Chapter 10
Kaanga Wai: Development of a Modern Preservation Process for a Traditional Maori Fermented Food

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10.1 Introduction

Kaanga wai (or kaanga kopiro) is a traditional fermented food produced by the Maori of New Zealand from maize (*Zea mays*). It has been prepared by Maori since the early 1800s (Asmundson et al. 1990). The traditional process involved putting whole cobs into woven flax bags and immersing them either in a stream of running water or in slow-moving swamp water (Whyte et al. 2001). The bags were kept submerged for 2–3 months, after which the maize was judged ready by squeezing

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the kernels to check that they had softened. The cobs were removed from the bags and kernels were scraped from the cobs before grinding using a stone mortar (Asmundson et al. 1990). The distinctive flavour was highly prized by some Maori and the product was consumed as a porridge, often with cream and sugar (Asmundson et al. 1990), but it was also boiled and mixed with manuka ash in a product known as Kaanga pungarehu (Roskruge 2007), or dried and used like flour in cake and bread making.

Modern production of Kaanga wai was almost non-existent until a revival in the last 20 years or so—pollution of streams, theft and the loss of suitable cultivars were significant factors, but the influence of western missionaries on Maori to give up their "unwholesome" and "uncivilised ways" and changes in the attitudes of young Maori also resulted in a decline in the number of people with the knowledge and experience to produce Kaanga wai. There is also very little published material on production and qualities of Kaanga wai.

The modern, non-commercial fermentation process differs little from the traditional method, but there has been some evolution to use more modern materials, such as hessian sacks, sometimes with muslin or cotton flour bag lining, instead of the flax bags. In some cases, the traditional whole cob process has been replaced by stripping the kernels from the cobs before the fermentation. Also, some practitioners are using drums with water reticulation to replace the need to place the cobs in natural sites.

Programmes have been founded to aid the re-establishment of the traditional varieties of corn and maize (generally Indian corn) for fermentation; many modern cultivars contain too much sugar to be suitable for Kaanga wai production (personal communication, Taanehopuwai Trust 2003).

10.2 The Traditional Fermentation Process

The best maize variety to use for the fermentation is an old cultivar referred to simply as "Kaanga" (Taanehopuwai Trust 2003), which is nuttier in flavour and is a much darker colour than sweet corn. These traditional varieties are generally referred to in literature as "Indian corn" and are maize cultivars which have open pollinated over generations. One old cultivar with very white kernels, found in the Waikato region of New Zealand, was known as Niho hoiho (horse's teeth) because of the size of the kernels and this was the old preference.

The two methods of preparation currently used are whole cob, and fermentation of kernels stripped from the cob (Figs. 10.1 and 10.2). In both methods, the cobs are left on the plant until the kernels have dried and hardened, judged on the plant once the cobs hang. This translates to a moisture level in the kernels of 12–14 % at harvest (Roskruge 2007). The outer leaves of the cob are left on and the whole cob is placed in a jute or hessian bag. The bag is completely immersed in running water in a pool in a creek and left for 2–3 months to ferment. At intervals the corn is checked by squeezing between finger and thumb—if the kernels are soft, then the corn is ready; if the kernels are still hard, the bag is put back into the water. If the kernel method

