How Do Ratite Meats Compare With Beef?: Implications for the Ratite Industry

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Abstract: *Emu and ostrich meats were compared with beef to identify and quantify their sensory attributes. A sensory panel was used to compare U.S. Department of Agriculture Choice top sirloin beef with emu and ostrich meat, both ground and intact forms. Comparisons of sensory quality and acceptability were made after zero, two, four and six months of frozen storage. Differences in flavor, juiciness and texture were detected between ratite meats and beef (the control). The differences were more pronounced for intact cuts than ground meat, with ratite meat usually being rated inferior to beef. Some differences in sensory acceptability across the six-month storage period were revealed. Implications for marketing the ratite meats are made based upon the study.*

Key Words and Phrases: *Acceptability, difference from control, emu, ostrich, sensory quality, storage.*

Beginning in the United States as a pure breeder market during the late 1980s, the ratite (emu and ostrich) industry has recently evolved into a mixed breeder and slaughter market. During this evolution, a growing number of restaurants and retail outlets have added ratite meats to their menus and shelves. Taylor et al. reported that one-fourth of 107 retail outlets across the United States had handled ratite meats, at least for a limited time, over the past several years. However, many of these outlets had not marketed the meat regularly because of a lack of retail demand for these new meat products.

One of the reasons for the lack of demand for ratite meats is that meat handlers and consumers are unfamiliar with the quality attributes of ratite meats (Taylor et al.). The first step in successfully marketing these meats will be to identify and quantify their sensory attributes and then to market the meats accordingly. A wealth of research has ascertained that consumers purchase items on the basis of their attributes, as first discussed by Lancaster. The current study attempts to identify and quantify some of the critical ratite meat attributes and offers suggestions for how the industry can promote its product.

Ratite products are more well-known and accepted in other parts of the world, especially in Europe. Ostriches originated in South Africa while emus came from

Australia. By 1996, the United States had become the world's second largest producer of ostriches, with 7,000 to 10,000 farms (van Zyl). Ostrich production is expanding in other countries as well, notably Australia, Zimbabwe and Israel. Whereas, in the past, emphasis was placed on the hide and feathers produced from ostriches, changing consumer preferences in meats have opened new opportunities for the meat from these birds. It would appear appropriate for the ratite industry to develop markets for its increasing production by promoting its meat as a product that meets these changing preferences.

Because of a lack of knowledge by consumers and meat handlers about ratite meats, these products remain in the "market introduction" stage of the product life cycle, as discussed by McCarthy and Perreault, and have not moved into the market growth stage, where demand tends to exceed supply. The overall lack of familiarity with ratite products is documented in Taylor et al. The major selling point for ratite meats is that they are lower in fat, cholesterol and calories than other red meats (U.S. Department of Agriculture). Ratites produce red meat; therefore, the ratite industry compares its meat with beef rather than poultry. Many in the industry argue that ratite meat tastes and looks very similar to beef (Taylor et al.). There is evidence that ratite meat may be a close substitute for beef in some instances—in 1996, a Louisiana ostrich processor began to export ostrich meat to Europe as a result of England's battle with bovine spongiform encephalopathy (mad cow disease). However, many U.S. restaurateurs and retailers relate these meats more closely to poultry than beef, primarily because it is a bird, not a mammal (Taylor et al.).

Because of the mixed perceptions meat handlers and consumers have about ratite meats, the industry needs assistance in determining how to appraise the market for its meat products and begin to move into the "growth" stage of its product life cycle. The overall objective of the study was to evaluate the sensory attributes of ratite meats relative to beef. The specific subobjectives were to: (1) identify what is already known about the attributes of ratite meats, (2) determine the differences in the edibility of ratite meats relative to beef in both ground and intact muscle forms, (3) determine the impact of storage time on the edibility of ratite meats relative to beef, and, (4) given these results, draw implications on the direction the ratite industry could go in marketing its meat products. In this study, we did not evaluate the rhea, which is also a ratite species. Thus, our conclusions apply only to emu and ostrich.

Attributes of Ratite Meat: What Is Already Known?

