

The End Product and Food Safety

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The End Product

The average American will consume more than 200 lb. of red meat and poultry this year. Approximately 60 to 65 lb. of that total will be beef, with ground beef as the most consumed form. In addition, Americans have more disposable income to spend on a wider variety of foods than ever before in our history and beef is no exception. Consumers can choose to purchase and consume beef from a variety of management systems (traditional, grass-finished, or organic) or beef from a specific breed or region of the country. Regardless of the type or form of beef consumers choose, they can be assured they are consuming a safe, wholesome food. Beef at grocery stores and/or eating establishments have gone through USDA Inspection, food safety plans such as the Hazard Analysis and Critical Control Points (HACCP), and come from an industry focused on food safety. Mistakes happen, but overall U.S. beef is the safest in the world.

The journey of beef from gate to plate, has not only focused on food safety, but beef farmers and meat processors also focus on providing a quality product. Beef quality can be described as desirable color and tenderness, along with superior flavor. American beef is considered to be the highest quality, most flavorful, and safest in the entire world. Each segment of the industry focuses on all of these parameters.

Beef Cattle Evaluation

Live animal evaluation is subjective, and even experienced cattle buyers will incorrectly evaluate the cutability and/or quality of an animal occasionally. Regardless, it is important for farmers to know the basic concepts of beef cattle evaluation. Comparing carcass traits (ribeye area, 12th rib fat thickness, marbling score) with live animal evaluations are key to becoming proficient in beef cattle evaluation.

Muscling and trimness are the traits to observe when evaluating live cattle. Muscling can be evaluated by standing behind the animal. Imagine how the body

looks without the legs: Does the torso look round or like an inverted triangle? A round torso is an indication of muscle, whereas an inverted triangle is indicative of a light muscled animal. Then, look at the stance of the front and hind legs. Does the animal have a wide (heavy muscled) or a narrow stance (light muscled)? Furthermore, a full brisket and fat deposition around the tail-head are good indicators of fat cover. Again, from behind the animal imagine the torso without legs; does the body look like a square, flat across the top of the animal? A square, flat topped animal is an indication of a fatter animal. Finally, when the animal moves can you see the shoulder blades working and does the body appear to jiggle? These can be indicators of fat cover on the animal. Determining the difference between muscling and trimness takes time, patience, and practice, but consistent evaluation and comparing live animal evaluations with carcass measurements can help accuracy.

Converting Cattle to Beef

- Must be humanely handled and stunned (captive bolt gun or gunshot; 1958 regulation, revised 2002 Farm Bill)
- Exsanguinate (bled by cutting the throat and/or severing the major veins and arteries from the heart)
- Remove the head and present for inspection (mandibular lymph glands, tongue, etc)
- Removal of hide, feet, and viscera
- Carcass is split, trimmed free of contamination, weighed, washed, and enters the cooler
- Must be USDA inspected if meat is to enter commerce; custom slaughter is only a service provided to farmers and meat cannot be sold legally
- Last step prior to chilling in the cooler is microbial intervention (hot-water wash ($\geq 180^{\circ}\text{F}$), steam cabinet, acid spray (lactic or acetic acid))
- Carcasses chilled for 24 to 48 hours by large processors (IBP, Cargil, etc.) before fabrication; small processors will

chill/age carcasses seven to 14 days to maximize tenderness and quality

Again, red meat and poultry that enter into commerce, by law, must be inspected by the USDA-Food Safety and Inspection Service (FSIS). All aspects of the process must be inspected; slaughter, fabrication, ground product, and the various processed meats. There are no exceptions to USDA-FSIS inspection, regardless of size of farm or number of animals. Animals that are custom processed cannot legally enter commerce and is intended for private (owner of the animal) consumption.

Note: There are two forms of inspection, USDA (sold in all 50 states) and state (only sold in said state) inspection. State inspection has to be equal to or better than federal inspection. Kentucky does not have a state inspection service.

Aging and Beef Fabrication

Meat is approximately 70 percent to 75 percent water; thus the average beef carcass will lose between 2 percent to 5 percent of weight in the first 24 hours due to evaporative cooling. Large and very large processors will fabricate the carcass into primals and subprimals within the first 24 to 48 hours. The primals and subprimals are placed in vacuum bags and then boxed. It takes approximately 20 to 25 days for boxed beef to be delivered to a local retailer from the packing plant. The cuts will age inside the vacuum bag, referred to as wet aged beef. Aging allows the residual enzymes to breakdown the connective tissue and proteins to produce a more tender product. Small meat processors have the ability to allow the carcasses to dry age in the cooler, as a whole carcass, for seven or 14 more days. Dry aging also produces a more tender beef product but the flavor has been described as more intense, nuttier, or earthier. Due to the size of the industry, the vast majority of beef available in retail grocery stores is wet aged.

