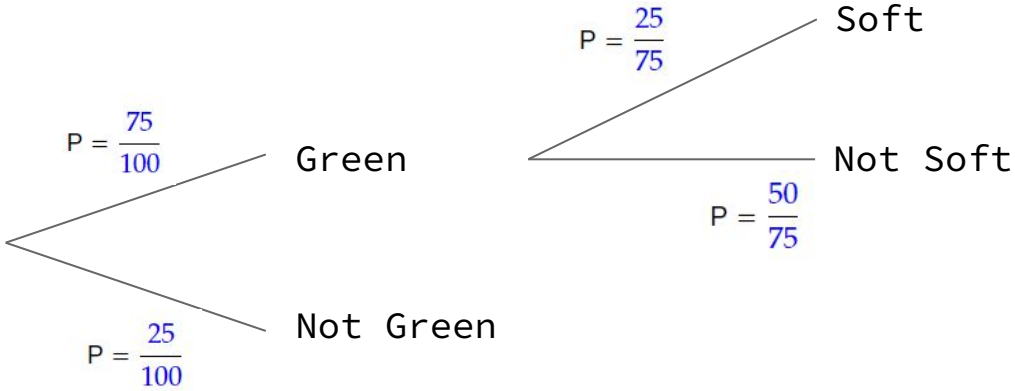

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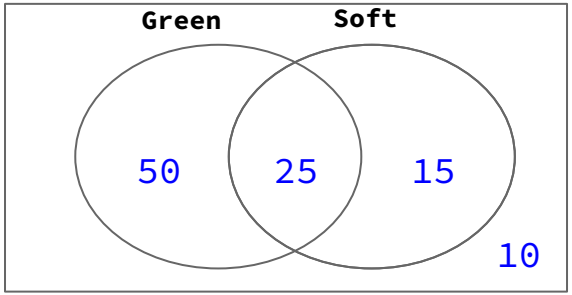

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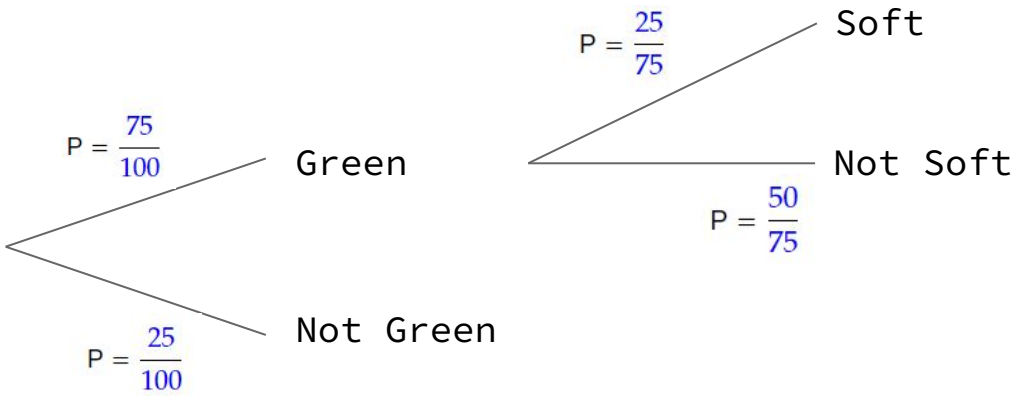

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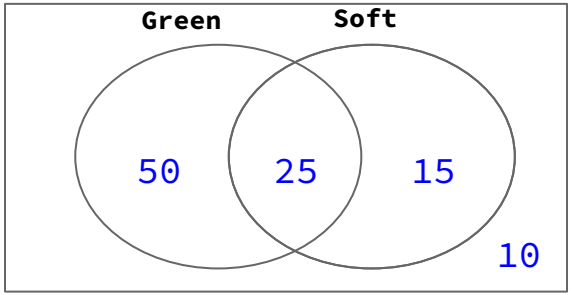