Table 1 presents information about the nutritional content of ratite meats relative to other meats (U.S. Department of Agriculture). A three-ounce serving of either ostrich or emu meat contains 22 grams of protein while beef and pork contain 22 and 24 grams, respectively. Ratite meats are also heart-healthy meats, containing 2 grams

Table 1.
Comparison of Attributes of Ratite Meats with Other Meats Commonly Consumed by U.S. Consumers, Three-Ounce Servings

Measure	Ostrich (Weighted Average of 10 Major Muscles)	Emu (Thigh)	Beef (Lean, Steak, Broiled)	Chicken (Roasted, Flesh Only)	Pork (Lean, Loin, Broiled)
Protein, g	22	22	22	27	24
Fat, g	2	2	15	3	19
Cholesterol, mg	58	58	75	73	84
Calories	97	109	235	140	275

Sources: U.S. Department of Agriculture; emu information from Louisiana Cooperative Extension Service, copies available from the authors; ostrich information is from Harris, et al., and Finck.

of fat, 58 milligrams of cholesterol, and 97–109 calories per three-ounce serving, compared to larger quantities in other meats such as beef, pork and chicken. While the extent to which the ratite industry has provided nutritional information to meat handlers and consumers is unknown, meat handlers' limited knowledge of the meats would indicate this information is not widely known (Taylor et al.).

Two previous sensory evaluations of ratite meat are known to the researchers, the first, completed by the Texas Agricultural Extension Service (Harris et al.), using ostrich meat, and the second, by Thompson et al., involving emu meat. In the first study, four ostrich cuts were compared with beef top loin steak in a blind taste test. Untrained consumers evaluated the samples for flavor, flavor intensity, texture, tenderness, like/dislike, and overall like/dislike. Beef was scored slightly better on all of the sensory attributes than was ostrich meat. Consumers, however, had only a single exposure to the ostrich products.

In the Thompson et al. study, a trained panel evaluated a variety of emu cuts that were cooked to different end-point temperatures. Results indicated that toughness increased and juiciness decreased as end-point temperatures were increased. Meat cuts from two different qualities of birds were compared in phase two of the study. Breeder quality birds were compared with birds possessing physical deformities, such as splayed legs, hump backs or twisted necks. Results indicated that the quality of the live bird had no effect on acceptability of the meat. Phase three of this study entailed the evaluation of U.S. Department of Agriculture (USDA) Choice beef ribeye, emu

flat filet, fan filet, mid-drum, outside drum and round cuts. The filet cuts, the highest quality cuts, were judged to be quite similar to the ribeye steak, while the lower quality cuts were less tender and juicy. Although beef was included in this analysis, it was evaluated with the emu cuts, not used as a standard of comparison (i.e., control).

While neither of these two studies addressed the long-term storage question, researchers at Texas A&M (Miller et al., 1995a) examined the impact of refrigerated, vacuum packaged storage on sensory acceptability of fan and outside leg muscles of ostrich. They recommended the product not be held for more than fourteen days prior to fabrication for retail or food service use. Their research on retail shelf-life of ostrich recommended a limit of three days.

The previously discussed studies did not address the following: (1) Are there significant differences in the edibility characteristics of beef and ratite meats (i.e., might ratite meat be marketed as a competitor with beef?). This study examined that issue. (2) What are the long-term (frozen) storage capabilities of ratite meats relative to beef? This study addresses whether ratite meats maintain their edibility compared to beef after extended storage periods (up to six months).

Evaluating the Edibility and Storability of Ratite Meats

This sensory study was designed to evaluate ground and intact muscle emu and ostrich meats at four different storage lengths: zero, two, four and six months. The two ratite meats, fan filet (ostrich) and flat filet (emu), were compared to USDA Choice top sirloin beef in a "difference-from-control" test (Meilgaard et al.), with sirloin serving as the control as well as being included as a blind sample in the test. The fan and flat filets are comparable to beef top sirloin.

In January, 1996, volunteers were sought from among red meat consuming employees of the Louisiana State University (LSU) Department of Food Science and Department of Agricultural Economics and Agribusiness to serve on a sensory panel to evaluate selected red meat products. A ten-member sensory panel resulted. While scheduling conflicts prevented individual panel members from participating in one or more sessions over the length of the study, at least eight panel members were present at each session.

Following established procedures, panel members were trained using ratite meats and sirloin in both ground and intact muscle forms. Procedures outlined by Meilgaard et al. were followed to assist panel members in developing and quantifying sensory attributes (descriptors) of ratite meats using beef samples as the control. The sensory attributes selected from these sessions for the intact muscle products were beefy flavor, liver-like flavor, juiciness, chewiness (texture), saltiness, overall difference from control, and comparison to control (preferences as compared to the control).