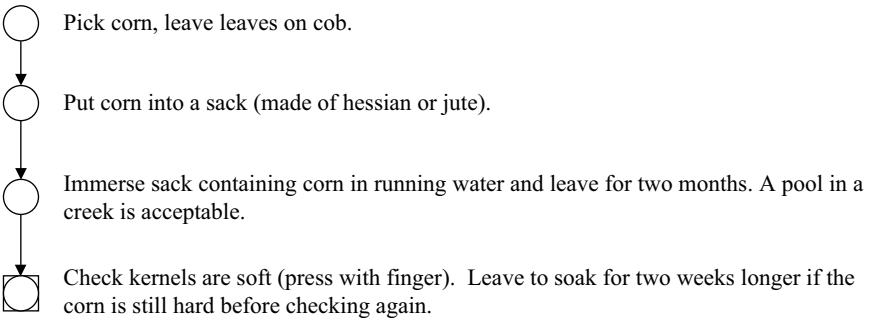

Fig 10.1 Flow diagram for the whole Cob method

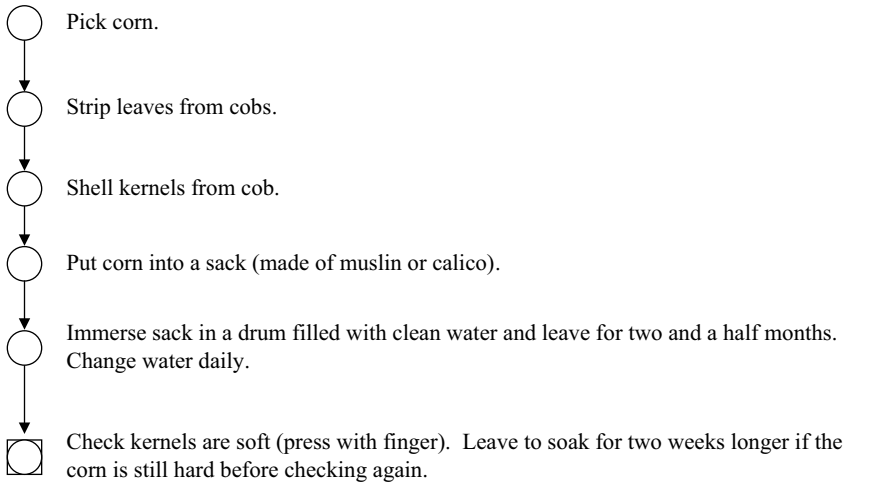

Fig. 10.2 Flow diagram for the Kernel method

is being used, the kernels are removed from the cob and placed in a muslin or calico bag, which is then placed in a drum of clean water. The water must be changed every day to simulate running fresh water. Again, the kernels are left for 10 weeks and checked for softness at intervals.

10.3 Microbiology and Safety

Since the Kaanga wai fermentation is uncontrolled and no starter culture is used, it is important to understand the course of the fermentation and the microbes to ensure that all appropriate steps are taken to minimise risks to the consumer.

Both aerobes and anaerobes can be isolated, together with typical fermentation products, such as lactic acid and volatile fatty acids (VFA) (Asmundson et al. 1990). Lactic acid is produced between 2 and 20 days, but is slowly replaced by VFA. At 1.5–2.5 months propionic acid appears, but *n*-butyric acid, which is probably what gives the product its characteristic smell, predominates by the time the process is considered complete.

As in most natural fermentations, there is a succession of bacterial types observed. Initially lactic acid bacteria predominate—strains of *Lactococcus* and *Leuconostoc* dominate the early fermentation and during this time the lactic acid concentration rises rapidly. *Lactococcus* disappears from the fermentation after 23 days, but *Leuconostoc* survives for more than 67 days (Asmundson et al. 1990).

A major concern with natural fermentations is that the pH may not fall sufficiently to inhibit *Clostridium botulinum*, a spore-forming strict anaerobe that produces botulin, a neurotoxin that is extremely toxic even at low concentrations (Byrne et al. 1998). Asmundson et al. (1990) isolated a butyric acid producing *Clostridium* species from their samples, indicating that *C. botulinum* could potentially be present in the product. However, it appears that *C. botulinum* does not compete well with large numbers of other microorganisms (Montville 2008) and toxin containing foods are generally devoid of other types of bacteria because of thermal processing (Jay et al. 2005). However, Whyte et al. (2001) have concluded that the Kaanga wai preservation process is relatively low risk, provided that there is an adequate cooking step before consumption. In addition, if the fermentation process has failed, potentially allowing pathogens to grow, there is reported to be an obvious strong, sharp, bitter taste that would warn against significant accidental consumption. It should be noted that botulin is so toxic that a taste sample might contain sufficient toxin to cause illness. However, the toxin is heat labile, so tasting a cooked sample would be safe. These workers concluded that normal safe food handling practices and the use of uncontaminated water for the production process would be sufficient to prevent food poisoning from consumption of this food.

10.4 Packaging

Traditionally, the Kaanga wai was consumed as soon as it was ready to eat. However, the Taanehopuwai Trust (a member of the Tahuri Whenua collective, www.tahuri-whenua.org.nz) wanted to develop a shelf-stable product that could be stored and prepared easily. A retortable pouch was the obvious choice. These packages have been described by Downing as consisting of a flexible pouch-shaped container generally made of a three-ply laminate consisting of polyester film, aluminium foil and polypropylene film to give "superior barrier properties for a long shelf life, seal integrity, toughness and puncture resistance" (Downing 1996). The retortable pouch is currently used for packaging a variety of food products, including meats, sauces, soups, fruits, vegetables and pet food.