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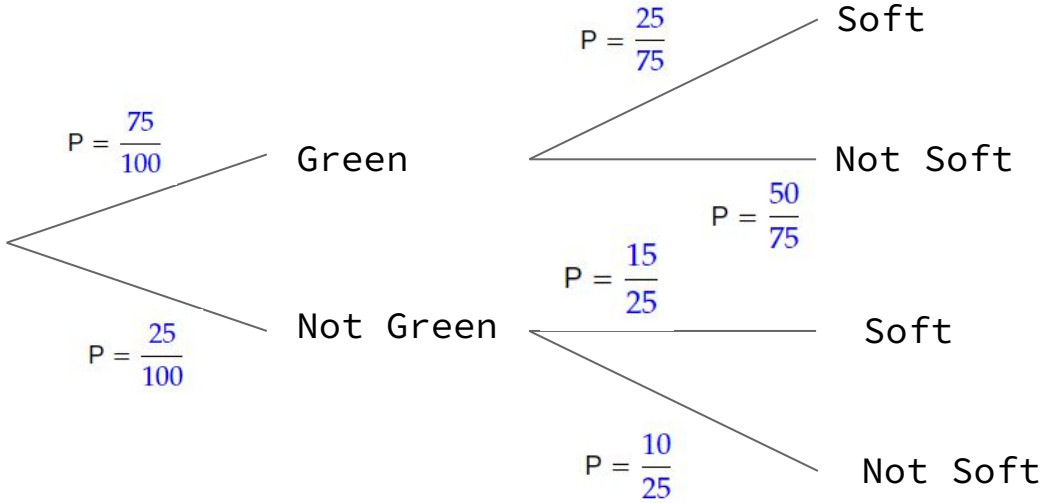

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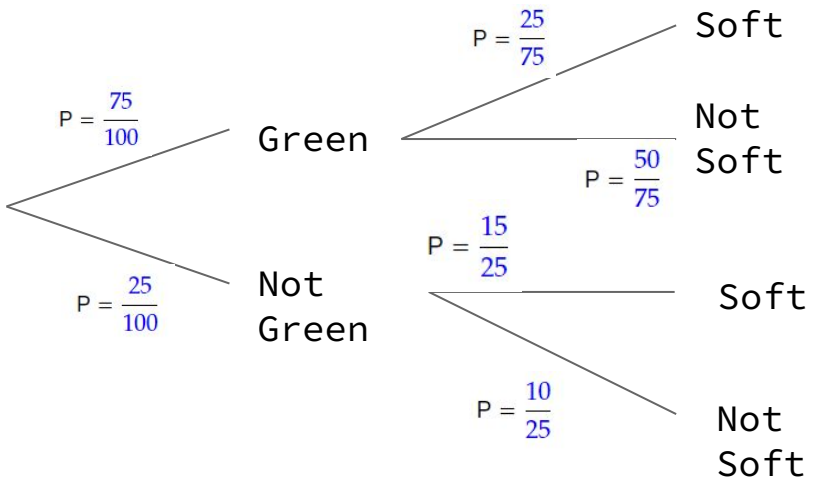

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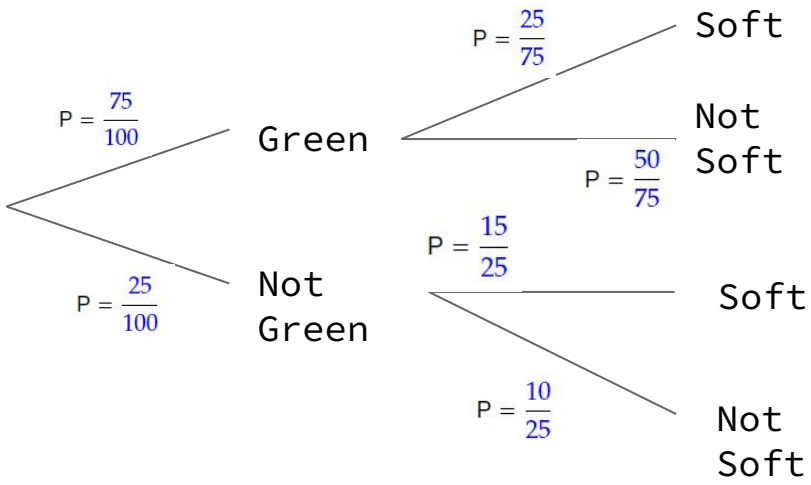

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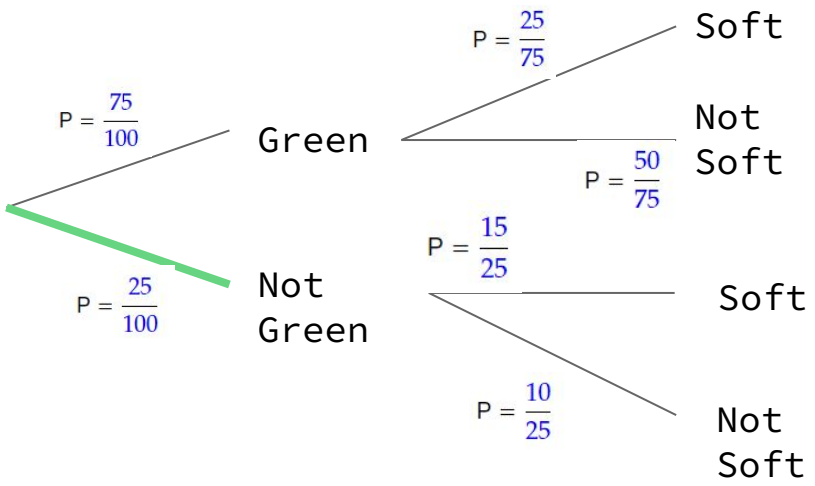

