AUSTRALIAN EGG
CORPORATION LIMITED

The Culinary Uses of Eggs

Identification of raw/low-cooked egg dishes that may be of food safety concern

A report for the Australian Egg Corporation Limited

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Foreword

This report provides an overview of the use of eggs in a commercial kitchen and how this can potentially translate to food safety issues in food service. The report is written from the perspective and understanding of a chef. The scope of the report is for non-food service sector stakeholders.

This report forms an additional part of the AECL *Salmonella* Initiative which works through-chain to identify *Salmonella* risks and appropriate management of those risks. As there is little or no evidence that relates to *Salmonella* risk for each individual cooking technique, this report has identified whether the egg used is raw, low-cooked, cooked or unknown when at the point of consumption and how this may potentially relate to *Salmonella* risk for each culinary function of eggs. A further section of the report provides a technical overview of the various measures that can be considered to manage *Salmonella* risk in food service, such as pH, cooking and storage conditions.

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This report is an addition to AECL's range of peer reviewed research publications and an output of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

Most of our publications are available for viewing or downloading through our website:

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Printed copies of this report are available for a nominal postage and handling fee and can be requested by phoning (02) 9409 6999 or emailing research@aecl.org.

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Abbreviations

AECL ..... Australian Egg Corporation Limited
aW ..... Water Activity
FSANZ..... Food Standards Australia and New Zealand

Executive Summary

An enduring challenge and reputational issue for the egg industry is caused by the presence of *Salmonella* spp. (particularly some *Typhimurium* serotypes, but not exclusively) on table eggs or in eggs products. These *Salmonellae* can be present and proliferate at many stages throughout the egg supply chain and, if not managed appropriately, can cause human salmonellosis. The presence and spread of *Salmonella* depends on numerous variables, and as such, there is no single effective control measure. This makes the issue of '*Salmonella* and eggs' a complex one, subject to a combination of both real and perceived risks. Data analysis performed at the National Centre for Epidemiology & Population Health at Australian National University indicates that approximately half of these cases of *Salmonella*-related foodborne illness may attribute eggs as the source (*Salmonella* can also be found associated with other numerous foods and food products).

It is difficult to manage *Salmonella* risk without a good working knowledge of the risks and an understanding of how to assess what is a risk. This is especially pertinent for the risks at the food preparation and consumption end of the egg supply chain as there are often numerous ways to produce a single menu item. The various risks (and level of risk) associated with that menu item will vary depending on the level of understanding of the food preparation staff / food handlers (and their level of training and expertise), the kitchen environment and location, the clientele and business requirements.

This report was compiled to provide an overview on the different use of eggs in a commercial kitchen from the perspective and understanding of a chef to be used by non-food service sector stakeholders as an initial point of reference. There is little or no evidence that relates to *Salmonella* risk for each individual cooking technique. Therefore, in each case the dish and/or egg preparation has identified whether the egg used is raw, low-cooked, cooked or unknown at the point of consumption and how this may potentially translate to increased *Salmonella* risk. Depending on the preparation method, over half of the uses could be classified as raw and/or low-cooked. It is unknown how this directly translates to potential food safety issues in food service and whether various preparations provide a better growth medium for *Salmonella* than others (and therefore an increased risk). A further section of the report provides a technical overview of the various measures that can be considered to manage *Salmonella* risk in food service, such as pH, cooking and storage conditions.

This report forms an additional part of the AECL *Salmonella* Initiative which works through-chain to identify *Salmonella* risks and appropriate management of those risks. It is essential that all stakeholders are aware of the through-chain risks as ultimately all can be held responsible if there is a human foodborne illness outbreak linked to the consumption of eggs. The information in this report will ensure that egg producers are aware of the risks of selling eggs to various customers who produce high-risk egg products. It will also provide state Health Departments and environmental health officers with a better understanding of the use of eggs in food businesses and provide them with an additional tool to assess food risk and potential appropriate regulatory measures to address risk on a broader scale. Food businesses, including egg producers, are responsible for their actions and ultimately food safety cannot rely on inspections alone; it requires an increased understanding of the risks by all through-chain stakeholders.

1. Culinary functions of eggs

Eggs are among the most versatile ingredients in the kitchen. Their use in the menu is only limited by the imagination of the chef. Eggs can be prepared and cooked in many ways and can be served in every course of the menu. A number of bird's eggs are edible and may be used in cookery but, of all varieties, hen's eggs are the most commonly used in the kitchen. The reason for this is that by comparison to other eggs, a hen's egg is relatively bland, more readily available and comes in different sizes, making it suitable for a multitude of uses.

Eggs contain a large amount of protein that coagulates when heated. The general rule of thumb when cooking eggs is to cook slowly and with moderate heat. In many cases, eggs included in dishes such as pâtés or baked custards are cooked au bain marie, a process that tempers and slows the transfer of heat within the product.