Beef cattle (live) yield only about 35 percent to 40 percent lean edible meat. During the conversion of muscle to meat (the hide, head, feet, blood, and viscera

have been removed), the difference between live weight and carcass weight is referred to as a dressing percentage. The average cattle will have a dressing percentage from 60 percent to 63 percent. From a conversion standpoint, a 1,000-pound live steer with a 62 percent dressing percentage will produce a 620-pound carcass. The 620-pound carcass will yield approximately 60 percent to 70 percent, depending on the amount of fat and bone removed from the carcass. In most cases, the 620-pound carcass will ultimately yield approximately 400 pounds of edible retail cuts with the majority as ground beef.

Retail Cuts of Beef

The four major primal cuts on a beef carcass are the round, loin, rib, and chuck. These cuts comprise approximately 75 percent of the weight of a carcass and account for roughly 90 percent of the carcass value (Table 9-1 illustrates the breakdown by weight and value of the primal cuts). The remaining 25 percent of the weight and 10 percent of the value come from the brisket, shanks, plate, skirt, and flank.

Steaks and roasts come from the primal cuts of meat. Each primal cut has its own characteristics in terms of tenderness, fat content, preferred cooking methods, and price. Retail cuts from the loin and rib are considered the most valuable due to tenderness and are suitable for any cooking method (grilling, pan frying, dry roasting, etc.). The round produces lean, affordable steaks and roasts that are intermediate in tenderness. The most economical cuts of beef come from the chuck. Retail cuts from the chuck have the most fat (marbling and seam fat) but are tougher due to being muscles of locomotion (larger muscle fibers and more connective tissue) and are more economical. Moist heat cooking methods (cook in liquid, stewing, etc.) work best for steaks and roasts from the round and chuck.

USDA Quality Grades

Meat inspection is mandatory to enter commerce; however, USDA Beef Quality and Yield Grading is a volunteer program, i.e. beef does not have to be graded to be sold. Quality grading is a predictor of palatability (flavor, juiciness, and tenderness), and ranges from USDA Prime (most desirable), Choice, Select,

Table 9-1. Percentage of total carcass weight and value of each of the major primal cuts.

Primal Cut	Percent by Weight	Percent by Value
Round	23	29
Loin	17	29
Rib	9	11
Chuck	26	21

Adapted from Boggs and Merkel, *Live Animal Carcass Evaluation and Selection Manual*. Third Edition.

Standard, Commercial, Utility, Cutter, and Canner (least desirable). Beef from carcasses with superior quality grades (USDA Prime and Choice) are expected to be the most tender, juicy, and flavorful.

The ribeye is exposed between the 12th/13th rib juncture for grading. Maturity and marbling are the two factors used to assign a USDA Quality Grade. The following are descriptions of those factors.

Maturity

Tenderness is predicted by the age/maturity of the animal at the time of slaughter. As an animal ages, it develops more connective tissue and the meat becomes tougher. The maturity scores range is from A to E in the USDA Beef Quality Grading system, with A being the youngest ($\approx \leq 30$ months old) to E as the oldest ($\approx \geq 96$ months old). Maturity is further subdivided into degrees ranging from 0 to 90 in increments of 10. Maturity is determined by the amount of ossification of the thoracic vertebrae, color and shape of the rib bones (red, round ribs = younger animal, bleached, flat ribs = older animal), fusion of the sacral vertebrae (more fusion of the vertebrae = older animal), and color of the lean (darker lean = older animal). USDA Prime, Choice, Select, and Standard grade are intended for A and B maturity scores whereas, USDA Commercial, Utility, Cutter, or Canner are for the older C, D, and E maturity scores. Carcasses scored as A maturity come from steers or heifers that were intended to enter the food chain, whereas B maturity carcasses come from heifers and both A and B carcasses are fabricated into steaks and roasts intended for grocery stores and eating establishments. Maturity scores C, D, and E carcasses are cull breeding stock and due to challenges with tenderness these carcasses are used for ground beef and/or processed meats

such as frankfurters, deli roast beef, jerky, etc. The following are estimates of the age of the animal at the time of slaughter for each USDA Maturity score.