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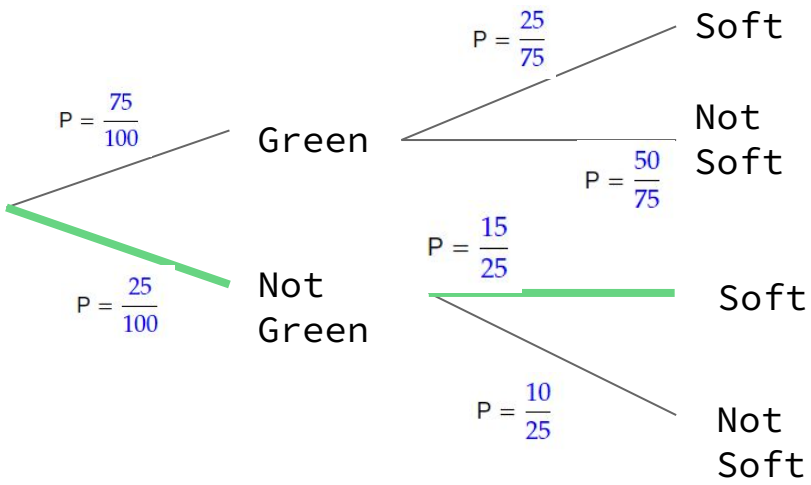

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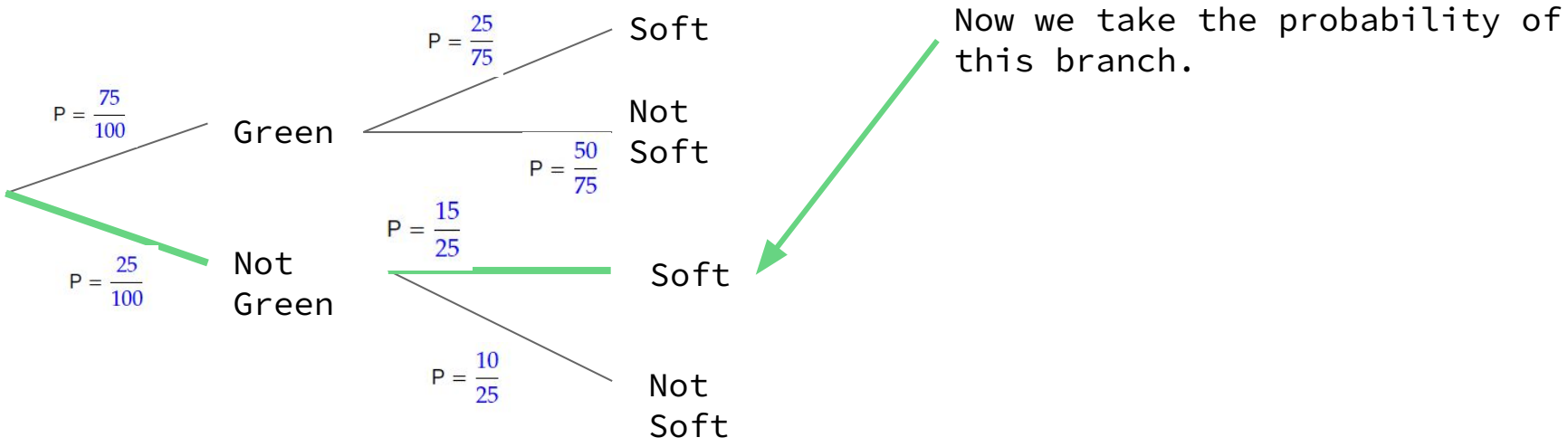

