A Problem Of Beriberi Disease

Beriberi: A Cure, a Cause, and the Significance of Chickens

Beriberi, a disease caused by a deficiency in thiamine, has a much longer history than I imagined upon hearing it mentioned for the first time. Having been recognized in cases even outside of Asia, it had many names: kakké in Japan, perneiras in Brazil, maladies des jambes in Louisiana. Polyneuritis was the term used by physicians. With scientific discovery in the 17th century focused on the work of chemist Louis Pasteur and bacteria (Carpenter 31), there was one major theory that seemed to dominate the study of beriberi, and that was the belief that it was caused by some bacterial infection. Christiaan Eijkman, one of many who sought to find the exact cause and cure of the deficiency, made great strides in his work with chickens and rice that helped pave the way for future research to unlock the great mystery of beriberi. While Eijkman's contributions are the most recognized in the study of beriberi (Eijkman won a Nobel Prize for it in his old age), accounts of his trials are best supplemented with the earlier work of Kanehiro Takaki and the later work of Adolphe Vorderman.

Kanehiro Takaki, a surgeon, was also an important figure in the beriberi case in that he debunked the traditional idea that beriberi, or kakké as it was known to Japan, was caused by a miasma, or poison, present in the soil. Having noticed the cases of the disease appearing aboard the Japanese naval ships, Takaki knew soil could not be the problem. He was also reluctant to accept hygiene as a factor since the ships were fairly new and made to the standards of the Europeans, who suffered far less, if any, cases of beriberi. In recognizing the differences between the diets of the Japanese fleets versus the German fleets, Takaki surmised that nutrition was the key to reducing incidences of the disease. His theory was proven to be correct, at least on a surface level, when the cases of beriberi decreased with the introduction of a diet that more closely resembled the diets of the Europeans. Takaki concluded, therefore, that beriberi was strictly a nutritional deficiency, although, like others at the time, he attributed it to an absence of protein or fat, both things the Japanese diet tended to lack in the summer months when cases of beriberi became the most prominent (Carpenter 2).

Despite this solution, other researchers held firm in their belief of beriberi as an infection caused by "microbes" (Carpenter 31). Christiaan Eijkman was not yet a part of any studies related to beriberi, but another Dutchman, Cornelis Pekelharing, who was assigned to a study in the East Indies, got permission for Eijkman to continue take part in his commission. Pekelharing was another believer of the infection mindset, or what Kenneth J. Carpenter calls "the microbial theory of disease" (31). After spending a few months performing autopsies, Pekelharing suspected a that a poison or infection was causing the peripheral nerve damage that he observed in the bodies. He began to culture bacteria from the blood of those infected with beriberi, attempting to infect animals and hopefully find a cure from there. Eijkman, having finally recovered from his illness, joined Pekelharing shortly after and was instructed to carry out the animal trials in his stead.

Like Pekelharing before him, Eijkman tried to culture certain strains of bacteria from the blood and injected them into, in his experiments, chickens. After a few months, he autopsied some of the dead chickens and found the same nerve damage that Pekelharing had observed. But after

separating the controlled chickens from the injected ones, Eijkman realized the birds were getting sick whether or not they had been given injections. A couple of months later, the birds then began to recover from the beriberi symptoms, which only confused the matter even further.

Fortunately, Eijkman was able to find out the entire issue may have been related to the rice that was being fed to the birds. Now, these experiments had been taking place in rooms that were attached to a military hospital, so the feeding of these birds were the responsibility of the hospital chef. Originally, the birds were being fed a red type of rice that had not been highly processed like the white rice that was being produced for people. But there had been a change of staff during the experiments, and the new chef had been asked to feed the chickens the leftover hospital rice for economic reasons (Carpenter 38). The staff had changed again, and the birds were back on their regular diet of “unpolished” rice. Eijkman noted that the timing of these staff and diet changes coincided with the chickens’ onset of and recovery from the beriberi symptoms. To test this theory, Eijkman took 3 diseased hens, 2 injected hens, and 2 controlled hens and fed them the feed-grade, unpolished rice (Carpenter 38-39). He also bought 4 new chickens and fed them the polished, day-old hospital rice. He found that the diseased hens recovered from their symptoms, and that the four new chickens became sick from the polished rice and recovered after being switched back to feed-grade rice. Eijkman began to speculate then that cooking rice somehow released a poison that was responsible for the beriberi disease.

This development was not all too exciting as rumors about rice being the culprit behind beriberi had been surfacing around this time in spite of Eijkman’s observations. It made a lot of sense too, considering beriberi was most prevalent in Asia, where rice was, and still is, a staple crop. Additionally, part of the success behind Takaki’s diet changes on the navy ship included switching out half of the usual rations of rice with barley, a whole grain that was not refined to the degree that white rice was, which suggested a connection between rice and beriberi. What Eijkman’s trials did do, however, was serve as truer empirical evidence to support that connection, since the diet in his trials was isolated to different types of rice.