The sensory attributes for the ground products were mealy texture, beefy taste, juiciness, lardy/waxy taste, liver-like/giblet taste, off flavor, overall difference from control, and comparison to control.

With the difference-from-control test, beef was designated as the "control" and the other samples were evaluated on difference from the control. Panel members were presented with a control sample and the test samples. Panel members were aware that some of the test samples, the "blind samples," were the same as the control sample. They were asked to rate the magnitude of the difference between the test sample and the control on the interval scales provided. The resulting mean difference-from-control estimates for the ratite samples and for the blind (beef) sample were analyzed using a one-way Analysis of Variance (ANOVA) with a randomized block design. This design uses panel members as blocks (judges) and animal species as treatments. The null hypothesis was that the mean for a specific sensory attribute was equal across species: H_0: $\mu_1 = \mu_2 = \mu_3$, where subscripts represent the different meats and μ represents the population mean for a specific treatment. The alternative hypothesis, (H_A), was that not all μ_i were equal across the three species.

Since more than one sample was being compared to the control, the Dunnetts' t-test was employed to determine which of the two samples was different from the control for each sensory attribute. The null hypotheses were: H_0: $\mu_1 = \mu_2$ and H_0: $\mu_1 = \mu_3$, where subscripts 1, 2 and 3 represent beef, ostrich and emu, respectively. Alternative hypotheses were: H_A: $\mu_1 \neq \mu_2$ and H_A: $\mu_1 \neq \mu_3$. Duncan's Multiple Range Test was used to determine whether panel member ratings for the sensory attributes differed over the six-month storage period. All interpretations were based on the five percent confidence level.

The ostrich, emu and sirloin meats used in the training and evaluation sessions were obtained from a Louisiana ostrich processor, a local emu producer and a local supermarket, respectively. Supplies of the three types of meats were obtained weekly, for three consecutive weeks (i.e., three replications), to ensure that the product for each session was obtained from a different animal. All product was cut into portion sizes appropriate for one session. Some of the meat was ground and formed into patties. All meat was then vacuum packaged, labeled and stored in a -20° F freezer.

For three consecutive weeks, at approximate two-month intervals, ground meat was evaluated on Wednesday and steaks/filets on Thursday. Two samples from each species were evaluated at each session. Maximum observations, considering three sessions (weeks) for each storage period, two replications at each session and a ten-member panel, would be 60 for each species and storage period. The identity of each sample was unknown to panel members; however, the control was clearly marked. Specialized facilities operated by the LSU Department of Food Science were used for storing, cooking and panel analysis of the samples.

Each sample was cooked on an electric grill to an internal temperature of 145° F, cut into small cubes and placed in a three-digit coded plastic container. Panel

members rated the unknown samples for flavor, texture and juiciness relative to the control sample using a -5 to 5 scale with a score of 0 denoting no difference from the control sample.

The overall differences from control and comparison to control measures were selected to provide additional evaluations of the two ratite meats relative to beef. The overall difference from control provided an overall or average numerical assessment of how different the sample was from the control, based on the attributes being evaluated. A 0-to-9 scale was used for this assessment, as suggested by Meilgaard et al. The comparison to control measure allowed the panel members to indicate whether they liked the test sample more, the same as, or less than, the control, a measure that presumably included all of the sensations associated with the products being assessed.

Ground Meat Edibility and Storability

The panel evaluated the three ground meat products on three successive Wednesdays, at two-month intervals, beginning in February, 1996. The mean values of the sensory attributes, by product, are provided in Table 2. The mean values for difference-from-control ratings for most sensory attributes were small. ANOVA results for the zero storage period indicate, however, that the samples differed significantly from the control for mealy texture and juiciness (Tables 3a and 3b). The judge effect was significant for all criteria except beefy taste. Ground ostrich had less mealy texture and less lardy/waxy taste than the ground sirloin (Table 4).

More of the sensory attributes were judged significantly different among the meats at two-month storage: mealy texture, beefy taste, juiciness and off flavor (Table 3a). Judge effects were significant for mealy texture, beefy taste, lardy/waxy taste, off flavor, overall difference from control and comparison to control. Both emu and ostrich were less mealy and less beefy tasting while ostrich was more juicy than the ground sirloin (Table 4). Emu had a significant off flavor at two-month storage.

