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Fast food hamburgers: what are we really eating?

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Abstract Americans consume about 5 billion hamburgers a year. It is presumed that most hamburgers are composed primarily of meat. The purpose of this study is to assess the content of 8 fast food hamburger brands using histologic methods. Eight different brands of hamburgers were evaluated for water content by weight and microscopically for recognizable tissue types. Glial fibrillary acidic protein (GFAP) staining was used to evaluate for brain tissue. Water content by weight ranged from 37.7% to 62.4% (mean, 49%). Meat content in the hamburgers ranged from 2.1% to 14.8% (median, 12.1%). The cost per gram of hamburger ranged from $0.02 to $0.16 (median, $0.03) and did not correlate with meat content. Electron microscopy showed relatively preserved skeletal muscle. A variety of tissue types besides skeletal muscle were observed including connective tissue (n = 8), blood vessels (n = 8), peripheral nerve (n = 8), adipose tissue (n = 7), plant material (n = 4), cartilage (n = 3), and bone (n = 2). In 2 hamburgers, intracellular parasites (*Sarcocystis*) were identified. The GFAP immunostaining was not observed in any of the hamburgers. Lipid content on oil-red-O staining was graded as 1+ (moderate) in 6 burgers and 2+ (marked) in 2 burgers. Fast food hamburgers are comprised of little meat (median, 12.1%). Approximately half of their weight is made up of water. Unexpected tissue types found in some hamburgers included bone, cartilage, and plant material; no brain tissue was present. *Sarcocystis* parasites were discovered in 2 hamburgers.

Keywords: Hamburger; Histology; *Sarcocystis*; Bovine spongiform encephalopathy

1. Introduction

It is estimated that Americans consume approximately 5 billion hamburgers each year—that translates into about 1.2 billion pounds of "meat [1]." The retail sale of fast food hamburgers is big business. Most consumers presume that the hamburger they eat is composed primarily of meat.

Previously, the meat content of a series of 8 hot dogs, another fast food meat product, was assessed and the results presented [2]. Although hot dog package labels listed meat as the first ingredient, this study revealed that more than 50% of their weight was water and that in most brands, meat (as evidenced by the presence of skeletal muscle tissue) comprised less than 10% of the cross sectional area of the hot dogs when examined microscopically [2].

The purpose of this study is to use routine morphologic-based techniques that are commonly used in the evaluation of tissue (light microscopy with hematoxylin and eosin stains, special stains, immunohistochemistry, and electron microscopy) to examine the histologic condition of 8 brands of fast food hamburgers to evaluate their content.

2. Methods and materials

Eight different brands of fast food hamburgers were purchased. The brands were anonymously designated H1 to H8 to prevent any bias during their evaluation in this study. The price of each hamburger was recorded. Each hamburger was weighed, and the price per gram of hamburger was calculated.

The water content of each hamburger was determined by weighing a portion of each hamburger, grinding it into small pieces, allowing it to desiccate in an oven (for 24 hours) to

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Table 1
Summary of Findings in the Eight Hamburger Brands Evaluated

Brand	Measured water content (%)	Estimated meat content (%)	Skeletal tissue	Connective tissue	Blood vessels	Peripheral nerve	Adipose tissue	Bone	Cartilage	Plant	Parasites	Oil-red-O	GFAP
			No. of tissue fragments/cross section (15.7 mm^2)										
H1	54.5	11.9	>20	>20	>20	1	9	0	1	4	1	2+	−
H2	50.7	8.7	>20	>20	>20	2	5	0	0	0	0	1+	−
H3	62.4	13.3	>20	>20	>20	2	6	0	1	0	0	1+	−
H4	49.5	14.5	>20	>20	>20	1	8	0	0	0	0	2+	−
H5	41.9	12.3	>20	>20	>20	4	6	1	2	0	1	1+	−
H6	37.7	14.8	>20	>20	>20	1	7	0	0	>20	0	1+	−
H7	48.4	2.1	5	>20	>20	1	0	0	0	>20	0	1+	−
H8	41.4	10.2	>20	>20	>20	3	4	1	0	1	0	1+	−

evaporate the water and then weighing the remaining dried material.