Eggs will overcook and toughen considerably at temperatures above 88°C. Too rapid cooking will toughen and burn egg whites and cause the yolk to become hard and chalky. In dishes such as omelettes and scrambled eggs, liquid will precipitate from the dish and can be seen as a watery substance in the pan. In other dishes, such as Crème caramel and Crème brûlée, the moisture turns to steam and causes holes to form in the texture of the cream.

Eggs are used in cookery to perform a wide range of functions, which are listed in Table 1. Applied examples are also provided.

Table 1. Culinary functions of eggs

Function		Applied Example
1.1.	Aerating	Sponge, cake, soufflé, meringue
1.2.	Clarifying	Consommé
1.3.	Emulsifying	Mayonnaise, hollandaise, béarnaise
1.4.	Thickening	Crème anglaise
1.5.	Binding	Patties, panada
1.6.	Aerating	Sponge, cake, soufflé, meringue
1.7.	Glazing	Egg wash
1.8.	Enriching	Liaison
1.9.	Setting	Crème brûlée, crème caramel
1.10.	Coating	Paner à l'anglaise, frit à la Juive
1.11.	Garnishing	Niçoise and Caesar salads, steak tartare
1.12.	Egg dishes	Omelette, eggs benedict
1.13.	Sous Vide	Various
1.14.	Other	Shakes and smoothies, eggnog/egg milk punch

In a culinary context, the definition of a **low-cooked** or **raw** egg product is:

Low-cooked: A dish or egg product in which the white, the yolk or both have not fully coagulated.

Raw: A dish or egg product where the egg undergoes no heat application at all.

Given these definitions, it is imperative that there is a heightened capacity for kitchen and person hygiene, preparation, storage and serving in businesses where eggs are used in this manner. It is also essential that there is an appropriate level of understanding of the risk exposure that various egg uses can translate to any food business (including egg producers).

The following sections outline the level of risk exposure for each of the culinary functions of eggs listed in Table 1.

1.1. Aerating

Aerating generally refers to using the egg white. It could be argued that the whole egg may be used, such as in the case of a sponge, or stiffly beaten egg whites which are used in soufflés, however they would be defined as **cooked** as they spend around 20 minutes in the oven each at temperatures higher than 165°C. There is published examples of some of the below culinary examples being contaminated with *Salmonella*, and more examples where the aerated egg product was suspected of being the source of *Salmonella* contamination. Preparation of these dishes involves beating the egg white/egg, which can create an aerosol. Therefore, any utensils that are used to prepare these types of dishes must be deemed clean before use, cleaned thoroughly after each use and the dish must be prepared in an area which can be cleaned easily and not contaminate other food preparation areas (or prepared at a different time to allow for a cleaning step in between). Utensils or kitchen equipment that has a number of sections must be checked regularly to ensure that there is no residue build-up over time (e.g. stick blender attachments).

The majority of the dishes/preparations below are classified as low-cooked or unknown. Therefore, any food products that contain these preparations should be refrigerated after preparation and consumed or discarded within a reasonable time frame. There are no guidelines for storage time for low-cooked products as it is unknown what effect the various types of heat treatment have on bacteria. It must be assumed that bacterial contamination is present (either in the raw ingredients, or through preparation or post-preparation handling) and that the preparation method has not destroyed the bacteria.

In the instance of aeration, culinary examples would include:

1.1.1. Meringue

The type of meringue can vary widely from ordinary meringue to Italian meringue, which will impact on the level of heat applied to the egg due to the varying time/temperatures of the different recipes. Therefore, some meringue could be classified as **low-cooked.**

Ordinary meringue requires the egg white to be beaten with the addition of a small amount of lemon juice (or cream of tartar – tartaric acid) and is best cooked at low temperatures (preferably in the oven overnight with just the pilot light on) to keep it white. Preferably it is dried all the way through (less water activity [aW]) so that it crunches when bitten but there are instances where a chewy centre is preferable, such as in the case of a Pavlova base or when a chef may be trying to introduce an additional texture (chewiness) to a completed dish. It is the need of many chefs to create dishes that have a variety of textures. In these cases

the egg could be described as being **low-cooked**. Meringues cooked at high temperatures invariably have chewy or undercooked centres.

Italian meringue requires molten sugar (sugar cooked to around 140°C) to be poured in a steady stream into the beaten egg white whilst continually being beaten. If it is not used immediately, it can be stored in a freezer for several days before the hygroscopic properties of sugar (the ability of sugar to absorb water from the atmosphere) will cause the sugar syrup to 'bleed' from the meringue. Italian meringue is used on top of lemon meringue pies and on items such as bombe Alaska and other bombe types. The top (or outside) is usually then fired with a blow torch to give a slightly burnt or brown look but the bulk of the meringue remains soft. In the case of Italian meringue, the only heat treatment it receives after the initial adding of hot sugar would be the firing of the surface. It is **unknown** whether the conditions for preparation of this dish would eliminate bacterial contamination as there is no extended heat treatment to the egg.