At four months of storage, three additional sensory attributes, liver-like/giblet, overall difference from control and comparison to control, were significantly different among the meats (Table 3b). The judge effects for all criteria were significant, except comparison to control. Emu and ostrich were both less beefy tasting, and ostrich was more juicy, than sirloin (Table 4). In addition, panel members detected a liver-like/giblet flavor and an off flavor in the emu sample. Both ratite products were significantly different from, and inferior to, the control. It should be noted that, even though these differences are statistically significant, the absolute magnitudes of the differences are quite small, especially for ostrich (Table 2).

Table 2.
Duncan's Multiple Range Test for Comparing Sensory Attributes of Ground Ostrich and Ground Emu Stored for 0, 2, 4, and 6 Months, Feb. to Aug., 1996

		Length of Storage			
Criteria	Scale	0 Mos.	2 Mos.	4 Mos.	6 Mos.
Ground Ostrich					
Mealy	-5 to 5	-0.571 c	-0.375 c	0.183 b	0.620 a
Beefy	-5 to 5	-0.589 a	-0.714 a	-0.883 a	-1.040 a
Juiciness	-5 to 5	0.571 a	0.018 b	0.367 ab	-0.660 c
Lardy/Waxy	-5 to 5	-0.161 b	-0.018 ab	0.400 a	0.060 ab
Liver like/Giblet	-5 to 5	-0.125 b	0.473 a	0.183 ab	0.180 ab
Off-Flavor	-5 to 5	0.250 a	0.351 a	0.467 a	0.500 a
Control Difference	0 to 9	1.982 a	1.929 a	2.100 a	2.530 a
Control Comparison	-1 to 1	-0.412 a	-0.286 a	-0.500 a	-0.500 a
Ground Emu					
Mealy	-5 to 5	-0.020 b	0.036 b	0.683 a	0.700 a
Beefy	-5 to 5	-0.679 a	-0.554 a	-1.042 a	-0.600 a
Juiciness	-5 to 5	-0.071 a	-0.125 a	-0.525 ab	-1.080 b
Lardy/Waxy	-5 to 5	0.000 a	0.143 a	0.150 a	0.204 a
Liver like/Giblet	-5 to 5	0.107 c	0.268 bc	1.167 a	0.674 b
Off-Flavor	-5 to 5	0.321 b	0.795 a	1.117 a	0.694 ab
Control Difference	0 to 9	1.875 c	2.236 bc	3.133 a	2.857 ab
Control Comparison	-1 to 1	-0.294 a	-0.291 a	-0.683 b	-0.551 ab

Note: Mean values in the same row not followed by the same letter are significantly different ($p \leq 0.05$).

At six months of storage, the ratite meats differed from the control for fewer sensory attributes. Mealy texture, juiciness, off-flavor and comparison to control were no longer significantly different (Table 3b). Judge effects were significantly different for all attributes. Ostrich continued to have less beefy flavor than sirloin (Table 4). Emu also continued to exhibit liver-like/giblet flavor and ground emu was judged as different from the control. Once again, the absolute differences were not great (Table 2).

In addition to the foregoing individual storage period analyses, the means for each of the sensory attributes were compared across the four storage periods to determine whether there were differences in any of the comparison criteria due to length of storage. The means were evaluated, using a Duncan's Multiple Range test, to

Table 3a.
Analysis of Variance (ANOVA) of Ground Meat Products, Short-Term Storage