A piece of each hamburger was fixed in 10% formalin and embedded in paraffin. Four-micrometer thick tissue sections from each hamburger were cut and stained with hematoxylin and eosin and periodic acid-Schiff (PAS). Histologic sections were examined by light microscopy. Tissue types identified were quantified in 10 random but adjacent, high-power fields (area, 15.7 mm^2 in aggregate).

The percentage of skeletal muscle was determined by placing a 588 block grid over 5 random contiguous photographed sections (taken at 50× magnification) from each hamburger. For each photograph, the number of grid line intersections that overlie skeletal muscle tissue were divided by the total number of intersections on the grid to generate an approximate percentage of skeletal muscle (meat) present in the photograph. The 5 values corresponding to each photograph obtained for each hamburger were averaged to determine an estimated meat content for the hamburger.

Five-micrometer thick frozen sections were stained for fat and lipid with an oil-red-O stain. Staining results were interpreted using a relative scale of 1+ (moderate) or 2+ (marked). Glial fibrillary acidic protein (GFAP) immunostaining (prediluted, Dako, Carpenteria, Calif) was performed using an automated staining system (Ventana, Tuczon, Ariz). Staining was evaluated as being either absent or present.

Hamburger tissue was extracted from paraffin blocks, deparaffinized, and processed for electron microscopic examination. The tissue was embedded in epoxy resin, and 1-μm thick plastic sections stained with toluidine blue and basic fuschin were generated. Thin sections were cut at 60 nm on copper grids and stained with uranyl acetate and lead citrate before examination with an electron microscope.

3. Results

Eight different brands of fast food hamburgers were evaluated in this study. The price per gram of hamburger ranged from $0.02 to $0.16 (median, $0.03). The measured water content and estimated meat content for each brand is presented in Table 1. The measured water content as a percentage of the total weight ranged from 37.7% to 62.4% (median, 49%). In 3 brands, manufacturer information regarding water content was available, indicating water contents of 44.7%, 45.7%, and 58.4%. These values were consistent with the results determined experimentally in this study. In 3 brands, the water content exceeded more than half of the weight of the hamburger.

The estimated meat content expressed as a percentage of the surface area on cross section ranged from 2.1% to 14.8% (median, 12.1%); all but 2 brands showed a meat content between 10% and 15%. There was no apparent correlation of meat content and price in hamburgers. The cross-sectional area of the 5 fields examined microscopically in each hamburger was 15.7 mm^2. The tissue types identified in each hamburger are summarized in Table 1. In 7 of 8 brands, more than 20 fragments of skeletal muscle were identified (Fig. 1A). More than 20 fragments of connective tissue and more than 20 blood vessels were noted in all hamburgers (Fig. 1B). Other tissue types identified in all hamburgers included peripheral nerve (Fig. 1C) and adipose tissue (Fig. 1D). Plant material was noted in 4 hamburgers (Fig. 1E). Rare fragments of cartilage were seen in 3 hamburgers (Fig. 1F) and bone in 2 hamburgers. Parasitic organisms situated within skeletal muscle fibers were identified in 2 hamburgers (Fig. 1G). The parasite was morphologically consistent with *Sarcocystis*.

Oil-red-O staining was graded as moderate (1+) in 6 hamburgers and marked (2+) in 2 hamburgers. Microscopic examination and GFAP immunoreactivity failed to demonstrate any brain tissue. Electron microscopic examination of skeletal muscle tissue from hamburgers was compared with normal skeletal muscle tissue from a human tissue. Hamburger muscle was generally preserved and had a recognizable banding pattern of skeletal muscle tissue comprised of myofilaments and Z bands (Fig. 1H), despite meat processing and cooking.

