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The Most Toxic Component of Chili Con Carne

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Abstract

In this paper, the toxicity of the three main ingredients chili peppers (capsicum), kidney beans and mince in the popular dish Chili Con Carne were investigated. It was found that all three components caused similar symptoms but had different measures of toxicity. Capsicum has a LD₅₀ of 161.2 mg/kg in rats and 118.8 mg/kg in mice. Kidney beans have a hemagglutinin unit of between 20,000-70,000 hau and Salmonella poisoning in mince can be caused by as few as 4.89×10^{13} bacteria (assuming un-limiting conditions). As the measures of toxicity could not be compared, the most harmful ingredient was deemed to be raw/undercooked meat as it could lead to *Salmonella* poisoning which can result in typhoid fever, found to cause around 500,000 deaths per year.

Introduction

Chili con carne is a popular dish which consists primarily of mince and kidney beans. It also contains chili peppers, onions, tomatoes and spices [1].

As a cooked dish the main component that can cause harm is the chili peppers (fruit of the capsicum plant) [2]. Foods from capsicum contain the chemical capsaicin, which can be harmful when ingested in both cold and warm food. If the dish is undercooked or raw then both the mince and kidney beans can cause harm. Raw meats such as beef mince can be contaminated by bacteria if not heated to a high enough temperature, commonly by *Salmonella* [3]. Kidney beans contain a toxic component that is present in relatively high levels when the beans are uncooked [4].

Toxicity of Capsicum

Symptoms caused by ingesting too much capsicum include severe burning mouth sensation, mouth pain, itchiness, vomiting, nausea and diarrhoea [5]. Capsaicin is a chemical that stimulates the same sensory receptors (TRPV1 receptors) in the mouth that detect thermal heat [6]. These receptors then activate the sympathetic nervous system and produce similar effects to when a person feels overheated [7]. This included thermogenesis (heat production in the body), systolic blood pressure and heart rate increase [8]. It can also cause inflammation as a result of nerve excitement. This is due to the effect capsaicin has on C-fibre primary afferent neurons which release neuropeptides [9].

A high dose of capsicum can cause tissue inflammation, which can trigger an inflammatory response such as anaphylactic shock [9].

The tissue inflammation can also cause gastrointestinal tract irritation and cases of this commonly occur when people take part in chili eating contests [9, 10].

It has been found from acute oral toxicity studies that the LD₅₀ (median lethal dose) of capsaicin is 161.2 mg/kg in rats and 118.8 mg/kg in mice [11] LD₅₀ is the dose of a substance required to kill 50 percent of the organisms in the sample population [12]. Although there is little information on the specific dose of capsaicin required to kill humans, there have been some recorded cases where people have died by eating too much chili peppers or chili powder. This is due the patient suffering anaphylactic shock as a result of ingesting capsaicin [9].

Toxicity of Kidney beans

Consumption of undercooked kidney beans results in symptoms of nausea, vomiting, diarrhoea and abdominal pains. These symptoms usually appear ~1-3 hours after consumption of raw or undercooked beans and recovery usually takes 3-4 hours after symptoms appear [4].

The toxic component of kidney beans is a type of lectin known as phytohaemagglutinin [13]. Lectins bind to certain specific glycoproteins present on the

cell surface of animal cells [14]. The lectins bind to epithelial cells in the gut when not digested properly [15]. This can cause gastroenteritis in humans (inflammation of stomach and intestines) as the lectin affects the Gastro Intestinal (GI) tract by inhibiting plasma membrane repair of GI tract cells and the exocytosis of mucus, which helps in the repair process [15].

In raw red kidney beans, the concentration of phytohaemagglutinin present is 20,000-70,000 hau (hemagglutinating units). As lectins are known to agglomerate red blood cells [15], this unit describes the level of this agglomeration caused by the kidney bean toxin [13]. Although there is no LD₅₀ value available for kidney bean toxicity, a study that has shown that rats fed raw kidney bean at a level of 1 % of their diet died after 2 weeks of consumption [17]. Although there have been several cases of kidney bean poisoning outbreaks in the late 1970's, there have actually been no recorded human deaths as a result of this type of poisoning [18].

Salmonella poisoning

Raw or undercooked meat causes harm when it is contaminated with bacteria such as *salmonella* [19]. The symptoms caused by this salmonella poisoning are diarrhoea, fever, vomiting and abdominal cramps [20].

Intestinal inflammation occurs as the result of the accumulation of *salmonella* bacteria in the intestine lumen [19]. The *salmonella* bacteria are usually constrained within the intestines but if the infection spreads to the blood it can survive in other areas of the body such as the lymphatic system [21]. This leads to typhoid fever which can become fatal if not treated with antibiotics [18, 21]. Non-typhoidal salmonellosis caused 378 deaths in the US in 2006 [22] whereas typhoid fever caused around 500,000 deaths per year [23].

For diseases caused by bacteria there is usually an infectious dosage at which a certain number of bacteria cause food poisoning symptoms. This value depends on the serotype and is usually 10³-10⁵ bactilli for *salmonella* [23].

Assumptions

As it is difficult to determine how many initial bacteria are present in the contaminated meat, for the calculation the minimum inoculum size

(minimum amount of bacteria present in infected meat) of 1 bacterium has been assumed.

For *Salmonella enterica* which invade the epithelial cells of the gut, the average generation time is ~95 minutes [25]. This is the time it takes for binary fission of the bacteria to occur (a.k.a. doubling time) [24]. This value is also dependent on the temperature and pH in the gut [25].

The symptoms of salmonella poisoning appear after ~12-72 hours of the bacteria entering the body [19]. For our calculation we assumed that symptoms appear after 72 hours (upper limit of incubation period range).

The calculation also does not take into consideration all of the factors that can limit bacteria growth in the human body such as space and nutrient availability.

Calculation

$$\text{Generation Time} = \frac{\text{Time interval}}{\text{Number of generations 'n'}}$$

$$\text{Number of generations 'n'} = \frac{\text{Time interval}}{\text{Generation Time}}$$

$$n = \frac{4320 \text{ mins}}{95 \text{ mins}} = 45.5 \text{ (3 s.f.)}$$

As bacterial cells grow by binary fission [24]:

$$\begin{aligned} N(\text{bacteria at end}) &= N(\text{bacteria at start}) \times 2^n \\ &= 4.89 \times 10^{13} \text{ (3 s.f.)} \end{aligned}$$

Therefore 4.89×10¹³ bacterial cells are present after the incubation period of 72 hours (3 s.f.).

Although this value is significantly bigger than the 10³-10⁵ bactilli expected for *salmonella*, it does not consider the limiting factors.

Conclusion

All three ingredients of chili con carne can potentially cause harm if the meal is uncooked. The symptoms caused by each are very similar and as the toxicities of each cannot be compared, it was deemed that the most harmful ingredient is undercooked meat. This is as it could result in *salmonella* poisoning and later typhoid fever, responsible for ~500,000 deaths per year. In comparison there have only been a relatively small number of deaths due to capsicum poisoning and no recorded deaths due to kidney bean poisoning.

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