Source	Zero Months			Two Months		
	SS	F	Pr > F	SS	F	Pr > F
Mealy						
Judge	29.962	2.01	0.0306	27.940	2.57	0.0052
Treatment	10.440	3.86	0.0232	27.250	13.76	0.0001
Error	208.448			152.470		
Beefy						
Judge	13.016	0.65	0.7791	50.338	3.51	0.0002
Treatment	2.083	0.58	0.5631	14.083	5.40	0.0054
Error	278.306			200.857		
Juicy						
Judge	48.558	3.29	0.0004	27.500	1.50	0.1378
Treatment	11.678	4.25	0.0145	11.285	3.38	0.0366
Error	206.710			257.160		
Lardy/Waxy						
Judge	35.476	4.56	0.0001	62.419	8.30	0.0001
Treatment	3.583	2.53	0.0827	1.083	0.80	0.4549
Error	108.917			105.348		
Liverlike/Giblet						
Judge	38.153	2.72	0.0031	32.156	2.91	0.0016
Treatment	2.369	0.93	0.3968	2.556	1.27	0.2832
Error	196.187			154.749		
Off-Flavor						
Judge	21.23	8.05	0.0001	18.135	3.34	0.0008
Treatment	0.143	0.30	0.7427	4.683	4.32	0.0158
Error	36.913			56.412		
Control Difference						
Judge	151.280	8.25	0.0001	130.054	7.38	0.0001
Treatment	0.333	0.10	0.9049	8.136	2.31	0.1029
Error	256.667			271.426		
Control Comparison						
Judge	10.583	2.96	0.0040	13.771	3.05	0.0015
Treatment	0.314	0.39	0.6751	1.475	1.63	0.1988
Error	35.770			69.556		

Table 3b.
Analysis of Variance (ANOVA) of Ground Meat Products, Long-Term Storage

Source	Four Months			Six Months		
	SS	F	Pr > F	SS	F	Pr > F
Mealy						
Judge	44.911	3.83	0.0001	94.673	8.34	0.0001
Treatment	7.511	3.20	0.0432	0.640	0.25	0.7762
Error	195.906			174.027		
Beefy						
Judge	37.701	2.79	0.0032	52.557	5.06	0.0001
Treatment	29.369	10.86	0.0001	10.720	4.64	0.0112
Error	225.811			159.363		
Juicy						
Judge	52.106	2.88	0.0024	88.129	4.29	0.0001
Treatment	27.053	7.47	0.0008	11.160	2.44	0.0905
Error	300.472			314.951		
Lardy / Waxy						
Judge	38.833	5.46	0.0001	93.509	14.12	0.0001
Treatment	2.100	1.48	0.2316	2.251	1.53	0.2202
Error	118.817			100.790		
Liverlike / Giblet						
Judge	43.506	5.29	0.0001	46.781	8.02	0.0001
Treatment	38.033	23.11	0.0001	8.008	6.18	0.0027
Error	137.411			88.755		
Off-Flavor						
Judge	43.339	4.96	0.0001	43.836	9.13	0.0001
Treatment	25.900	14.82	0.0001	2.206	2.07	0.1304
Error	145.961			73.072		
Control Difference						
Judge	130.894	6.36	0.0001	157.629	9.13	0.0001
Treatment	108.578	26.38	0.0001	17.204	4.48	0.0130
Error	343.672			262.781		
Control Comparison						
Judge	2.411	0.66	0.7626	9.389	2.74	0.0058
Treatment	6.633	9.04	0.0002	0.972	1.27	0.2831
Error	61.256			52.254		

Table 4.

Dunnetts' T test Results for Difference between Means of Individual Products (Emu and Ostrich) and Control Ground Beef, February to August, 1996

	Length of Storage			
Criteria	0 mos.	2 mos.	4 mos.	6 mos.
Mealy				
Emu	0.054	-0.571*	0.233	0.160
Ostrich	-0.500*	-0.982*	-0.267	0.080
Beefy				
Emu	-0.268	-0.518*	-0.925*	-0.200
Ostrich	-0.179	-0.679*	-0.767*	-0.640*
Juicy				
Emu	-0.375	0.464	-0.158	-0.660
Ostrich	0.268	0.607*	0.733*	-0.240
Lardy/Waxy				
Emu	-0.196	0.179	-0.050	-0.156
Ostrich	-0.357*	0.018	0.200	-0.300
Liver Like/Giblet				
Emu	-0.036	0.089	0.967*	0.494*
Ostrich	-0.268	0.295	-0.017	0.000
Off-Flavor				
Emu	0.036	0.405*	0.900*	0.294
Ostrich	-0.036	-0.039	0.250	0.100
Difference from Control				
Emu	-0.071	0.539	1.900*	0.827*
Ostrich	0.036	0.232	0.867*	0.500
Comparison to Control				
Emu	0.000	-0.202	-0.467*	-0.191
Ostrich	-0.118	-0.196	-0.283*	-0.140

Note: For each mean difference value, * indicates significant difference from the control ground beef at $p \leq 0.05$.

determine if length of storage had an effect on sensory quality and acceptability of the two ratite products (Table 2). Ground ostrich became significantly more mealy textured after two months storage, slightly less juicy during storage and exhibited some difference in lardy/waxy and liver-like/giblet taste over the storage period. Ground emu also became more mealy textured, less juicy, exhibited more liver-like/giblet taste, became more different from the control and became more inferior

relative to the control over the six-month storage period. These differences in means across the different time periods imply that ratite product quality decreases somewhat during storage relative to sirloin, especially for mealy texture and juiciness.