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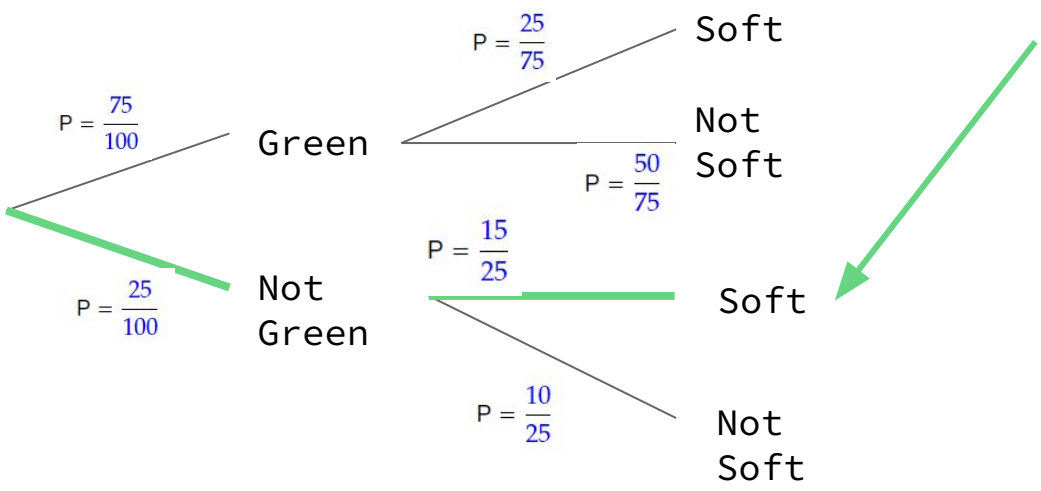

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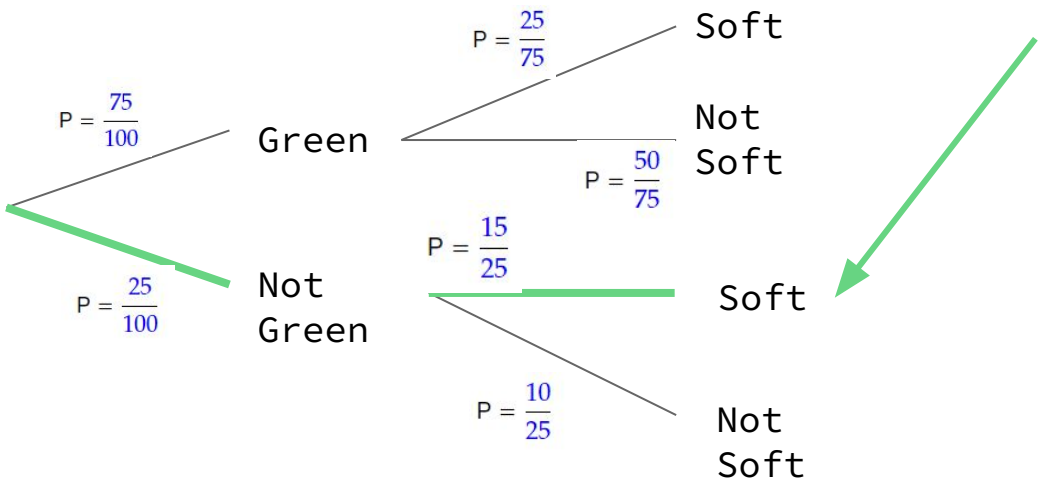

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This is how we use a tree to find a conditional probability.

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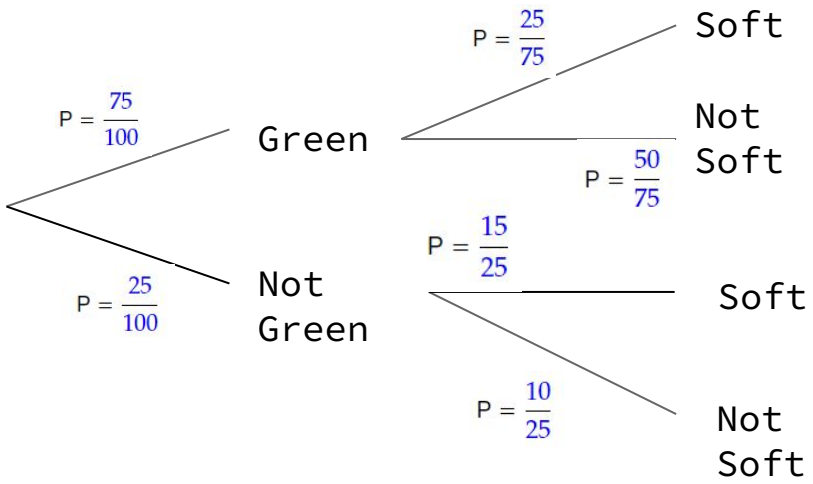

