

Functional and chemical properties of food

Below are two practice questions; the first question shows students responses and examiner feedback; the second question is for you to try yourself.

LEMON MERINGUE PIE



Filling

3 large egg yolks
 175ml water
 2 level tablespoons cornflour
 50g caster sugar
 2 lemons

Meringue topping

3 large egg whites
 150g caster sugar

Chapter 4: Practice question 1 (with student responses and examiner feedback)

Explain how the scientific principles and working characteristics of the following ingredients work to produce the lemon pie filling and the meringue topping.

egg yolk (10 marks)

cornflour (10 marks)

egg whites (for meringue topping) (10 marks)

Functional and chemical properties of food

Responses

The following responses were provided by students. The level and detail within the responses increases. More examples with reasons have been provided that allow students to achieve higher marks. The use of subject-specific language shows more informed understanding of the subject content.

Ingredient	Preparation and cooking of the filling – scientific and working characteristics	
Egg yolk	<p>Basic level response</p> <p>The egg yolk sets when it is heated, this is called coagulation. The egg yolk mixes with the sugar, lemon juice, corn-flour and water to make the filling. (2 marks)</p>	<p>Examiner feedback (2 marks)</p> <p>This is a basic answer – the student has understood the basic concept regarding the function of coagulation but has not expanded in relation to the other ingredients, further explanation is required for additional marks.</p>
	<p>Medium level response</p> <p>When the egg yolk is mixed with the other ingredients used to make the lemon filling, the protein molecules denature, causing them to stretch. When the sauce is heated to 70°C the coagulated egg yolk traps the other ingredients between the molecules, setting the sauce. It is important that all the ingredients are blended well together to allow the egg yolk to set the sauce smoothly. (6 marks)</p>	<p>Examiner feedback (6 marks)</p> <p>The student has thoroughly explained how the ingredients combine together and the function of the egg yolk for setting purposes. Good use of key terms, which are used well to demonstrate good understanding. Temperatures are accurate and working characteristics of protein is evident.</p>
	<p>High level response</p> <p>The protein molecules in the egg yolk are held together by chemical bonds. When the egg is mixed for use in the pie filling the bonds break, allowing the egg yolk to change shape – this is called denaturation. It is caused by the mechanical action of mixing the yolk with the other ingredients.</p> <p>When all the sauce ingredients are blended together they need to be heated slowly and stirred continuously to prevent lumps forming.</p> <p>The denatured protein molecules are larger and take up more space. Because of this, they knock into each other and start to join together in large groups – this is called coagulation. As they coagulate, the protein molecules trap and hold the water, lemon juice and sugar from the sauce in pockets between them. When the sauce mixture is heated to 70°C the protein molecules in the egg yolk continue to coagulate, contributing to the thickening of the lemon sauce.</p> <p>The egg yolk also contains a small amount of fat, which helps to create a smooth blended lemon sauce. (10 marks)</p>	<p>Examiner feedback (10 marks)</p> <p>The student shows a detailed and thorough understanding of the function and working characteristics of egg yolk as a setting agent for the filling – the response is logical and key terms are used accurately. The student has combined the preparation and cooking aspects very well indeed.</p>

Cornflour	<p>Basic level response</p> <p>The cornflour helps to set the lemon sauce filling. It is a starch, which sets when it is heated with the other ingredients. It is important to stir the sauce all the time when it is cooking to stop any lumps from forming. (3 marks)</p>	<p>Examiner feedback (3 marks)</p> <p>This is a basic answer – the student has understood the basic concept regarding the function of starch but has not expanded the description in relation to the other ingredients. The answer discusses the preparation rather than the working characteristics. Further explanation is required for additional marks.</p>
	<p>Medium level response</p> <p>Cornflour is a starch. It needs to be blended with the water and lemon juice to avoid any lumps from forming when the sauce is heated. When the starch is heated the granules begin to swell and burst. This process is called gelatinisation. The sauce needs to be heated to 80°C before it is completely cooked and a gel is produced. (7 marks)</p>	<p>Examiner feedback (7 marks)</p> <p>The student has thoroughly explained how the ingredients combine together, the function of the cornflour and the gelatinisation process. Good use of key terms and which are used well to demonstrate understanding. Temperatures are accurate and working characteristics of gel creation is evident.</p>
	<p>High level response</p> <p>Cornflour is a powder; it should be blended carefully with the lemon juice and a small amount of water to avoid any lumps forming when the sauce is cooked. Cornflour is a starch; when the starch granules are put into water and heated to 60°C they start to absorb the liquid and begin to swell and increase in size. This makes the sauce begin to thicken. It is important to stir regularly to avoid lumps forming.</p> <p>When the sauce reaches 80°C the starch granules burst and release the starch granules. They form a 3D network which sets the sauce – this is called gelatinisation and works with the egg yolk to set the blended sauce fully. As the sauce cools down the long starch molecules form a solid gel. (10 marks)</p>	<p>Examiner feedback (10 marks)</p> <p>The student shows a detailed and thorough understanding of the function and working characteristics of the gelatinisation process, how the ingredients combine together and what their functions are in this process – the response is logical and key terms are used accurately. The student has combined the preparation and cooking aspects very well indeed.</p>