Steak/Filet Edibility and Storability

The panel evaluated the steaks/filets on three successive Thursdays, at two-month intervals, beginning in February, 1996. In this section, the products evaluated were the flat filet of the emu; the fan filet, or inside round, of the ostrich; and USDA Choice top sirloin steak (the filets represent one of the best cuts in the ratites and the top sirloin is a comparable cut in beef). The mean values for each sensory attribute are reported in Table 5. The ratings for each of the sensory attributes were significantly different in the zero storage period (Table 6a). The judge effect was significant for all attributes except comparison to control. Emu and ostrich filets exhibited less beefy flavor than the sirloin (Table 7). Emu had more liver-like taste. The ostrich samples were more juicy, chewier and had less salty flavor than sirloin. In addition, both ratite meats were judged to be different from, and inferior to, sirloin (Table 7).

This trend continued in the two-month storage period, at the end of which all except one of the sensory attributes (juiciness) were statistically different (Table 6a). The judge effect was significant for all sensory attributes. Results of Dunnetts' t-test differed from zero storage only in that ostrich was not significantly different from sirloin for juiciness and overall comparison to control (Table 7).

At the four- and six-month storage stages, panel ratings for each sensory attribute were statistically different (Table 6b). Judge effects were significantly different for all attributes except comparison to control for both periods and juiciness and chewiness for four months only. Both emu and ostrich meats had less beefy flavor (Table 7). Emu had more liver-like/giblet taste in both periods. Ostrich meat was more juicy than sirloin at six months and emu meat more juicy at four months. Ostrich meat was more chewy and less salty than sirloin at both four and six months. Both emu and ostrich were significantly different overall and inferior to the sirloin (Table 7). As with the ground product, the means for each of the sensory attributes for intact muscle tissue were compared across the four storage periods to detect any differences in the ratite meat from beef due to storage. Based on Duncan's Test, ostrich cuts tended to gain more liver-like/giblet taste, changed in juiciness and became more inferior to sirloin over storage (Table 5). Emu cuts also tended to become more inferior to sirloin during storage. In general, the mean differences across storage periods were smaller than for the ground product, indicating that emu and ostrich cuts stored better than their ground products.

Table 5.
Duncan's Multiple Range Test for Comparing Sensory Attributes of Ostrich and Emu Steaks Stored for 0, 2, 4, and 6 Months, February to August, 1996

		Length of Storage			
Criteria	Scale	0 mos.	2 mos.	4 mos.	6 mos.
Ostrich Fan Filet					
Beefy	-5 to 5	-1.395 a	-1.304 a	-1.630 a	-1.468 a
Liver like/Giblet	-5 to 5	-0.339 c	-0.054	0.556 a	0.192
Juicy	-5 to 5	0.734 a	0.375	0.019 b	0.830 a
Chewy	-5 to 5	0.815 a	0.857 a	0.167 b	0.957 a
Salty	-5 to 5	-0.815 a	-1.018 a	-0.667 a	-0.936a
Difference From Control	0 to 9	2.226 a	2.429 a	2.593 a	2.681 a
Comparison to Control	-1 to 1	-0.218 a	-0.277	-0.611c	-0.500
Emu Flat Filet					
Beefy	-5 to 5	-1.323	-1.589 b	-0.926 a	-1.043 a
Liver like/Giblet	-5 to 5	0.452 a	0.964 a	0.796 a	0.787 a
Juicy	-5 to 5	0.129 a	0.143 a	0.074 a	0.383 a
Chewy	-5 to 5	0.008 a	-0.339 a	-0.259 a	0.255 a
Salty	-5 to 5	-0.363 a	-0.196 a	-0.056 a	-0.043 a
Difference From Control	0 to 9	2.266 a	2.929 a	2.389 a	2.479 a
Comparison to Control	-1 to 1	-0.298 a	-0.589 b	-0.463	-0.575 b

Note: Mean values in the same row not followed by the same letter are significantly different ($p \leq 0.05$).