œufs à la neige / île flottante (snow eggs / floating island) are a meringue that is poached. These dishes are not as commonly prepared as they used to be but would be classified as **low-cooked** egg dishes.

1.1.2. Marshmallow and nougat

These dishes are prepared in a similar way to Italian meringue as they use molten sugar cooked to around 140°C which is then slowly poured into stiffly beaten egg whites. In all cases, the sugar is allowed to cool slightly before adding to the egg whites. In the case of marshmallows and nougat, they may be stored at room temperature in airtight containers. It is **unknown** whether the conditions for preparation of these dishes would eliminate bacterial contamination as there is no extended heat treatment to the egg. If suspect, storage conditions could further exacerbate issues.

1.1.3. Sabayon

A sabayon is a light fluffy mixture of whipped egg yolks or whole eggs with a liquid, used for a variety of purposes in the kitchen (see emulsion sauces below). An example of a dish that is served would be the Italian dish Zabaglione. This dish requires egg yolks, whole eggs, Madeira or Marsala, white wine, sugar and possibly a few other ingredients whisked together over low heat until light and fluffy. The egg is not fully cooked as to do so would ruin the dish and introduce a scrambled egg texture and taste. Therefore, these dishes would be classified as **low-cooked**. Zabaglione is often served warm either with fruit and sponge biscuits or used as a sauce for other desserts. As a time saving measure during food service in a busy kitchen more than one serve could be prepared at a time. Rather than produce a sabayon for each order, a few may be produced and held at a warm temperature (approximately 45°C) for approximately 15 minutes.

1.2. Clarifying

This method uses the egg white to clarify liquids, such as stocks, so they are crystal clear. Egg white is mixed with minced beef or poultry meat and vegetables and added to a cold stock. It is slowly brought to a boil and then turned down to simmer for a number of hours. The clarification occurs as soon as the mince / egg / vegetable mixture comes to the top (goes by the name of a raft, float and cake) but the prolonged simmering at high temperatures would ensure the egg is **cooked**. It could be assumed that any bacteria present in the raw ingredients, or introduced during handling, would be significantly reduced in food products prepared in this manner, and therefore the risk of *Salmonella* would be low. There is always the risk that cooked products can become contaminated after preparation through improper

handling and storage practices. Therefore it cannot be assumed that once a dish is subjected to a heat treatment that it is an inherently safe dish.

1.3. Emulsifying

An emulsion is basically described as combining two ingredients that don't normally mix by adding an additional ingredient that both ingredients will mix with. In a culinary sense this means the use of egg yolks, and there are numerous examples, including many sauces. The majority of the dishes/preparations below are classified as raw or low-cooked. Therefore, any food products that contain these preparations must be refrigerated after preparation and consumed or discarded within 24 hours. It should be assumed that bacterial contamination is present either in the raw ingredients, or as a result of preparation or post-preparation handling techniques. It is also important to consider the temperature gradient that can exist in bulk manufactured raw food products stored at refrigeration temperatures. The centre of the bulk preparation may never reach the required storage temperature, especially if the container is accessed often during the 24 hour period and spends time at ambient temperature. Therefore, the volume of preparation of these food products should also be considered. The cleanliness of utensils used to prepare these dishes must be at the highest possible standard to reduce the risk of introducing bacteria during preparation.

In the instance of emulsifying, culinary examples would include:

1.3.1. Cold emulsion sauces (e.g. mayonnaise)

Mayonnaise is a cold emulsion sauce and there are literally hundreds of derivatives. The most common variations include tartare, remoulade, cocktail and thousand island. With mayonnaise generally only the egg yolk is used, although some recipes use the whole egg. The base mayonnaise recipe requires raw egg yolk to be mixed with mustard and some vinegar, oil is then added gradually until all is incorporated and the finished sauce has more vinegar or lemon juice added (to bleach the sauce slightly and add flavour). A small amount of boiling water is then added to stabilise the sauce. It is then seasoned with salt and pepper and stored or further ingredients added to make a derivative sauce. Generally one egg yolk is mixed with 200mL of oil, however recipes vary. Commercial volumes range from 500mL made by hand to 20L produced in a large mixer. Larger quantities will take longer to cool to storage temperature than smaller quantities, however the time/temperature gradient isn't known, and would depend on additional ingredients and the type of storage container. These are **raw** egg products as there is no cooking at any stage.

1.3.2. Aïoli

Aioli is not a derivative of mayonnaise but is prepared in a similar manner, and is therefore classified as a **raw** egg product. Egg yolks are used as emulsifying agents.