4. Discussion

The water content, as determined in this study, comprised nearly half (median, 49%) of the weight of the hamburger. This would include other liquids that may be added in the manufacturing of the hamburger as well as water from the

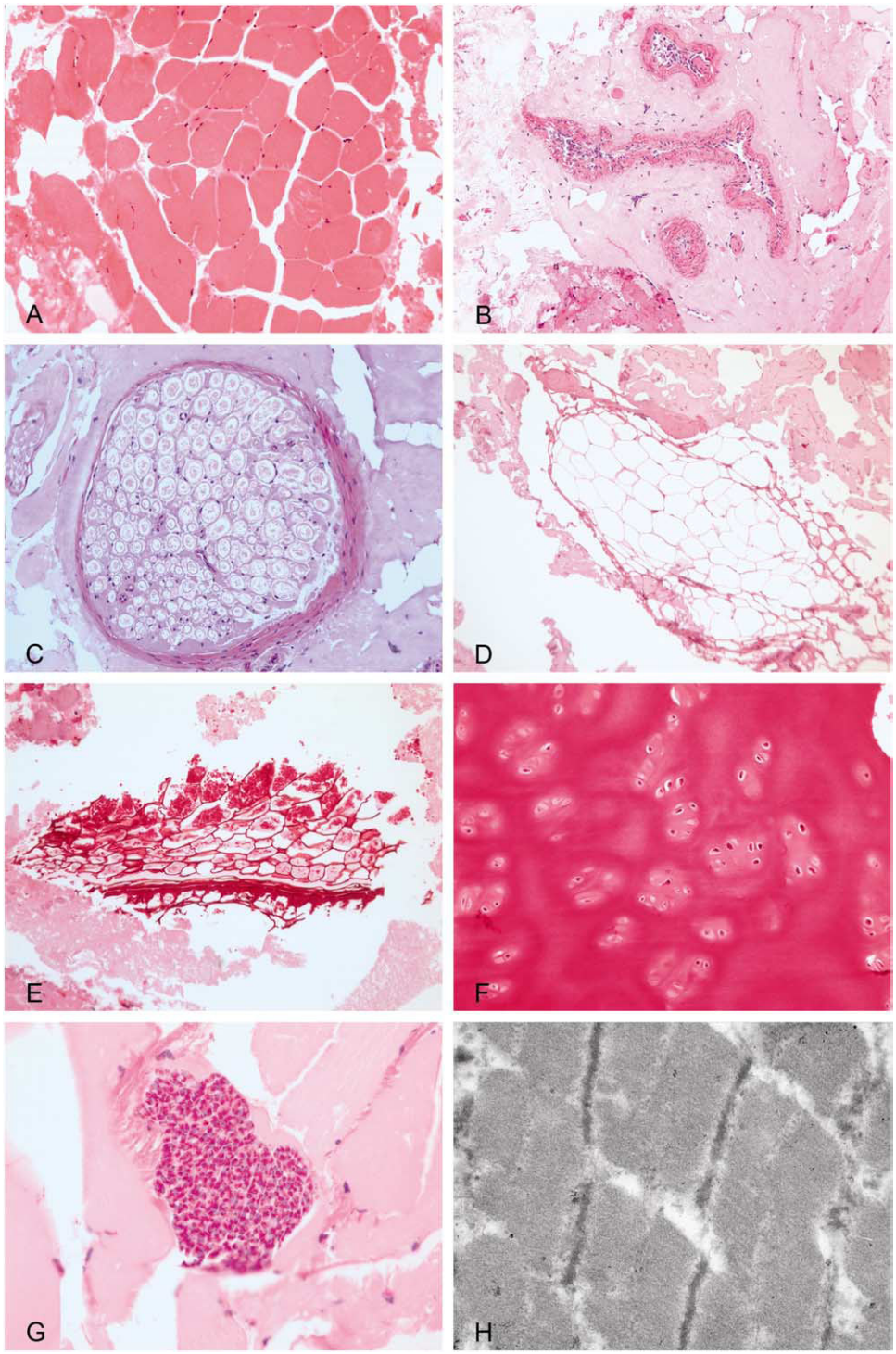

Fig. 1. (A) Brand H1. High magnification appearance of skeletal muscle (meat) in cross section. The cell nuclei are still visible under the cell membrane (hematoxylin and eosin, medium power). (B) Brand H4. Fragment of soft tissue containing several blood vessels embedded in connective tissue (hematoxylin and eosin, medium power). (C) Brand H8. Cross section of a peripheral nerve fascicle (PAS stain, medium power). (D) Brand H8. A fragment of adipose tissue (hematoxylin and eosin, low power). (E) Brand H7. Plant material that is likely used as a filler (PAS stain, medium power). (F) Brand H5. A fragment of articular cartilage (hematoxylin and eosin, medium power). (G) Brand H1. *Sarcocystis* parasites situated within the cytoplasm of a muscle fiber. Similar parasites were identified in 2 of 8 hamburgers studied (PAS stain, high power). (H) Brand H1. Ultrastructural appearance of skeletal muscle showing a fairly intact banding pattern with readily visible Z bands.