Implications for the Ratite Industry

The ratite industry's claim that its meat is a heart-healthy red meat that tastes similar to beef appears to be reasonably accurate. While both ratite meats were statistically different from beef in sensory perceptions, both compared closely enough to beef to be marketed competitively with beef. Many potential handlers and most consumers have little or no experience with ratite meats and may perceive it as an exotic or "zoo" animal. Therefore, it is important for the ratite industry to create a relationship with well-established meats. This educational process may help in dispelling the consumer perception that ratite meats are "exotic" and allow consumers to try the product. The oleo margarine industry followed this procedure in getting the public to adopt its product, even adding a yellow color to increase the resemblance to butter.

The almost complete lack of fat in ratite meats would appear, a priori, to suggest problems with juiciness. However, this study indicates that, in most instances, ratite

Table 6a.
Analysis of Variance (ANOVA) of Intact Steak Products, Short-Term Storage

Source	Zero Months			Two Months		
	SS	F	Pr > F	SS	F	Pr > F
Beefy						
Judge	106.032	9.40	0.0001	122:841	9.59	0.0001
Treatment	64.331	31.38	0.0001	80.393	31.38	0.0001
Error	176.294			198.552		
Liverlike						
Judge	80.681	8.54	0.0001	64.268	6.62	0.0001
Treatment	19.406	11.29	0.0001	36.750	18.92	0.0001
Error	147.775			150.500		
Juicy						
Judge	41.683	3.27	0.0004	34.935	1.93	0.0448
Treatment	32.874	14.18	0.0001	6.512	1.80	0.1688
Error	199.418			280.405		
Chewy						
Judge	40.303	2.02	0.0292	46.823	2.63	0.0054
Treatment	32.591	8.98	0.0002	54.250	15.26	0.0001
Error	312.145			275.444		
Salty						
Judge	57.439	8.93	0.0001	93.601	11.60	0.0001
Treatment	15.507	13.26	0.0001	25.190	15.61	0.0001
Error	99.959			125.059		
Control Difference						
Judge	121.287	7.95	0.0001	170.744	9.15	0.0001
Treatment	79.116	28.53	0.0001	70.440	18.87	0.0001
Error	238.496			289.309		
Control Comparison						
Judge	4.745	1.55	0.1171	11.790	2.74	0.0039
Treatment	2.954	5.32	0.0058	9.735	11.31	0.0001
Error	47.796			66.723		

meats were as juicy or juicier than beef when both were cooked comparably. However, cooking procedures are related to the juiciness of ratite meats. Ratite meat should be cooked to an end temperature, rather than visually, as is frequently done with beef (Miller et al., 1995b). Even when fully cooked, emu and ostrich meats

Table 6b.
Analysis of Variance (ANOVA) of Ground Meat Products, Long-Term Storage

Source	Four Months			Six Months		
	SS	F	Pr > F	SS	F	Pr > F
Beefy						
Judge	32.059	2.89	0.0025	45:1445	3.15	0.0009
Treatment	59.309	26.77	0.0001	51.972	19.95	0.0001
Error	165.052			165.451		
Liver Like						
Judge	48.910	5.11	0.0001	83.500	7.72	0.0001
Treatment	10.901	5.69	0.0041	12.439	6.33	0.0024
Error	142.682			124.883		
Juicy						
Judge	25.790	1.45	0.1625	43.557	3.49	0.0003
Treatment	11.568	3.26	0.0412	16.213	7.14	0.0012
Error	264.377			144.187		
Chewy						
Judge	27.725	1.28	0.2440	63.618	4.63	0.0001
Treatment	13.568	3.14	0.0460	18.766	7.52	0.0008
Error	321.571			158.467		
Salty						
Judge	74.750	11.20	0.0001	30.923	3.59	0.0002
Treatment	18.111	13.57	0.0001	29.106	18.58	0.0001
Error	99.417			99.460		
Control Difference						
Judge	187.194	8.95	0.0001	108.578	5.66	0.0001
Treatment	43.370	10.37	0.0001	51.599	14.80	0.0001
Error	311.713			221.389		
Control Comparison						
Judge	2.596	0.78	0.6513	6.469	1.63	0.0978
Treatment	5.049	7.55	0.0008	7.152	9.91	0.0001
Error	49.812			45.828		

frequently retain some of their deep red color and may not turn brown as does beef. If ratite meat is cooked to the same visual degree of doneness as beef (i.e., no color remaining), it is likely to become unacceptable to the customer. Thus, it is our opinion that the ratite industry needs to devote resources to educating consumers about how to cook ratite meats, perhaps through package labeling.