1.3.3. Warm emulsion sauces (e.g. hollandaise and béarnaise)

Hollandaise and béarnaise sauces are examples of warm emulsion sauces and there is anywhere up to 20 derivatives of these two sauces. Only the yolk is used and it is mixed with a reduction (a preparation of boiled vinegar and other flavourings – herbs, onions, peppercorns, etc.) and whisked over heat (direct or indirect) until a light fluffy mixture called a sabayon (see 1.1.3 above) is formed. The egg yolk is not completely cooked or it will scramble and be incapable of emulsifying the sauce, not to mention give an unpleasant taste and

texture. Warm clarified butter is then added, further seasonings are incorporated and the finished sauce has a small amount of cold water added to help stabilise the sauce. A standard ratio of ingredients for these sauces is one egg yolk to 100g of butter and 6-9mL of reduction per yolk, depending on how sharp you want the sauce. Therefore, these sauces (and dishes prepared with these sauces) are classified as **low-cooked.**

Both hollandaise and béarnaise sauces are particularly finicky about the temperature they are stored at. Commercially, they are produced just prior to service and held at around 45°C in a warm spot in the kitchen. If they get too hot the sauce will separate. If they get too cold, the sauce looks okay, but will separate once in contact with hot food. For bacteria such as *Salmonella* these storage conditions can be particularly beneficial for bacterial growth. Therefore, dishes that include a hollandaise or béarnaise sauce (or one of their derivative sauces), such as eggs benedict (a dish further complicated as it also contains poached eggs which themselves are **low cooked** items), should be prepared just prior to service and held only for that service period (generally 2 hours plus or minus).

Hollandaise is also used as the base for the following sauces: Mousseline (also called Chantilly); Maltaise; Moutarde; Noisette and Grimrod.

Béarnaise is also used as the base for these sauces: Choron; Foyot (also called Valois); Paloise; Rachel and Tyrolienne.

Other sauces that contain low cooked or raw egg product include: Carbonara sauce, a creamy bacon and egg sauce used on pasta (low-cooked), Caesar dressing and some salad dressings where raw eggs in some form are used as emulsifying agents.

1.4. Thickening

Eggs, either whole or the yolks, are prized in the kitchen for their thickening ability.

There are many examples of dishes that use eggs for this reason, such as crème anglaise (which is also the base for ice cream and bavarois, also known as Bavarian creams), lemon curd (in above-mentioned lemon meringue pie), eggnog and possibly hand stirred crème brûlée. In each of these dishes the egg is only heated sufficiently to effect thickening. Temperatures at which this will occur vary according to the number of eggs or yolks in the liquid, but in all cases the egg is only partially cooked; no coagulation of the egg is permissible or the dish will be ruined. Therefore, dishes that use eggs for thickening are classified as **low-cooked**.

It should be assumed that bacteria are still present in any dish that is classified as raw or low-cooked. Therefore, a high standard of kitchen and staff hygiene should be maintained and cross-contamination during preparation should be avoided. This may include staggering the preparation of various dishes, to prevent bacteria present from ingredients used in an earlier prepared dish contaminating a raw or low-cooked food item. Utensils or kitchen equipment that have a number of components must be checked regularly to ensure that there is no residue build-up over time (e.g. stick blender attachments).

Any food products that contain these preparations should be refrigerated after preparation and consumed or discarded within a reasonable timeframe. There are no guidelines for storage time for low-cooked products as it is unknown what effect the various types of heat treatment have on bacteria. It must be assumed that bacterial contamination is present (either in the raw ingredients, or through preparation or post-preparation handling) and that the preparation method has not destroyed the bacteria.

1.5. Binding

Binding describes where a whole egg or the yolk is incorporated into a preparation to bind ingredients together. Examples include steak tartare, hamburger patties and meat loaves. Hamburger patties are usually fully **cooked**, but in some instances this may not be the case (poor cooking by the chef/cook, or in the U.S for example, you may order a ground meat patty medium rare in your burger). In these cases, the dish would be classified as either **low-cooked** or **raw** depending on the level of cooking. The bacterial risks associated with food prepared in this manner are the same as those for all the uses described in section 1.1 – 1.4 above as the level of risk will depend on the level of heat applied to the food product, the initial contamination level on the raw ingredient, the efficacy of the storage time / temperature and cleanliness of the kitchen and utensils.

1.6. Glazing

Depending on its purpose, an egg wash is prepared by beating a whole egg (or by adding some milk and or water) or by using the yolk alone. Egg wash is used to provide a gloss finish to pastry items which are cooked at high temperatures for extended periods of time and therefore would be classified as **cooked** egg dishes. Egg wash may also be used to 'glue' prepared items together, such as in fresh pasta produced in-house. This type of pasta contains raw egg however it is subsequently boiled until al dente. It is however **unknown** whether this level of cooking is sufficient to destroy bacteria. Not all freshly made pasta is dried prior to cooking and those types may be left out of cold storage for extended periods of time prior to cooking (it would be expected that filled pasta would be refrigerated). Although only a small amount of egg is used for glazing, the risks would be heightened if the dish is low-cooked and the item was in storage for an extended period of time prior to consumption. It can be assumed that any bacteria present would be able to proliferate, but the initial level of contamination would be lower than for other food items that utilise a whole, or whole section of, an egg.