Eijkman continued his trials with the chickens to find out the exact difference that made the one type of rice harmful. One of the other ideas floating around the dangers of rice was that polished rice spoiled quicker, and so at first, Eijkman thought that perhaps the chickens had gotten sick because the day old rice they were fed was spoiled. He began his new trial by feeding the chickens freshly cooked polished rice, but the chickens still became sick. Then he thought that maybe there was something in the white rice that was preventing its nutrients from being fully absorbed, so Eijkman began feeding the chickens more minimal amounts of the red, feed-grade rice, but the chickens died of starvation, and having autopsied the birds, Eijkman found no trace of the peripheral nerve damage observed when having fed them the white rice. Eijkman then heard of another theory that suggested infected water may be the cause of the beriberi disease, since he was still cooking the white rice before feeding the birds, and rice was cooked in water. This idea too turned out to be incorrect after he used water from a local well to give to the birds, who were unaffected by it. Eijkman’s next trial focused on the cooking of the rice. For this trial, Eijkman fed the birds uncooked polished rice and cooked unpolished rice to test if cooked rice was the reason for the disease. But the results were no different. The polished rice still made the chickens sick, whereas the unpolished rice did not.

At this point, Eijkman took the time to see how the different types of rice were processed. He noticed that for the polished rice, the bran, what he called “silver skin”, was removed, whereas

it was left intact for the feed-grade rice. Eijkman saw two possibilities from this practice: one, the bran protects against bacteria, or two, the bran contains important substances that are absent in processed grains.

To test for the first possibility, Eijkman milled his white rice fresh, wondering if perhaps the white rice had become contaminated sitting on a shelf in absence of its bran. But the chickens still got sick. In his next trial, he used both ground unpolished rice and whole unpolished rice to feed to the birds. None of the chickens became sick, which suggested that the second possibility was more probable. Eijkman began to surmise that perhaps it was the fiber in the bran that made unpolished rice safe for consumption. In the following trial, he added the rice husks to the white rice before feeding it to the chickens, assuming that the bulk and texture from the husks would act as an ample substitute for the bran. The chickens still got sick. Then Eijkman measured the proportions of proteins in the grains, assuming that perhaps a difference in protein, as suggested by Takaki and other doctors at the time, was the answer. Finding that the protein content of both types of rice were equal in proportion based on the quantity of rice eaten by the birds, he deduced that protein was not a factor. Eijkman's last couple of trials debunked the idea that rice was the only cause of beriberi by feeding the chickens tapioca starch, which led to the same peripheral damage present in the chickens that had died from beriberi.

A conversation with physician Adolphe Vorderman helped to expand upon Eijkman's research. Vorderman, a physician as well as a prison inspector, was a friend of Eijkman's and was very interested in the chicken trials. As an inspector in Indonesia, he observed many cases of beriberi in some of the Javanese prisons, and not others. Comparing the prisoners' diets to the chickens', Vorderman suggested that since the quality of the rice varied from prison to prison, they could find out from prisoner statistics if Eijkman's findings with the chickens were relevant to the human strain of beriberi.

Vorderman began by writing letters to each prison, inquiring about the type of rice that was being served to the prisoners and about the prevalence of beriberi. From the responses he received, it became clear to him and Eijkman that incidences of beriberi were most present in the prisons that served white, polished rice. The two received permission to conduct a larger study at the prisons that year in 1896, but Eijkman, becoming ill once again, had return to Holland, leaving Vorderman in charge of the new study. The physician spent the next five months studying the samples of rice fed to the prisoners, the hygiene of each building, and the cases of beriberi at the one hundred and one prisons in Java. The data showed no correlation between hygiene and incidences of beriberi, but it did show a correlation between rice and the incidences of beriberi, proving that Eijkman's chicken trials had some merit in their implications that whole grain, or brown, rice had some property that protected against the disease (Gabriel & Fogel 75-77).

Eijkman continued his studies in Holland, repeating the chicken trials at home, but despite the progressive research he was doing in the beriberi studies, he remained adamant in the idea that beriberi was caused by infection. Eijkman argued against Takaki's findings that claimed beriberi was the result of an unbalanced diet, believing that it was only one of many factors that helped to remedy the disease. And, in fact, his own findings were also harshly criticized. One person ridiculed the fact that his chicken and rice studies took over six years (Carpenter 52). Nonetheless, the chicken trials are widely recognized in the field of biology as one of the greatest experiments in its history, according to Gabriel and Fogel (74), and, in 1929, the Nobel Prize organization recognized Eijkman's efforts as the necessary stepping stone to the

discovery of vitamins at the beginning of the 20th century, awarding Eijkman in the field of Physiology or Medicine.