Maturity	Age
A	less than 30 months of age at slaughter
B	30 to 42 months of age at slaughter
C	42 to 72 months of age at slaughter
D	72 to 96 months at slaughter
E	older than 96 months at slaughter

Marbling

Juiciness and flavor are predicted by the amount of marbling in the ribeye. Marbling degrees are determined by the amount and distribution of the flecks of fat within the ribeye. The marbling degrees range from practically devoid, traces, slight, small, modest, moderate, slightly abundant, moderately abundant, and abundant (Figure 9-1). Marbling is further subdivided into degrees ranging from 0 to 90, in increments of 10. Ribeye and loin cuts from USDA Prime carcasses will be sold to five-star, white tablecloth restaurants and higher end grocery stores, whereas cuts from USDA Choice and Select carcasses can be found in grocery stores and typical steakhouses. Blind taste test research indicates that as the marbling degree increases the overall flavor scores increase; however, consumers view USDA Prime as too fatty and expensive for purchase in grocery store meat cases.

Determining the Final Quality Grade

Once the maturity and marbling scores have been determined, a USDA quality grade is assigned, with younger, higher marbling degree carcasses receiving the superior grades (Prime and Choice). USDA quality grades can be further subdivided into high (+), average (0), and low (-), based on the degree of maturity and the marbling score.

USDA Yield Grades

USDA Yield Grades are lesser known, but still just as valuable. Beef yield grades predict the percentage of boneless, closely trimmed retail cuts from the round, loin, rib and chuck (Table 9-2). Beef yield (YG) grades range from 1 to 5; YG 1 carcasses

are very trim and heavy muscled whereas YG 5 carcasses are fat and light muscled. Official USDA yield grades are calculated to the nearest tenth (i.e., yield grade 2.7); however, only the whole number is stamped on the carcass (i.e., yield grades 2.0 to 2.9 are assigned yield grade 2; YG are not rounded up).

The components used to calculate the USDA yield grade are hot carcass weight, fat thickness over the ribeye at the 12th rib, ribeye area at the 12th rib, and percentage of kidney, pelvic, and heart fat. The regression equation to calculate yield grade is as follows:

$$\begin{aligned} \text{YG} &= 2.2 \\ &+ (2.5 \times \text{adjusted 12th rib fat thickness}) \\ &+ (0.2 \times \text{KPH}\%*) \\ &- (0.32 \times \text{ribeye area, sq. inches}) \\ &+ (0.0038 \times \text{hot carcass weight}) \end{aligned}$$

*KPH% is added to the equation as a whole number, rather than a converted percentage.

Yield grades of 1 to 3 are usually considered acceptable; grades of 4 and 5 are considered to be too fat and unacceptable. Even when yield-grade-4 and -5 carcasses are closely trimmed, there are large amounts of seam fat.

Collecting Carcass Data for Determining Yield Grades

Adjusted 12th rib fat thickness. The 12th rib fat thickness is measured a tenth of an inch, three-fourths of the way down the ribeye (from the carcass split). The USDA grader will adjust the fat thickness to account for fat that was lost during hide removal or if they feel the amount of fat at the 12th rib is not representative of the entire carcass.

Kidney, pelvic, and heart fat percentage. Kidney, pelvic, and heart (KPH) fat is a dry fat sometimes referred to as suet, which is one of the first layers of fat deposited on the growing animal. KPH is subjectively determined as a percentage of the carcass weight and requires some experience and skill to accurately estimate. Keep in mind the carcass weight when determining a KPH% as the percentage of the same amount will be deferent in a 600 lb. vs. an 800 lb. carcass.

Ribeye area, square inches. The ribeye area/ribeye muscle (*Longissimus dorsi*) is

Figure 9-1. Photo examples representing the minimum marbling requirement for the most common marbling scores with their corresponding USDA Quality Grade in parentheses.

a. Moderately Abundant
(USDA Average Prime)



d. Modest
(USDA Average Choice)



b. Slightly Abundant
(USDA Low Prime)



e. Small
(USDA Low Choice)



c. Moderate
(USDA High Choice)



f. Slight
(USDA Select)



measured utilizing a dot grid. Each square in the grid represents a tenth of an inch.

Hot carcass weight. Traditionally, the hot carcass weight is found on the carcass tag attached to the carcass.