1.7. Enriching

Many sauces, soups and some stews are finished with what is known as a liaison. This is a mixture of egg yolks and cream and is added just prior to serving the dish. The standard recipe includes three yolks to 100mLs of cream added to one litre of liquid. The yolk is mixed with cream and tempered with some of the hot liquid in which it is to be added to. It is then added to the dish and heated slightly in the final dish. The purpose of a liaison is to slightly thicken and enrich the finished dish. The egg yolk however is **low-cooked**, because if it is heated too far it will scramble and ruin the dish. There are numerous menu examples and include pomme duchesse, veloutés (both sauces and soups) and a stew known as a fricassée. Other dishes prepared using a liaison are not very common. Carbonara sauce would be the most common example although in this dish the egg is not really considered a liaison. Veloutés are seen often enough on menus although the term may be used incorrectly (velouté means velvety in French).

Parfaits contain low-cooked egg yolk that are then frozen and would be classified as **low-cooked**. Tiramisu and dessert mousses of most types contain raw egg in some form and frozen soufflés contain low-cooked egg yolk and raw egg white and all would be classified as **raw** egg products. Parfaits use a sabayon base (egg yolk, sugar, water and a flavouring) and then whipped cream is incorporated. Mousses vary according to type and recipe. Chocolate mousse for example has the yolks added to the melted chocolate and egg whites stiffly whipped and added to the final mixture to lighten and aerate it. In tiramisu the yolk is creamed with the sugar and then the mascarpone cheese. Egg white may be added to aerate the mixture as in mousses. Frozen soufflés are prepared in a similar manner to parfait.

These dishes can have a particularly heightened risk of bacterial contamination as the food items may be raw and only include the use of the yolk. The white (or albumen) of an egg has antibacterial properties that can temper the growth of bacteria (these properties degrade as the egg ages), however, yolk alone provides the perfect medium for proliferation of innumerable types of bacteria (including pathogens). Therefore, the recommendation for substantially reducing the risk of foodborne illness from dishes that utilise the yolk of an egg only would be that they are prepared to order or refrigerated and consumed / discarded by the end of the food service day (< 24 hours), and considerations made for heightened kitchen hygiene and utensil cleanliness.

1.8. Setting

Eggs that are used to set a dish are generally fully **cooked** and generally use one egg for every 100mLs of liquid to be set. Examples would include pâté, quiche or frittata and provided the centre of the dish was set, the egg would be fully cooked.

Dessert items such as crème caramel and crème brûlée (crème brûlée can be cooked two ways – on top of the stove and stirred or in the oven cooked au bain marie) are generally cooked au bain marie (in a water bath) that tempers the heat flow and prevents the rising affect that eggs can have when cooking. Bains marie are also used to prevent syneresis (where the egg contracts, squeezes out water which then turns to steam and creates small holes in these products). A chef may undercook one of these products in the attempt to prevent syneresis from occurring, however, a crème caramel once turned out would not stand up and would therefore not be servable. Oven-cooked crème brûlée is more suspect and therefore classified as **low-cooked,** as this 'baked custard' is served in the ramequin or dish it was cooked in, so an undercooked preparation may not be noticeable to a chef.

Dishes that are prepared in this manner will have a varied degree of risk of bacterial contamination. However, given that they all require some degree of heat applied through the preparation process, the risk is lower than any raw egg product. It should always be assumed that post-preparation contamination can occur, and this is particularly important for products prepared au bain marie as the water bath can become contaminated with ingredients during food preparation, the bacteria may be able to proliferate at time / temperatures applied during cooking, or the bacteria may not be destroyed.

1.9. Coating

An egg wash can be used to crumb items (e.g. fish, chicken, ice-cream) or apply other coatings. Generally these dishes are **cooked** further and it would be expected that the egg would be fully cooked in the finished product. Crumb and egg wash should be discarded immediately after use. This is of particular importance when crumbing chicken as kitchen staff may not realise how dangerous the crumbing set (i.e. the egg wash and the crumb) can be when stored in the kitchen (depending where in the kitchen it could be as hot as 40°C). Deep fried ice cream is usually crumbed twice or more. The purpose of the crumb is to protect the ice cream from melting whilst in the deep-fryer. It would be suspected that the crème anglaise (to make the ice-cream) may be the bigger issue, however not all establishments will use house prepared ice-cream (ice-cream must contain egg yolk or it is termed ice-confection).

