Nutritional and toxicological studies on New Zealand Mutton bird meat (*Puffinus griseus*)

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New Zealand mutton bird or tītī (*Puffinus griseus* and order procellariiformes*)* nest in New Zealand during the summer months, migrate to the northern hemisphere during May and return in September. Their eggs are laid during November and December and the chicks are hatched in the following January and February. Large numbers of them are harvested from April to May in New Zealand. They are wild seabirds annually harvested by Maori according to the customary rights agreement set by Treaty of Waitangi.

NZ mutton birds also called Sooty Shearwaters are noted for their high proportion of body fat.These birds are interesting since its sole diet is based on krill and other small marine organisms that are potentially rich in n-3 fatty acids and other marine bioactive compounds. The proximate composition, fatty and amino acids and cholesterol content of mutton bird pectoral muscle were determined and compared with other common meat to explore the nutritional value of this New Zealand delicacy. The concentration of twenty two essential and toxic elements including silver (Ag), aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), manganese (Mn), lead (Pb), selenium (Se), potassium (K), calcium (Ca), magnesium (Mg), boron (B), iron (Fe), nickel (Ni), sulphur (S), sodium (Na) and cobalt (Co) and zinc (Zn) in mutton bird breast meat (*Puffinus griseus*) were measured over two years to evaluate its safety for human consumption. Persistent organochlorine, dichlorodiphenyltrichloroethane (DDT) and their metabolites, and aldrin and lindane were also measured.

Twenty bird carcasses were purchased in both 2006 and 2007 from a local source. Meat samples from the pectoral muscle of two carcasses were pooled to generate 10 samples for each year. These were used for trace element analysis using inductively coupled plasma-mass spectrometry (ICP-MS). Trace elements were in the range of 0 to 1.09 mg/kg wet weight for Ag, 0 to 3.32 for Al, 0.17 to 0.79 for As, 0.01 to 0.07 for Cd, 0.03 to 0.15 for Cr, 3.56 to 4.88

for Cu, 0 to 0.15 for Hg, 0.22 to 0.50 for Mn, 0 to 0.09 for Pb, 0.66 to 1.18 for Se and 11.49 to 23.70 for Zn. In 2006, Ag, Al, Mn and Zn concentrations were significantly higher but Pb and Hg concentrations significantly lower compared to the 2007 samples ($P < 0.05$). Apart from one sample in 2006, all the samples were below the published maximum level for concern. However, our preliminary data indicated that the higher level of Cd and other metals in the skin of mutton bird may compromise the overall safety to humans consuming the skin of mutton birds. It is suggested that the evaluation of the metals in different parts and/or the whole mutton bird at different seasons is required to assure complete safety to the consumers.

Furthermore, the nutritional value of mutton bird meat was studied over two harvesting seasons (2006 and 2007) to investigate the impact of seasonal variation. The moisture and carbohydrates contents ranged between 54.0 to 55.0 % and 2.8 to 3.0 %, respectively, and no seasonal effects were evident in these components. The values for fat and ash contents were higher and the protein content lower for birds harvested in 2007 compared with the 2006 values which ranged from 11.8 to 13.0, 10.3 to 11.7, and 20.3 to 18.5 % for fat, ash and protein content respectively. The major amino acids in mutton bird pectoral muscle were glutamate, aspartate, lysine, leucine, and arginine. Higher lysine concentrations and lower proline, cystein and methionine were found in mutton birds compared with the literature values for beef, lamb and pork. The essential amino acid content in mutton bird (43.8 and 44.9 % in 2006 and 2007, respectively) was slightly higher than those found in beef and lamb meats (42-43%).

The major fatty acids detected were palmitic (C16:0), stearic (C18:0), oleic and isomers (C18:1), eicosenoic (C20:1), Docosahexaenoic acid (DHA) (C22:6), icosapentaenoic acid (EPA) (C 20:5) and these accounted for approximately 77% of the fatty acids. The $\omega 3/\omega 6$ ratio of fats from pectoral muscle was 1.3. The cholesterol concentration varied slightly in the two years with 184.4±37.37and 134.4±25.55mg/100 g fresh weight for 2007 and 2008 respectively. Mutton bird was shown to contain significantly higher cholesterol content (134.4-184.4) than other common meat such as chicken (80.3-88.9), lamb (62.3), fish (52.79) and beef (51.97). Overall, the nutritional value of mutton bird muscle was similar to or superior to the traditionally protein sources such as seafood and red meat. Annual variations existed in the composition of Mutton bird pectoral muscle but this is not of nutritional consequence but might be a useful indicator for ecological events such as feed availability and other environmental issues. Mutton bird seems to be a good source of essential minerals, Zn and Fe compared with other traditional meats source. Mutton bird meat is nutritionally as good as the major sources of red or white meats. It may even have advantages over the other common meats (beef, lamb, fish and chicken) due to its high protein and monounsaturated fatty acids (omega n-3 and n-6) content. However, its high cholesterol content may represent a risk factor for some people.

Keywords: mutton bird, trace elements, minerals, fatty acids, amino acids, cholesterol, seasonal variation breast meat, nutrition and toxicology.

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