10.5 Thermal Processing

Foods packed and stored in hermetically sealed containers must be heat processed to ensure safety, particularly if the product pH is above 4.5 since these conditions may allow the growth and toxin production of *C. botulinum* (Weddig et al. 2007). The thermal process is designed using the known heat resistance of *C. botulinum* spores and the measured heat penetration into the slowest heating point (SHP) of the product. It is critical to determine the SHP accurately to ensure that the entire product receives an adequate thermal process. To ensure that worst-case conditions were accounted for in the development of the thermal process, an assumption was made that Kaanga wai would be classified as a low acid food, since its pH may be greater than 4.5, so by regulation, it must be given a thermal process that will reduce the number of *C. botulinum* spores present by a factor of 10^{12}. This is referred to as a 12-D process (Weddig et al. 2007)

10.6 Determination of the Thermal Process

Retortable pouches have a complex geometry, particularly if there is a gusset at one end. To measure the heat penetration and determine the SHP, thermocouples were inserted into the pouches through the base and held in place by plastic pillars (Figs. 10.3 and 10.4).

The pillars ensured that the thermocouples remained in the desired position within the pouch and were made of plastic, rather than metal, to minimise the heat sink effect. The thermocouple was secured in the base of the pouch, using a rubber washer on the outside of the pouch and a brass washer and nut on the inside, thus effectively sealing the pouch so that it did not leak during retorting. The pillars were secured through the sides of the pouch using rubber o-rings and cap screws. Pillars were placed at three different positions within the pouches to enable the SHP to be determined.

The quantities of Kaanga wai presently available are relatively small. The pouches were therefore filled with 540 g of Cream Style Corn (Wattie's, Hasings, New Zealand) and vacuum-sealed at 350 mbar. This product is similar to the fermented Kaanga wai and provided a convenient model system, though it should be noted that Cream Style Corn has already been processed and the starch is therefore gelatinised, altering the thermal conductivity of the product. An automatically controlled retort (steam pressure vessel) with an Allen-Bradley supervisory control and data acquisition system (Rockwell Automation, Milwaukee, Wisconsin) was used to process sealed pouches at 115 °C for 90 min (see Fig. 10.5). The temperature profiles from the thermocouples were recorded and the real time value of F_0 was automatically calculated using Simpson's rule (Timings and Twigg 2001).

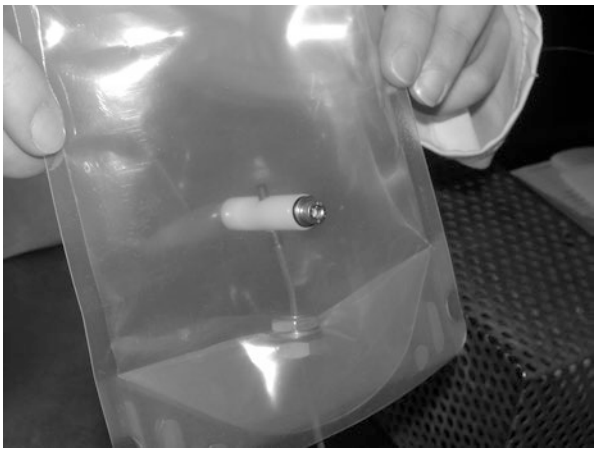

Fig. 10.3 Thermocouple held in place in retortable pouch

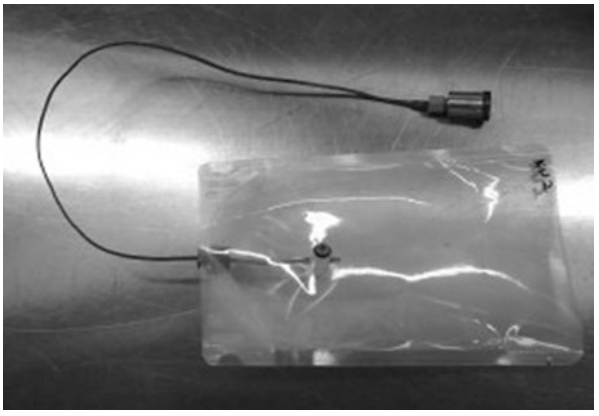

Fig. 10.4 Pouch assembled ready for retorting

Fig. 10.5 Automatically controlled and monitored retort (steam pressure vessel)

From the temperature–time profile, the lethal rate can be determined from the equation:

$$L = 10^{\left((\theta-\theta_{\text{ref}})/z\right)} \tag{10.1}$$

where L = lethal rate, θ = product temperature (°C), θ_{ref} = reference temperature (°C), and z = the temperature range over which the D-value decreases by a factor of 10 (°C).