Table 7.
Dunnetts' T Test Results for Difference Between Means of Individual Steaks (Emu and Ostrich) and Control Beef Steak, February to August 1996

	Length of Storage			
Criteria	0 mos.	2 mos.	4 mos.	6 mos.
Beefy				
Emu	-1.209*	-1.589*	-0.778*	-1.021*
Ostrich	-1.282*	-1.304*	-1.482*	-1.447*
Liver Like/Giblet				
Emu	0.427*	0.964*	0.630*	0.660*
Ostrich	-0.363	-0.054	0.389	0.064
Juicy				
Emu	0.419	0.250	0.593*	0.383
Ostrich	1.024*	0.482	0.537	0.830*
Chewy				
Emu	0.145	0.018	0.278	0.128
Ostrich	0.952 *	1.214*	0.704*	0.830*
Salty				
Emu	-0.248	0.000	-0.167	-0.128
Ostrich	-0.699*	-0.821*	-0.778*	-1.021*
Difference From Control				
Emu	1.403*	1.554*	0.982*	1.170*
Ostrich	1.363*	1.054*	1.185*	1.372*
Comparison to Control				
Emu	-0.298*	-0.589*	-0.278*	-0.511*
Ostrich	-0.218*	-0.277	-0.426*	-0.436*

Note: For each mean difference value, * indicates significant difference from the control beef steak at $p \leq 0.05$.

The ratite industry should be cautious in promoting its meat as having long-term frozen storage capability comparable to beef, especially in ground form. Successful long-term storage is attractive to meat handlers, especially those who must store meat over extended time periods.

The mild "beefy" flavor of ratite meats poses a challenge in marketing the product to beef consumers. Processors and food service firms have, in many cases, overcome the mild flavor problems in broilers by adding flavors to cooked or processed broiler products. Unlike beef, which is seldom marketed or served with added flavors, broiler products are often marketed with added flavors, from fast food chicken to

upscale restaurant entrees. Processors of ratite meat could consider the potential of selling cooked products, thus helping to overcome both the cooking and flavor problems. Potential follow-up research could compare ratite meats with a milder flavored fresh pork cutlet.

The highly significant judge effect was unexpected. Panel members discussed sensory attributes to be used and evaluated a number of samples for each attribute during the training period. These results tend to confirm that sensory evaluation remains somewhat subjective and some physiological and psychological errors are unavoidable, even after extensive training.

Can the ratite industry use the promotion of its products as being heart-healthy and similar in taste to beef to gain a significant market share? This question cannot be answered conclusively, as other factors also need to be considered in assessing the market and its growth. Ratite meat is selling at retail from $12 to $18 per pound for prime muscle cuts and $4 to $6 per pound for ground product (National Cattlemen Beef Association). This ranges from two to three times the price charged in supermarkets for comparable beef products. The current premium prices and relatively low supplies of product limit retail outlets for ratite products to specialty meat shops and upscale grocery stores, where higher prices and unique products are common. If the ratite industry intends to remain in these markets, it will likely need to promote the health benefits of ratite meats, relying on these unique characteristics to encourage purchase and consumption among current and former red meat consumers. Concentration on this limited niche market, with customers characterized by health consciousness, higher education and/or higher income, will, however, limit the industry's growth potential.

Conclusions

Conclusions from this research include the following:

- Ratite meats compare favorably with beef in many edibility characteristics.
- The primary difference in sensory quality between the two ratite meats and top sirloin beef was the less pronounced beefy flavor in the former. The milder flavor can be attributed to an almost complete lack of fat in the meat.
- Unlike beef, juiciness can be obtained in ratite meats without fat.
- The results of the long-term storage capability of ratite meats relative to beef may indicate some difficulties in promoting ratite meat as having storage potential comparable to beef. Additional research is needed to help resolve this issue.
- The ratite industry can promote to consumers that ratite meats are lower in fat, cholesterol and calories than other meats, and have similar edibility characteristics to beef.

Notes

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