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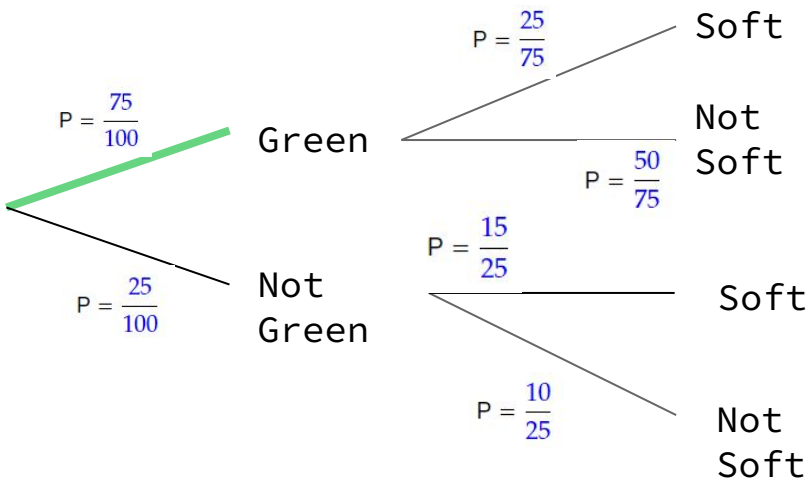

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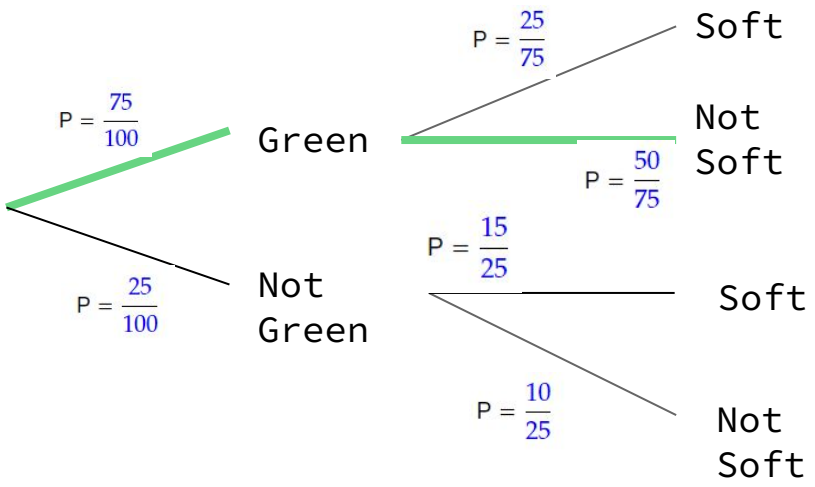

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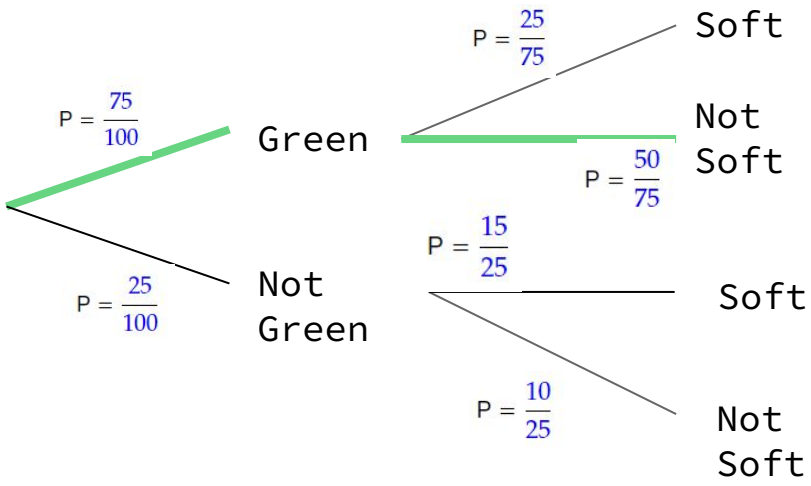

We can use the multiplication rule.