With this technique, the risk of bacterial contamination is primarily to the coating agent and egg wash (crumbing set). As this process involves a primary egg wash to stick the secondary coating it is very likely that the egg wash will contaminate the coating. The level of contamination will depend on the technique used. It is important to consider that both the egg wash and the coating are classified as a **raw** egg products and should be refrigerated within 2 hours and discarded within 24 hours of first use. Although most products are cooked at high

temperatures for extended periods of time, there are some processes (like deep-fried ice-cream) where the heat application is only brief so as to not damage the integrity of the food that has been coated. Therefore, the bacterial risk of these dishes will depend on the time / temperature variables of the dish being prepared.

1.10. Garnishing

An example of where a raw egg is used as a garnish is steak tartare. This dish consists of finely chopped raw beef fillet, raw egg yolk and a multitude of other raw ingredients. It is prepared and served raw in front of the customer from a gueridon trolley. An egg yolk is used as the basis for a flavoursome mayonnaise-based sauce which binds and 'pickles' the finely cut meat as it is mixed in. This dish is classified as a **raw** egg product and should be considered high risk, especially considering the risk of cross-contamination from/to the raw meat. This is particularly important if the dish is pre-prepared and stored prior to consumption. A considerably high level of hygiene and kitchen cleanliness would be required where this dish is prepared to limit the incidence of cross-contamination between raw ingredients and different preparations. These dishes should be prepared to order.

Dishes that use **low cooked** eggs as a garnish include Niçoise salad and Caesar salad.

Royal Icing is used to finish wedding and Christmas cakes, to produce edible flowers and other decorative pieces for cakes, on some biscuits and is also used as an edible 'glue' for attaching decorative pieces to cakes or Gingerbread houses. It consists of beaten egg white, icing sugar and glycerine. The white is not cooked and is therefore classified as a **raw** egg product and should therefore be discarded within 24 hours of preparation. However, it is common practice for bakery items that incorporate this preparation to be stored for longer than 24 hours. The risk would still be less than if egg yolk alone was used (such as 1.7 Enriching, above). Alternatively, powdered or pasteurised eggs can be substituted for this preparation to reduce the initial risk.

Buttercream icing is used in the preparation and decoration of gateaux and pastries. There are at least two methods used to produce buttercream icing with eggs, one of which uses a sabayon of egg yolks, sugar and water. As with other sabayons, the egg yolk is **low cooked**.

Compound butters are flavoured butters, usually served with grilled items. Some compound butters contain raw egg and therefore would be classified as **raw** egg products. Raw egg yolks are sometimes added to help emulsify and enrich the butter that effectively takes the place of a sauce. Compound butters are named according to their ingredients or tradition but commonly used ones include: Café de Paris, Beurre Maitre D'hôtel (Lemon parsley butter), Anchovy butter, Montpellier butter, Prawn or Crayfish butter, Truffle butter and at least 30 other examples. Once prepared the butter undergoes no cooking and is simply allowed to foam/melt over the grilled item. As this preparation often involves the use of raw yolk only, then the risk of bacterial proliferation is considerably higher than if the whole egg was used (as the antibacterial properties of the egg white are not present to temper bacterial growth), and should be treated as a enriched product (section 1.7 above).

The time / temperature considerations of the icing and butter preparations will be important components of the level of risk. The cleanliness of the kitchen and utensils will be an important component to the safety of these dishes. It is common for these preparations to accompany cooked dishes (e.g. cakes; grilled items) and if applied to a dish while it is still hot, and not consumed immediately, there is a risk that bacteria will proliferate.

1.11. Egg dishes

The preparations in sections 1.11.1 – 1.11.5 are often made to order and involve varying degrees of heat application, so the risk is considerably low as there is no time for the bacteria to proliferate to levels that can cause human illness (although this will depend on the starting level of contamination and the level of heat over time applied).

1.11.1. Poached eggs

Poached eggs and dishes that contain poached eggs, such a Caesar salad or eggs benedict, and are classified as **low-cooked** egg dishes. As mentioned above, a Caesar dressing may also contain both the raw egg product in the dressing as well as a low-cooked egg in the dish.

1.11.2. Omelettes

Correctly cooked omelettes are prepared to still be slightly runny in the centre (a term that is known in cookery as baveuse) and therefore omelettes cooked in this manner are classified as **low-cooked**.

1.11.3. Scrambled eggs

Scrambled eggs should be lightly cooked in the same way as an omelette, and are therefore classified as **low-cooked**. Scrambled eggs cooked at too high of a temperature are also subject to syneresis (see section 1.8 above). This is observed as water in the pan and the resultant dish is generally rubbery in texture. Good chefs will be aware of this and will attempt to prepare a dish where this does not happen.