Meringue	<p>Basic level response</p> <p>Meringues are made from egg whites that have been whisked using an electric whisk. This needs to be done at high speed to make air bubbles, which are trapped in the egg-white protein. Once the egg white makes peaks it is time to add the sugar, a little at a time, and whisk in. It is baked on top of the pie in a slow oven. (3 marks)</p>	<p>Examiner feedback (3 marks)</p> <p>This is a basic answer – the student has understood the basic concept regarding foam creation; the explanation of sugar addition is clear. There is a lack of key terms and understanding of the working characteristics of egg-white protein. Further explanation is required for additional marks.</p>
	<p>Medium level response</p> <p>When egg whites are whisked to make the meringue, using an electric whisk, air becomes trapped between the protein molecules. This causes a foam to be produced. The protein in the egg white stretches and denatures. It is important not to over-whisk the egg white at this stage as it can collapse. Once the mixture is forming soft peaks you can begin to add the caster sugar, a little at a time, using the whisk. The sugar will help stop the meringue from collapsing – at this stage it will be set. The meringue should be put on top of the filling and cooked slowly to make sure it is fully cooked and crunchy. (5 marks)</p>	<p>Examiner feedback (5 marks)</p> <p>The student has thoroughly explained how the ingredients combine together and the function of the egg-white foam and its creation. The explanation of protein denaturation is clear, with good use of key terms that are used well to demonstrate good understanding. The description of working characteristics of sugar in the preparation and cooking is good.</p>
	<p>High level response</p> <p>The bowl used should be very clean as any fat will prevent the egg white from foaming. The egg whites used in the meringue are a liquid made up of protein & water. The egg whites need to be whisked using a mechanical action to make a meringue. When this happens the speed and heat created by the blades of the fast whisk cause some of the egg protein to denature, they create a framework which allows the air to be trapped in the egg white, creating a gas in liquid foam. The denatured egg white protein molecules join up and coagulate forming a stabilised foam with small air bubbles. The meringue should be whisked until it is a soft peak then begin to add the caster sugar a tablespoon at a time whisking in between each addition until all is added, the meringue should be soft & glossy. The sugar acts as a stabiliser and reduces the risk of syneresis happening after cooking. The meringue should be cooked slowly about Gas mark 2, 150°C to make sure it is fully cooked and crisp on top. (10 marks)</p>	<p>Examiner feedback (10 marks)</p> <p>The student shows a very detailed and thorough understanding of the function and working characteristics of egg-white foam and its creation in the preparation and cooking of the meringue. The process, and how the ingredients combine together and their functions in this process, are accurately and very well explained – the response is logical and key terms are used accurately. The scientific principle that underpins formation of protein foam is excellent.</p>

Functional and chemical properties of food

Mark scheme

For 7–10 marks: The response shows **thorough** knowledge and understanding of scientific principles and working characteristics of ingredients needed in relation to the preparation and cooking of the part of the dish. The answer gives several detailed reasons that relate to functions and scientific principles below. Excellent use of subject-specific terminology.

For 4–6 marks: The response shows **good** knowledge and understanding of the scientific principles and working characteristics of the ingredients needed in relation to the preparation and cooking of the part of the dish. The answer gives several reasons that relate examples of the points below. Examples have been stated. Good use of subject-specific terminology.

For 0–3 marks: The response shows **some** knowledge and understanding of scientific principles and working characteristics of ingredients needed in relation to the preparation and cooking of the part of the dish.

Points to include in the answer

- **Scientific principles/working characteristics of protein in lemon filling and meringue**

Key terms

- **Chemical bonds:** these are bonds that hold large protein molecules together in compact, folded bundles
 - **Denaturation:** this means that the chemical bonds have broken and the protein molecule has unfolded and changed shape
 - **Coagulation:** this means the joining together of lots of denatured protein molecules, which changes the appearance and texture of the food
 - **Gas-in-liquid foam:** A foam consists of very small bubbles of gas (air in the case of the meringue), dispersed in a liquid (egg white)
- **Denaturation**
 - Egg-yolk protein molecules can easily be denatured by mixing – this means that the chemical bonds that hold the protein molecule bundle together can be broken, which makes the protein molecule bundle unfold and change shape.
 - **Coagulation**
 - Denatured protein molecules are larger and take up more space than they used to.
 - Because of this, they knock into other denatured protein molecules and start to join together in large groups – this is called coagulation. The egg yolk when heated will continue to coagulate and thicken the mixture – this is complete at 70°C.
 - As they coagulate, the protein molecules trap and hold water from the lemon sauce in pockets between them.
 - Due to their ability to coagulate, the proteins in eggs are used in some recipes to hold other ingredients together, e.g. lemon juice, sugar, water.