Direct Marketing of Beef Products

Keys to success:

- Know your product(s).
- Know your consumer clientele.
- Know local and federal regulations.
- Develop the necessary infrastructure.
 - » Processing capabilities
 - » Distribution avenues
 - » Market segments
 - » Cooperative arrangements
 - » Cash-flow requirements

Local foods are extremely popular with consumers; the popularity of the Kentucky Proud program has exploded. Beef farmers may want to take advantage of this popularity and add direct marketing as part of the farms promotion. The following are basics that beef farmers may want to consider before direct marketing beef.

Step 1. Gather Information

Direct marketing beef from your farm can be an excellent way to promote your farm's brand, but it requires tremendous effort. The first step is finding a USDA inspected facility that is willing to work with you and help you with maintaining quality and labeling of your product.

The meat processors inspection stamp/legend must appear on all packages; thus the processor needs to know that you are direct marketing beef. In addition, good meat processors can be pre-booked for several months in advanced, which can make it difficult to create a consistent product flow. Beef farmers may want to pre-book several dates in advanced to ensure product flow.

Next, direct marketers need to determine where they are going to sell their beef. Traditionally, direct marketers sell at farmer's markets. The Kentucky Department of Agriculture oversees registered farmer's markets and roadside stands and they have guidelines/rules that must be followed to sell. These guidelines can be found at <https://www.kyagr.com/marketing/farmers-market.html>. Others may want to bypass the farmer's market and either sell off the farm or directly to restaurants/grocery stores. Contact the local/state health department (Kentucky Cabinet for Public Health) to understand the rules and regulations for selling off the farm. Finally, be cognizant when selling to restaurants and grocery stores as they want a consistent product and a consistent supply. This can be difficult for a small, family-owned beef farm.

Pitfalls of direct marketing:

- Possible upfront financial investment
- Cost/profit ratio of products
- Lack of marketing skills/plan
- Lack of processing infrastructure
- Liability insurance
- Regulatory requirements

Step 2. Evaluate Your Business Approach

Do you as an individual have the personality to deal with people on a business level? Are you a salesperson? Can you make the appropriate sales pitch to a wide variety of clients? Can you handle rejection? Can you deal with negative comments about your product? Can you manage employees (to be successful you may have to expand your workforce)? Are you capable of listening and responding to regulatory officials on a daily basis? How would you respond to consumer complaints? These are all issues requiring someone who has the ability to deal with a wide variety of people on different levels from production through marketing and sales.

Table 9-2. Corresponding percent closely trimmed retail cut from the chuck, loin, rib, and round for several yield grades.

Yield Grade	% Retail Cut ¹	Yield Grade	% Retail Cut ¹
1.0	54.6	3.5	48.9
1.5	53.5	4.0	47.7
2.0	52.3	4.5	46.6
2.5	51.2	5.0	45.4
3.0	50.0	5.5	44.3

¹ Calculated from the formula:
 % retail cuts = 51.34
 - (0.0093 x hot carcass weight)
 - (5.78 x adjusted fat thickness, 12th rib)
 + (0.74 x ribeye area)
 - (0.462 x percent kidney, pelvic, and heart fat).

The most challenges facing new direct marketers is being able to handle the aforementioned situations. Moreover, the biggest challenge to the aforementioned situations is that the direct marketer is dealing with these issues alone or as a family. This can create more stress or be more than what was initially considered. A key point to remember during your initial startup is that "the consumer is always right" and that everyone is your consumer, this can be difficult for farmers.

If you have the premium product and the personality to succeed in dealing with people, you are a prime candidate for direct marketing. This is when small details began to demand more attention to ensure success. Advanced planning and discussions with regulatory agencies and meat processors is a must prior to startup. By involving all necessary federal and state governmental agencies (i.e., USDA, FDA, EPA, public health, Department of Agriculture, etc.) you not only avoid potential costly mistakes but also exhibit your desire to properly follow regulations and produce a safe and wholesome food product.

Step 3. Develop a Marketing Plan

Issues such as consistent animal supply, processing capacity, labeling, product transportation, marketing, cash flow, etc., are extremely important aspects necessary for a successful direct marketing. It is important that interested parties develop a business and marketing plan prior to direct marketing beef. In many cases, this will be required for financial institutions if outside capital is required

for startup. Not only will these plans assist you in developing your approach to direct marketing, but they may also prompt you to evaluate the way you do business in your other operations as well.