tissues themselves. The water content was slightly higher (median, 57%) in a series of 8 hot dogs that were previously studied [2]. Meat content, as evidenced by the presence of skeletal muscle, occupied a small amount of the cross-sectional area (median, 12.1%; range, 2.1%-14.8%) as determined by light microscopic examination; most of the content of the hamburgers were made up of other tissue types and water. Some of the other tissue types observed are associated with skeletal muscle (adipose tissue, blood vessels, connective tissue, and peripheral nerve) and are not unexpected findings. Bone and cartilage, observed in some brands, were not expected; their presence may be related to the use of mechanical separation in the processing of the meat from the animal. Small amounts of bone and cartilage may have been detached during the separation process (advanced meat recovery). The United States Department of Agriculture regulations allow for up to 150 mg of calcium (usually in the form of bone) per 100 g of meat product [3]. Plant material, observed in some brands, was likely added as a filler to give bulk to the burger. The amount of meat observed in the hot dogs previously studied was less (median, 5.7%; range, 2.9%-21.2%) [2]. To improve the accuracy of this assessment, five 50× magnification fields were analyzed, and an average percentage of meat content was determined for each burger. For the hot dogs, a single field marked by the most meat was analyzed [2]. The differences in methods between the 2 studies may explain the variability in the range of values seen in each group. There was no correlation between the price of the hamburger and meat content; this is in contrast to hot dogs where there was a general correlation between these 2 parameters [2].

The amount of lipid observed was considerable and was seen in both adipose tissue and as lipid droplets. Despite the processing and cooking of the meat, the skeletal muscle appeared to be fairly well preserved on ultrastructural examination. Some preservation of the normal banding pattern of the skeletal muscle tissue was noted; in particular, the Z bands, made up of α actinin material, were clearly visible.

An unexpected finding was the presence of parasites in 2 of the hamburger brands. The morphology of the organisms is consistent with *Sarcocystis*. *Sarcocystis* is an intracellular parasite that infects many animals including cows, dogs, cats, monkeys, pigs, reptiles, and birds. Species-specific prey-predator life cycles have been defined with the following 3 species involving cattle: *Sarcocystis cruzi* (cattle-dog), *S. hirsuta* (cattle-cat), and *S. hominis* (cattle-human) [4]. Animals acquire the infection by eating contaminated meat from another infected animal or by being exposed to the feces of an infected animal. Many cattle harbor cysts in muscle; to minimize the spread of the infection, carnivores should not be allowed to eat raw or uncooked meat from infected animals [4]. Rare cases of infection in humans have been reported; in most cases, humans probably have acquired the infection by eating food or drinking water contaminated by feces from an infected animal. Human infection is only rarely associated with symptomatic disease [5]. Properly cooking meat contaminated with the organism should inactivate it. Similar to humans, most infected animals are asymptomatic; infection in cattle has been associated with increased risk of abortion and rarely encephalitis or myositis [4].

Because of a concern about contracting spongiform encephalopathy from eating contaminated meat, hamburgers were examined for brain tissue. There was no evidence of brain tissue either on microscopic examination or by staining with GFAP antibody. This is of particular concern because of bovine spongiform encephalopathy (mad cow disease). This fatal disease can be transmitted to humans (variant Creutzfeldt-Jakob disease) by eating contaminated beef [6,7].

In conclusion, the amount of actual meat present in fast food hamburgers, as evidenced by the presence of skeletal muscle, was still relatively low. Water content comprises approximately half of the weight of a fast food hamburger. Hamburgers contain the same tissue types observed in hot dogs, including unexpected tissues such as bone and cartilage. *Sarcocystis* parasites were observed in the skeletal muscle in 2 of the hamburgers examined. Brain tissue was not identified in any of the hamburgers examined in this study.

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