Functional and chemical properties of food

- **Making the lemon sauce**
 - Mix the lemon zest and cornflour together in the saucepan, then blend in 2 tablespoons of water. Ensure the paste has no lumps.
 - Pour the remaining water into the saucepan.
 - This is important as it allows the starch to become hydrated and prevent lumps from forming when the cornflour mixture is heated.
 - Add the egg yolks, sugar and finally the lemon juice.
 - Bring slowly to the boil and cook until sauce is fully thickened. Stir with a wooden spoon, using a figure-of-eight action, to cover the entire pan.
 - The sugar and the protein in the egg yolk work together to protect the starch from the potential thinning effect of the acid in the lemon juice, allowing a smooth sauce to be created. It should be the consistency of thick custard.
 - This sauce is thickened in two ways:
 - By the coagulation of the egg yolks and the gelatinisation of the cornflour starch, the egg will coagulate setting the mixture – this is called a coagulated protein network.
 - The starch grains in the cornflour swell, burst and gelatinise, thickening the sauce.
 - The key temperatures to remember are: 60°C/80°C and 100°C.
- **Creating an egg-white foam/meringue**
 - When the egg white is whisked to make the meringue, the fast action of the whisk traps air to make the gas-in-air foam.
 - Some of the egg-white proteins denature, breaking the bonds which hold them together – they begin to unfold.
 - The denatured protein molecules begin to join together because of the action and heat of the whisking: this is called coagulation.
 - This structure then forms walls around the air bubbles, stabilising the water from the egg white.
 - If the mixture is over-whipped at this stage the foam will collapse, squeezing out the water. This is called syneresis and it tends to happen more easily in older egg whites than very fresh ones.
 - Once the egg whites are at the soft peak stage, whisk in the sugar, a tablespoon at a time, on fast speed.
 - It is important to whisk for about 30 seconds to a minute after each addition of sugar, as this allows the sugar to dissolve and be easily incorporated into the mixture.
 - Continue to add the sugar, whisking all the time, until you have a stiff and glossy mixture with a satin sheen. The air bubbles will be very small at this stage.
 - The egg-white protein will be fully extended, full of air, at which stage a stable foam has been created.
- **To bake the meringues**
 - Spread on top of the set filling and put into the oven at Gas 2/150°C. At this stage, when heated inside the oven, the egg-white protein structure coagulates and sets, forming the meringue structure.
 - The convection heat also drives out some of the water, so the foam sets and becomes more solid.

Functional and chemical properties of food



- **Gelatinisation in the lemon sauce using cornflour**
 - Gelatinisation: this means the swelling of starch granules when they are cooked with a liquid to the point where they burst and release starch molecules.
 - When cornflour starch is heated in a liquid, it gelatinises.
 - The starch is stored in plants.
 - To make a blended sauce, it is important to mix a small amount of the liquid with the dry starch to a paste, then gradually add the remainder of the liquid – this helps to prevent lumps forming in the final sauce.
 - When starch granules are put into water and then heated at about 60°C, they start to absorb the water, which causes them to swell up and get bigger. This makes the sauce start to thicken, because there is less room for the swollen granules to move around.
 - It is important to stir the sauce regularly as it is heating up, to prevent the starch granules from staying at the bottom of the liquid, where they would swell up, stick together and cause the sauce to have a lumpy texture.
 - At about 80°C, the starch granules are so swollen that they start to burst and release starch molecules into the surrounding liquid.
 - These released starch molecules form a 3-dimensional (3D) network that traps water molecules and stops them moving around so much.
 - At boiling point (100°C), the sauce completely thickens.
 - The sauce should be cooked for a few minutes to make sure all the starch is cooked.
 - The sauce is now ready to pour out and serve.
 - This whole process is known as gelatinisation.
 - As the cooked sauce cools down, the starch molecules start to form longer chains and the water molecules stay trapped inside them, so the sauce gradually becomes a solid gel.

Chapter 4: Practice question 2

This question is linked to the making of bread rolls.

Explain what is happening in each picture in relation to the making of bread rolls. In your answer make it clear how the scientific principles and working characteristics of the ingredients work together to produce the bread.