$$P(G \cap S^C) = P(G) \cdot P(S^C|G)$$

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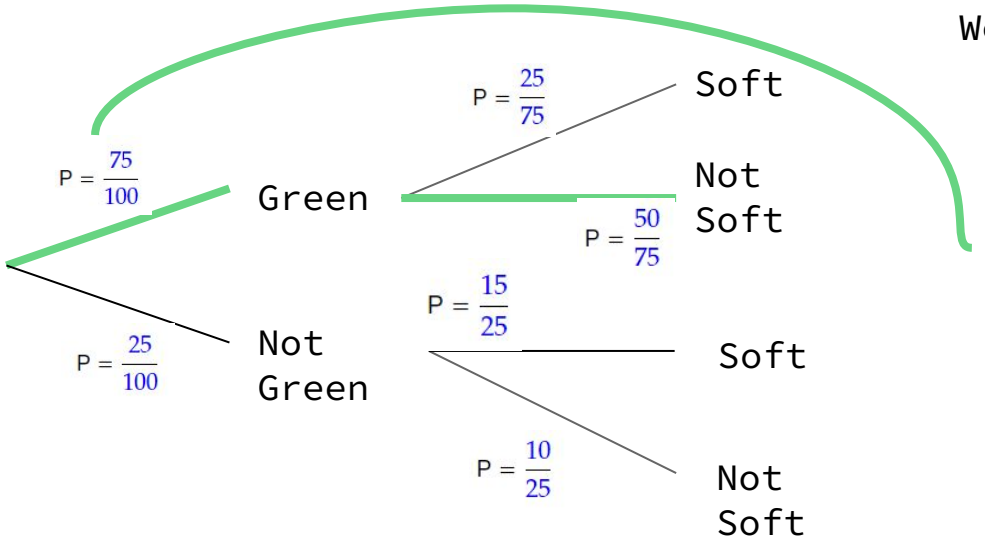

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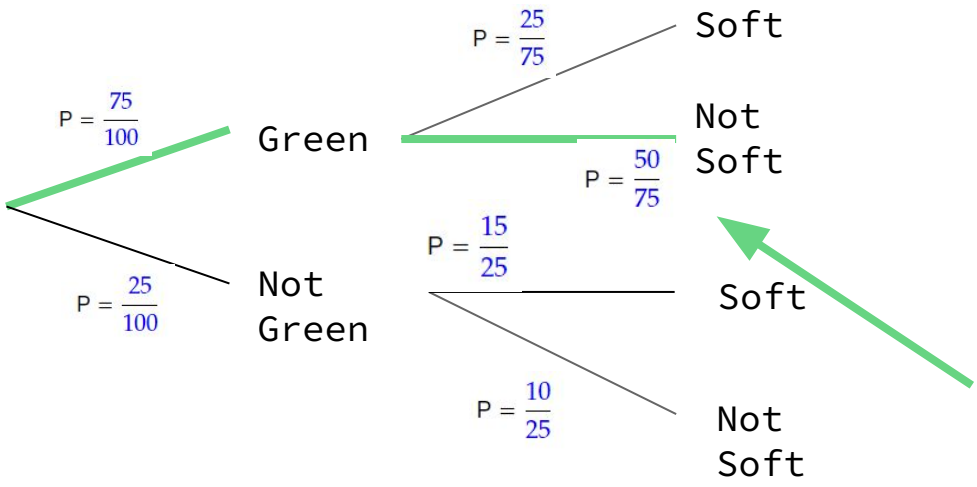

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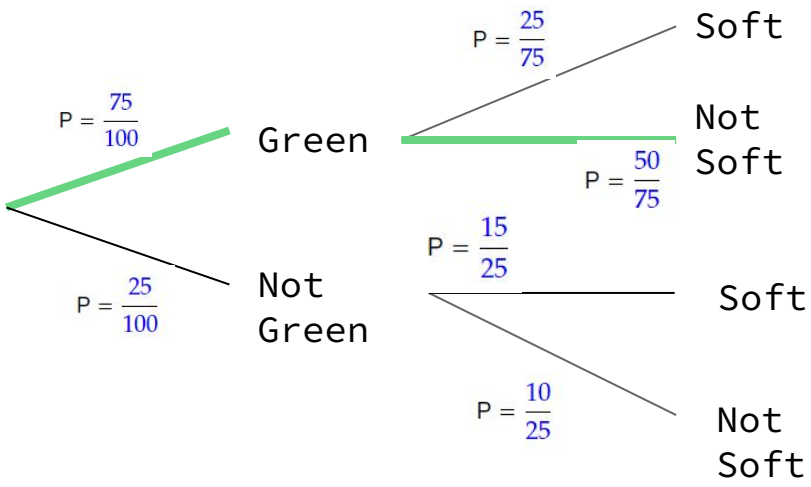