From the lethal rate, the lethality (or equivalent time) of the process can be calculated, using the following integration:

$$F = \int_0^t L dt = \int_0^t \left(10^{\left((\theta-\theta_{\text{ref}})/z\right)}\right) dt \tag{10.2}$$

where F = lethality (F_0 = lethality using a reference temperature of 121.11 °C and z = 10 °C). L = lethal rate. So, for a 12D process:

$$F_0 = D_r\left(\log C_0 - \log C\right) = 12D_{\text{r}},$$

where F_0 = integrated lethal value of heating using a reference temperature of 121.11 °C and z = 10 °C. D_r = value of D determined at 121.1 °C, C_0 = initial concentration of spores, and C = final concentration of spores.

A local processor of canned corn recommended an F_0 of 9 min, which, taking D_r as 0.21 min and z as 10 °C would result in a 42 decimal reduction in spores, ensuring the safety of the finished product. The SHP was found to lie between 60 and 80 mm from the base of the pouch and the final process design was a processing time of 100 min at 115 °C.

10.7 Thermal Processing of Kaanga Wai

The Kaanga wai was prepared for processing according to the following flow diagram (Fig. 10.6).

The appearance of the minced product was quite different from the traditional product, which is made by pounding the whole kernels with the bottom of a strong glass bottle. Mincing of the kernels resulted in a smaller particle size, with more of the kernel contents released, increasing the starch content of the liquid fraction and giving a drier appearance.

Traditional preparation of the Kaanga wai involves mixing the mashed kernels with water in the ratio 1:4 (Kaanga wai:water). For this reason, various ratios of water to corn were processed and compared. Where higher ratios of water were used, there was a tendency for the product to separate before thermal processing. This problem was resolved by pre-gelatinising the product in water at a ratio of Kaanga wai:water of 1:2 before filling into pouches. The finished product was homogeneous, though slightly too thick. The final process could therefore include a pre-gelatinisation step, or the pouches could be processed in an agitating retort.

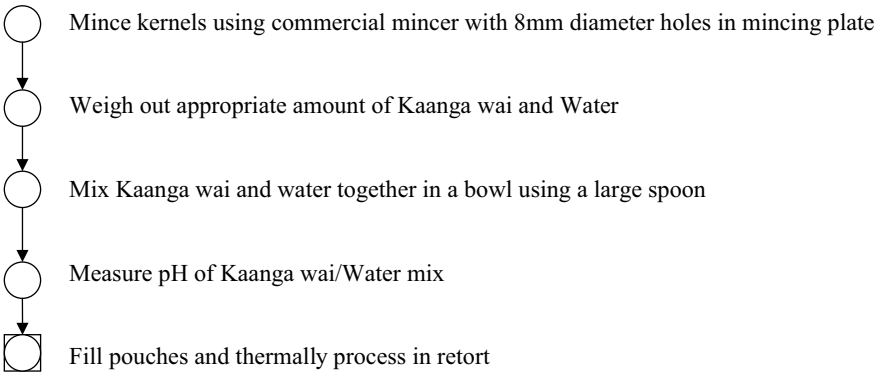

Fig. 10.6 Kaanga wai preparation

The large amount of water required to produce a product of the required consistency suggests that there is a large amount of starch still present in the fermented corn and implies that little starch is hydrolysed during the fermentation.

10.8 Comparison of Traditional Kaanga Wai with Model Cream Style Corn during Thermal Processing

When the lethality curves for commercially minced Kaanga wai were compared with the Cream Style Corn model, it was found that heat transfer occurred much more rapidly into the Kaanga wai. This is almost certainly because the Cream Style Corn had already been gelatinised by its earlier processing and was thus more viscous, whereas the Kaanga wai thickened only during the heating process. The use of the model is therefore not valid, though the product would be over-processed, rather than potentially dangerously underprocessed.

10.8.1 Sensory Evaluation

Preliminary sensory evaluation of the new product was undertaken with a consumer panel drawn from local Maori familiar with the traditional product. This in itself presented difficulties: there has been little production of Kaanga wai for many years and finding sufficient Maori who knew the product was challenging. The retorted product was compared with a sample of the traditional Kaanga wai, which was prepared by adding two cups of the fermented corn to four cups of boiling water and simmering for 1 h. The retorted product was slightly too thick, so a small amount of water was mixed into the product before it was heated to boiling point. Both products were kept at 65 °C in a Bain-Marie prior to being served to the panellists.