(4x5 marks)

Stage of bread rolls	How and why the ingredients work together
<p>Stage 1: Making and mixing the dough</p> 	
<p>Stage 2: Kneading the dough</p> 	

Stage 3: Shaping and proving the dough



Stage 4: Finished baked rolls




Chapter 4: Mark scheme for practice question 2

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Explain what is happening in each picture in relation to the making of bread rolls. In your answer make it clear how the scientific principles and working characteristics of the ingredients work together to produce the bread.

(4x5 marks)

Stage of bread rolls	How and why the ingredients work together
<p data-bbox="194 432 612 461">Stage 1: Making and mixing the dough</p> 	<ul style="list-style-type: none"> • Sieve the flour; strong plain flour is used because it has a high gluten content, which will make the dough elastic, stretchy and able to rise. Wholemeal bread flour can also be used. • Add a sachet of quick-activating yeast and mix. • Yeast is a raising agent. • Add 1 tsp sugar and ½ tsp salt – mix thoroughly. • It is important not to add the salt with the yeast as this can retard the growth of the yeast. • The salt adds flavour and develops the strength of the gluten. • The sugar will help to activate the yeast. • Use a food thermometer to check the temperature of the liquid – it needs to be between 25°C and 37°C. If it is too hot it will kill the yeast. • Use a wooden spoon to mix the flour and water together until they are combined to a slightly lumpy, workable dough; add more water if necessary to produce an elastic pliable dough. • The addition of water to the flour forms the gluten, allowing the dough to become elastic. • The water also hydrates the gluten, allowing it to become elastic and giving it plastic qualities so it can be stretched and shaped during kneading. • The yeast enzymes will begin to act on the sugar; enzymes in the flour also help to create the fermentation process. • The yeast will begin to ferment, creating CO₂ gas that will, in addition to steam, act as the raising agent for the bread. Alcohol is also produced by the fermentation process, but evaporates on cooking.
<p data-bbox="194 1471 507 1500">Stage 2: Kneading the dough</p> 	<ul style="list-style-type: none"> • Tip the dough onto a lightly floured surface and knead for at least 10 minutes until it is smooth and elastic. • This can also be done in a tabletop mixer with a dough hook. • Knead the dough vigorously; the natural sugars in the flour are released and help the gluten development, and create an even texture. • Gluten makes the dough stretchy – it will shrink back. • Kneading the dough allows for thorough distribution of the yeast and CO₂ gas. • The long, coiled gluten molecules stretch and bend, developing the structure of the dough during fermentation.

Stage 3: Shaping and proving the dough



- The dough is shaped into rolls and put onto a floured baking tray.
- The dough can be covered with oiled cling film to prevent it from drying out and forming a skin.
- It is placed in a warm place to prove, until doubled in size.
- Too high a temperature will kill yeast and prevent rising.
- During proving, fermentation continues.
- Enzymes in the flour turn the flour into glucose.
- CO₂ gas is produced.
- If over-proved the dough will collapse as gluten is over-stretched.

Stage 4: Finished baked rolls



- Once the dough has doubled in size it is ready to be baked.
- The bread can be brushed with water, oil or milk, depending on the type of crust required. Water gives a crusty roll, oil a softer roll.
- Rolls need to be placed into a hot oven – Gas mark 7/220°C for 10–15 minutes.
- At 54°C yeast is killed.
- The heat inactivates the enzymes and expands the gases in the dough.
- The alcohol evaporates in the heat of the oven when the rolls are baked, so that there is no alcohol left in it when the bread comes out of the oven.
- The water is absorbed by the starch grains in the flour, which swell and gelatinise, creating the bread structure. Some of the water turns to steam, which helps the dough to rise.
- The gluten network coagulates, producing a framework with the starch, and traps the gas and steam bubbles.
- The soft, inside texture of the bread is produced.
- The bread should be tested by tapping the bottom – it should sound hollow.
- The outside of the crust should be golden brown.
- This is created by the dextrinisation process of dry heat on starch.

Mark scheme

For 4–5 marks: The response shows **thorough** knowledge and understanding of scientific principles and working characteristics of ingredients needed in relation to the preparation and cooking of the bread rolls. The answer gives several detailed reasons that relate to functions and scientific principles below. There is excellent use of subject-specific terminology.

For 3 marks: The response shows **good** knowledge and understanding of the scientific principles and working characteristics of ingredients needed in relation to the preparation and cooking of the bread rolls. The answer gives several reasons that relate examples of the points below. Examples have been stated. There is good use of subject-specific terminology.

For 0–2 marks: The response shows **some** knowledge and understanding of scientific principles and working characteristics of ingredients needed in relation to the preparation and cooking of the bread rolls.