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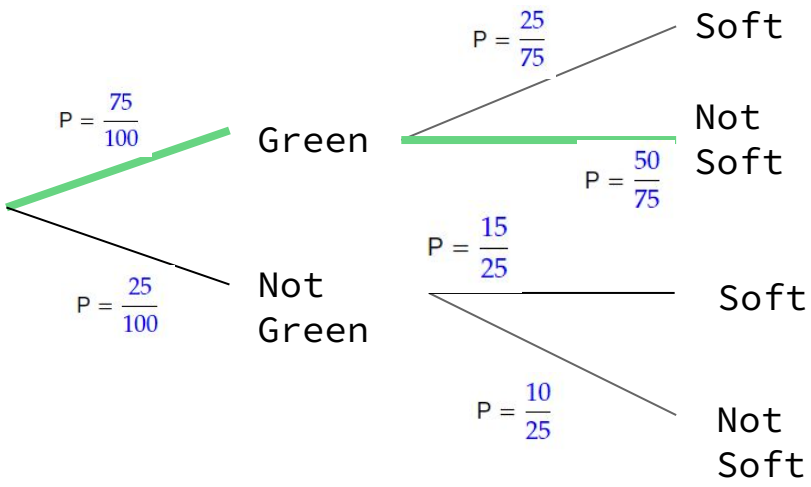

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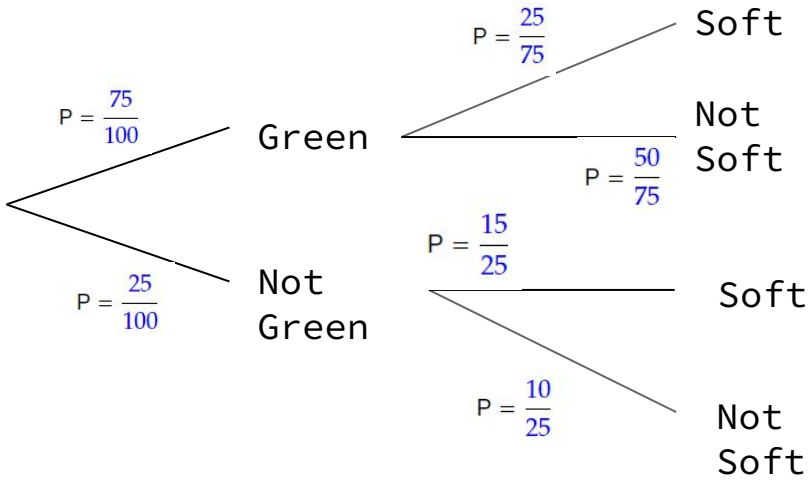

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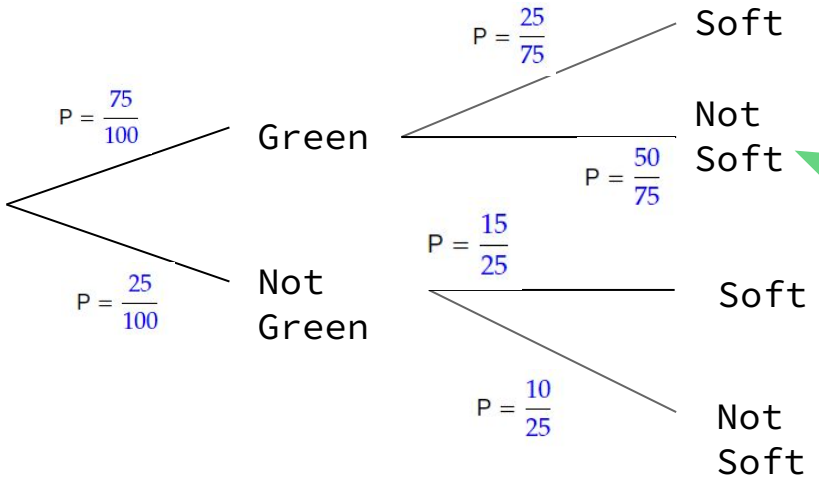

When you take a single branch's probability, it is the probability that event happens given that the entire path before it happened.

The probability at this branch is the probability that the avocado is not soft given that we know it is green.

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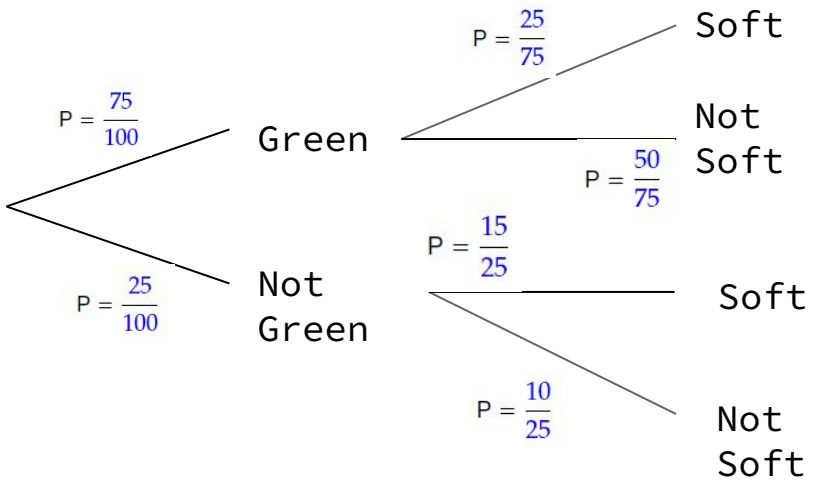