1.11.4. Boiled eggs

Boiled eggs can be cooked to a variety of thoroughness and can be classified as **raw** (raw yolk and some raw albumin), **low-cooked** and **cooked** depending on how they are prepared. Using the 'cold water start' method, a soft-boiled egg will take three minutes from the time the water boils, while a hard-boiled egg will take seven minutes (depending on size). Boiled eggs should be refrigerated immediately after cooking if they aren't to be eaten immediately. Boiled eggs should be stored at refrigeration temperatures and used within a few days of cooking as the majority of preparations will be classified as low-cooked or cooked and there is no standard storage time for these types of products. However, cooked eggs are easily contaminated with bacteria post-preparation and provide an ideal medium for bacterial growth even if fully cooked. The porosity of the egg is increased during cooking (damage to the shell integrity; especially if cold eggs are added to warm/hot water which can cause cracking/fractures) and whatever cuticle may have remained on the egg prior to cooking is completely removed during the cooking process. Therefore, a cooked egg in shell should not be assumed to be at less risk of bacterial contamination / proliferation than an egg that has been cracked out prior to cooking.

1.11.5. Fried eggs

Fried eggs can be cooked to a variety of thoroughness and can be classified as **raw** (raw yolk and some raw albumin), **low-cooked** and **cooked** depending on how they are prepared and the degree of cooking.

1.11.6. Other

Other egg dishes include eggs en cocotte, coddled egg and scotch eggs.

Scotch eggs are firstly soft boiled then peeled, surrounded with a sausage mince, crumbed and deep fried. It is desirable for the yolk to still be soft. If the sausage mince is applied too thickly, there is also a chance of serving undercooked mince.

The risk with these dishes centres on bacterial cross-contamination between utensils used to prepare the dishes. Although the final dish is often thoroughly cooked (or at least that is the aim), the various raw ingredients can be contaminated prior to use in other dishes that may not be cooked as thoroughly.

1.12. Sous vide cookery

Sous vide means ‘under vacuum’. It is a method of cookery where food is vacuum-sealed in food safe plastic pouches and cooked in a bath of water with precise temperature control. It can be used as a very controlled method of poaching. “62 degree eggs” on many menus indicate that the eggs are cooked at precisely 62 degrees. These eggs, and variations of these, would be classified as **low-cooked** as the eggs may not be fully cooked.

Sous vide cookery can be used to cook brûlée mixes (crème Anglaise, etc.) to good effect as the recipes work on a temperature and time gradient. The method is employed as a way to improve the safety of a dish. Some chefs have attempted to pasteurise egg pulp in the kitchen using the sous vide method, however the efficacy of this is unknown.

Any heat application method that applies a low/moderate level of heat over an extended period of time (to not coagulate the egg components but still cook the egg) is, in theory, similar to commercial egg pasteurisation. This means that although the temperatures aren’t at a level that will kill the majority of bacteria instantly or quickly, the extended time at lower temperatures can also kill bacteria through gradual degradation. It should be noted though that the time taken to reduce the bacterial contamination will vary depending on the time and the initial bacterial load.

1.13. Other

Some high protein shakes and some smoothies may contain raw eggs in an attempt to boost the protein content of the drink. Therefore, these egg products would be classified as **raw** and should be treated as other raw egg products - this involves immediate consumption, or storage of the preparation at refrigeration temperatures and ensuring that it is consumed or discarded within 24 hours. The level of cleanliness should be high for any utensils used to prepare of these types of drinks, as any aeration can spread food and therefore any associated bacterial contamination onto other food preparation surfaces / utensils / equipment. This provides ideal bacterial growth conditions and can easily contaminate any new dish that is prepared on the surface / with that utensil / equipment.

2. Eggs, *Salmonella* and Food Service

2.1. Receiving eggs

Only eggs that are visibly free from organic matter (faeces, feathers, dirt, etc.) should be used in the production of food for human consumption. Although bacteria can still be present on a visibly clean egg, the presence of organic matter significantly increases the risk that food prepared with those eggs will become contaminated. Not least because the bacteria can be present in the organic matter, but also the longer the organic matter is in contact with the shell, the greater the chance that bacteria from the organic matter can transfer into the internal contents of the egg through the porous shell. This is of particular risk if the dirty eggs are used to produce foods that are raw or low-cooked. Under the Food Standards Australia and New Zealand (FSANZ) Standard 2.2.2 it is prohibited to sell cracked or dirty eggs.

2.2. Cooking

Thorough cooking will destroy most bacteria, including *Salmonella.* This would be considered a kill step and the most effective way to manage *Salmonella* risk in a commercial kitchen. The time / temperature variables of heat application will impact on the level of bacterial destruction, as does the conditions to which the *Salmonella* has been exposed to prior to heat treatment. It is also known that the ingredients in the food within which the *Salmonella* is present also affect the growth and survival of *Salmonella*.