The products were compared with a difference test designed to detect whether there is an overall difference between the products rather than a difference in a specific characteristic. The test used was a two-out-of-five test. The number of panellists required to take part in this panel in order to give statistically significant results is between 10 and 15 people.

A nine-point hedonic scale test was used for acceptance testing. Panellists were asked to rate two samples presented (one of each product). The number of panellists required to take part in this panel in order to give statistically significant results is between 60 and 100 people.

The numbers of panellists available fell below these minima, so the results are not statistically significant, but do give an indication of consumer response to the product. In the difference test, only one out of seven panellists correctly identified the two samples that were the same. There was no difference in acceptance between the two samples; both had a mean acceptance rating of "Like slightly". This may, however, be misleading, as panellists generally fell into two groups—either they liked the product very much (5/7) or they disliked the product (2/7).

10.8.2 Shelf Life Testing

It is impossible to conduct accelerated shelf life testing of the retorted Kaanga wai as there are no substantially similar products on the market with which to compare results. Shelf life testing must therefore take place over a full year, with appropriate tests being conducted every month. Suitable trials would involve two sets of samples, one set being frozen to provide a reference and the other stored at constant temperature and humidity (20 °C and 75 % RH). These constraints are critical, as moisture and gas exchange with the product through the laminate of the pouch is possible. So far, such trials have not been conducted. Ideally, appearance, texture and flavour of the product should be tested by a trained panel, using difference and acceptance tests. If resources are limited, a larger consumer panel could be used. This presents some problems for Tahuri Whenua, as in order to ensure accuracy and repeatability of results; at least 40 consumers will be needed each month to test the samples. Other analyses that should be made at the monthly intervals are colour, viscosity and texture measurements.

If the sensory panel results are shown to be correlated with instrumental measurements, then quality standards can be developed that will allow instrumental tests to be used to determine acceptability of the product to consumers.

10.9 Legal Issues

Because of the implications of the New Zealand Food Act (1981) and the unique position of Maori as partners in the Treaty of Waitangi, there are a number of issues that may have to be resolved if this process is developed further, especially those relating to intellectual property.

The product is partially processed at an unlicensed premise, i.e. the corn is fermented in a stream. This will become important if the product is sold to consumers outside the Iwi (tribe), as the product would then be considered to be commercial and would therefore be required to meet the Food (Safety) Regulations 2002 (New Zealand Government 2002). This specific issue might be addressed through the application of HACCP principles and effectively regarding the fermentation phase as "harvesting". Perhaps the aspect of most concern during the fermentation phase is the potential for chemical contamination of the product from farm run-off and industrial discharge. Proper application of HACCP would require that the water be tested for presence of industrial and agrichemicals on a regular basis.

Care must also be exercised in the handling of the raw fermented corn. The fermentation occurs under essentially uncontrolled conditions, so whatever microorganisms present in the water and on the corn may take part in the fermentation process. Some of these microorganisms may be harmful to the workers or may produce toxins in the raw material.

During the development of the process described above, the pH of the fermented product was found to lie between 3.67 and 3.75. Further testing will be required on many batches of Kaanga wai to determine whether it is a low acid food (i.e. has a pH greater than 4.5). If it is found that the pH is occasionally greater than 4.5, then the product will either require acidification or be processed as a low acid food. In either case, a scheduled thermal process will have to be filed and the product will have to be processed according to the schedule at an approved food processing premises, in accordance with Regulation 14 of the Food Safety Regulations 2002 (NZFSA 2011).

The second issue is that of intellectual property. The fermentation process is a traditional method employed by the New Zealand Maori (and incidentally, in the production of "tocos" by the Ancash Indians of Peru) and should probably be regarded as public property. However, under the Treaty of Waitangi, the rights of Maori must be carefully considered in relation to traditional plants, medicines and foods. A problem could arise if any individual or group were to try to patent the process or to develop the process commercially and then patent it. Ownership and use of traditional knowledge is a major issue for both Maori and Pakeha (non-Maori) and has been the subject of the WAI262 claim to the Waitangi Tribunal. The report of the Tribunal was released in July, 2011 and will influence future law and policy affecting Māori culture and identity, native flora and fauna (Waitangi Tribunal 2011).

Further investigation of all these issues will be essential if the process is to be fully commercialised and the product sold to the general public.

10.10 The Future

The best option for the Tahuri Whenua at this stage of development of the product would be to prepare the raw material to the processing stage and then contract a suitable food manufacturer to package the product and apply a heat treatment, possibly in accordance with a scheduled process.

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