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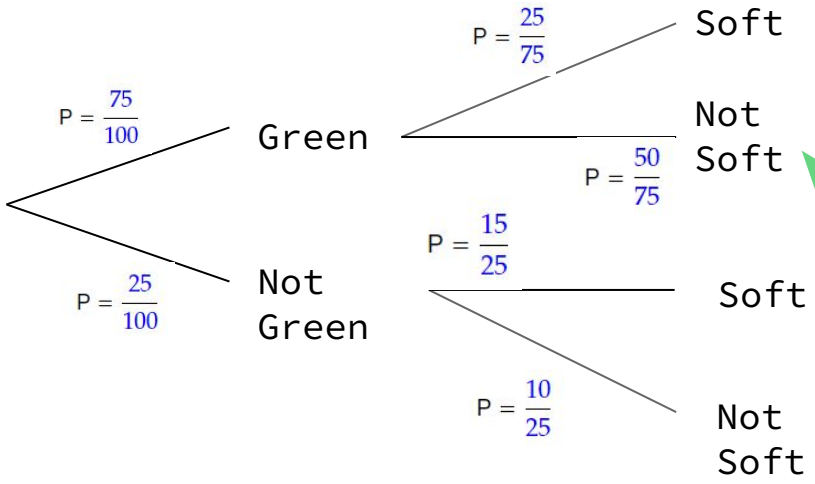

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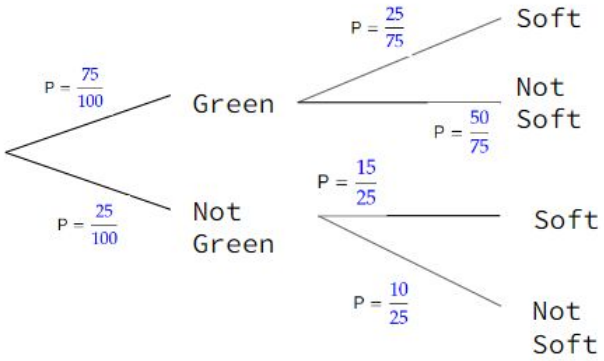
Since we know the probability that an avocado is soft given not green, the probability of not green, and the probability of soft, we can use Bayes' Theorem.

$$P(G^C|S) = \frac{P(S|G^C)P(G^C)}{P(S)}$$



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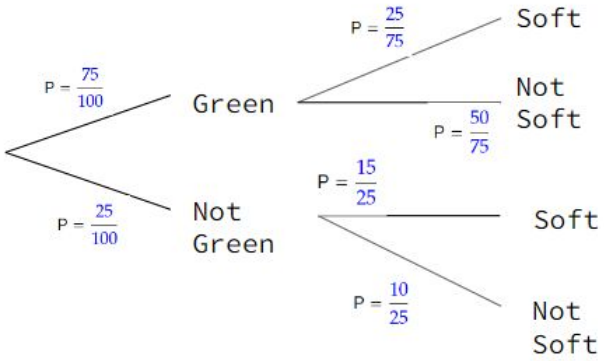

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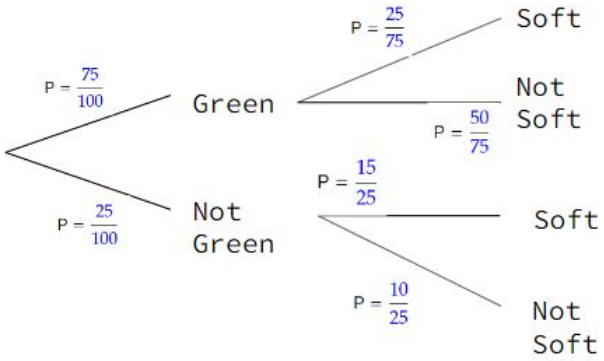

$$P(S|G^C) = \frac{15}{25} \quad P(G^C) = \frac{25}{100} \quad P(S) = \frac{40}{100}$$

$$P(G^C|S) = \frac{\frac{15}{25} \cdot \frac{25}{100}}{\frac{40}{100}} = \frac{15}{40}$$

This is how we can use Bayes' Theorem to find conditional probabilities.

Other Resources

Here are some other resources for conditional probabilities:

- DSC 40A Probability Roadmap
- Visual Example
- Previous Lecture Video