Heat resistance is increased in environments of low water activity but decreased in low pH environments. The addition of sugar to a food decreases the water activity of that food, and foods with very low water activity (such as chocolate) can present a high risk of *Salmonella* persistence and therefore presence.

Pasteurised egg products have been through a process that maintains the integrity of the egg contents but destroys bacterial contamination. The level of bacterial destruction will depend on the efficacy of the pasteurisation process. FSANZ Standard 1.6.1 currently requires that a single lot of commercially produced pasteurised egg be tested at least 5 times (25 g samples) for *Salmonella* only. Under FSANZ Standard 4.2.5 it is prohibited for egg producers to distribute egg pulp (contents of the egg) that has not undergone a kill step (i.e. pasteurisation or a time / temperature process that is shown to destroy bacteria). It could be argued that the mass preparation of egg pulp in a commercial kitchen to produce a raw egg product does not comply with this standard as no kill step is applied through the process.

2.3. pH

The pH of egg products is a variable that can be used to manage *Salmonella* risk in egg products, however, the food needs to be palatable. *Salmonella* will not grow at a pH below 4.2 (inhibits growth but does not destroy *Salmonella*). Common culinary sources of acids are vinegar, lemon juice, cream of tartar (tartaric acid), reductions for warm emulsion sauces (that are based on vinegar), wine, and other citrus fruits (such as lime). It is possible to balance the palatability and the pH of some foods. One benefit of cooking eggs with acid added is that is can extend the temperature to which a dish (such as a sabayon) can be heated without scrambling the eggs. Desserts could use fruit acids (such as lemon juice). It is not known whether the application of these types of acids could be generally applied to reduce the final pH to impact *Salmonella* growth, as there are many variables. These include, the initial acidity of the fruit used (can vary depending on season; size of fruit), the relative volumes of acid to food product, the pH of the food product prior to acidification and the appropriateness of the type of acid to the food product being prepared.

The optimum pH range for *Salmonella* growth is 6.5 – 7.5, and the minimum pH that influences growth can be influenced further by the incubation temperature and the presence of other substrates (such as salt). It needs to be considered that *Salmonella* must survive the highly acidic conditions in human stomach (below pH 3.5) in order to colonise the gut and cause disease. However, the relative volume of food in the stomach can protect *Salmonella* from these extreme pHs and it can therefore survive through to the gut. The type of food in the stomach may also influence whether the *Salmonella* are able to cause disease.

Another consideration is the ability to accurately measure pH in a commercial kitchen. Not all chefs would have the skills and knowledge (or time) required to undertake this, however there would be many instances where testing of food and possibly pH does occur for food safety reasons. This would apply particularly to mass-produced catered foods. For example, commercial food processors and hospitals (and other establishments that cater for 'at risk' groups) may have HACCP programs that require the testing of food samples. Some establishments that use sous vide or molecular gastronomy techniques may also test foods for a number of reasons. However, it could be expected that the common cafes and restaurants would not consider measuring the pH of food items.

2.4. Temperature, humidity and storage

Most salmonellae are not able to grow below 7°C. Therefore it is critical that foods that contain eggs that have not undergone a kill step (i.e. pasteurised eggs or thorough cooking) are either refrigerated or consumed immediately. It would be generally recommended that raw and low-cooked egg products should be discarded at the end of the food service day and no less than 24 hours after manufacture. These products must be handled following the "2 hour / 4 hour" rule and be refrigerated within 2 hours and discarded if out of the fridge for longer than 4 hours. It would be advisable to produce no more than a single service day's estimated amount of product to avoid discarding excessive amount of product. Containers should be cleaned thoroughly (at high temperature with appropriate chemicals) between batches (batches not topped-up) to prevent any bacteria that might have been present in a previous batch from contaminating any future batches.

The temperature gradient of the food product will vary depending on the size and shape of the container, the efficacy of the cold storage area in reducing the temperature, and how often the container is accessed (i.e. removed from refrigeration for use and then returned). It is possible that the internal temperature of a food may not ever reach the 'safe' storage temperature (i.e. below 7°C). These variables will impact on the safety of the food product, and will rely on the cleanliness of the ingredients and handling at the time of manufacture.

Humidity can impact on the safety of eggs in a number of ways. It can cause condensation on the surface of an egg which can happen in a number of situations, such as in an air-conditioned environment (dry) with very high humidity, or at ambient temperature in a humid environment. Water on the surface of an egg shell not only facilitates movement of the bacteria into the internal contents of the egg (*Salmonella* is a motile bacterium) but also provides opportunity for bacterial proliferation on the egg surface. Most bacteria present in a dry, desiccated environment will not grow (but won't necessarily die either).

3. Recommendations

There are a number of recommendations associated with this report:

- This report should be reviewed, updated and maintained in collaboration with key environmental health officials and food service outlet representatives, to ensure accuracy and usefulness of information.
- A summary handout that can be provided to relevant stakeholders should be produced.

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