Furthermore, you have to decide what it is you want to achieve through direct marketing your product. Will this become your primary source of income? Many niche markets have grown to become major enterprises. Or are you looking to stabilize cash flow throughout the year to offset live animal price fluctuations? This is an important decision, as it will drive the efforts and input into your direct marketing program. Many university and government programs are designed to assist in the development of a marketing/business plan.

Step 4. Join with Other Direct Marketers

There is strength and security in numbers. The knowledge base is expanded, product flow is more consistent, the product becomes more consistent, etc., by combining efforts with other direct marketers. The group works toward a common goal in overcoming shortfalls in reaching customers, processing roadblocks, marketing efforts, transportation deficiencies, etc.

Sources of information:

- Networking with other producers
- Direct marketing/value-added conferences and workshops
- Kentucky Department of Agriculture
- University of Kentucky
- Local Cooperative Extension office
- Trade publications/associations
- United States Department of Agriculture-Agricultural Marketing Service

Summary

Plan, plan, plan! Prior thought and planning will be the keys to success. In addition, never give up. More than likely, someone before you has encountered a similar problem and developed a solution. The key to direct marketing is having a great consumer-demanded product and the perseverance to turn obstacles into opportunities.

Food Safety

It is estimated that around 325,000 people visit the hospital due to foodborne illness symptoms each year. Regulatory agencies have focused on prevention-based programs over the last 30 years to combat the different pathogens that could potentially contaminate meat products. Food safety is most important when it comes to food products. Simply cleaning, separating, cooking and chilling food properly can minimize or remove the chances of contamination and cross contamination. People handling meat products should wash their hands right, just before and after handling meat. Separating cooked meat, raw meat, and non-meat products such as fruits and vegetables from each other can prevent cross contamination. All beef products must be cooked to a minimum internal temperature of 145°, and ground beef products should be cooked to a minimum internal temperature of 160°. Temperatures should be measured accurately using a food-grade thermometer. Following the basic practice of keeping hot food hot and cold food cold is extremely important when handling beef products and cooked beef samples. Storing and refrigerating beef properly and quickly is not just good for food safety; it also ensures a higher quality beef product.

Meat sold anywhere in the United States must be produced, processed, and packaged in a United States Department of Agriculture (USDA) inspected facility even meat sold at the farmers market. Both the USDA and the Kentucky State's Food Safety Branch provide clear guidelines for how to ensure the safety of beef from the time it is harvested, processed, packaged, transported, and sold at the booth in the farmers market. These key areas include packaging, storage, labeling, and sampling.

Packaging

Perishables such as beef should always be safely covered to preserve the quality and to keep blood and juices beef from flowing onto other food. Beef should be sealed in packaging to prevent direct contact with ice or ice water. Water is a perfect medium to spread blood and bacteria to other foods and could cross

contaminate non-meat products. Beef products that are going to be stored, marketed, and sold frozen should be packaged in a plastic bag or foil meant for freezing. Selling packaged beef at the farmers market can be tough, consumers often like to see the different beef cuts and compare color, marbling, and weights. This could lead to consumers wanting to look at different packages in the cooler before they buy, which means the packages will be subjected to temperature variations from being taken out of the ice chest and handled many times. This also could disturb the vacuum packaging as packages are punctured and damaged when they are moved around in the cooler. A customer reaching into the cooler with dirty hands could contaminate the outside of a package, other packages in the chest and even the ice in the ice chest.

Vendors could use attractive signs and photos at the booth to allow consumers to visualize what kind of meat they are going to get if they buy. Effective marketing and communication could help avoid a contamination or foodborne illness incident. Kentucky Department of Agriculture (KDA) Farmers Market Manual Guidelines also say that meat vendors should contact the local health department to obtain a "mobile prepackaged retail sales permit."

Storage

Meat products should be stored frozen at 0° or refrigerated at 41° or lower, even during transport and at the farmers market. Especially during the farmers' market season, when outside temperatures reach 90° and above, beef products should be refrigerated or frozen within one to two hours. KDA's guidelines state that vendors should avoid the use of Styrofoam chests and use a plastic cooler or ice chest instead. Ice used in the ice chest or cooler should not come in direct contact with meat, nor should the meat be allowed to float in ice water. Vendors should also have ways to keep water from coolers from draining onto meat products or non-meat products for sale at the market. Vendors should pay special attention to meat stored at home before it is taken to the farmers market. Besides regulating the temperatures correctly, they should not store the meat for sale in the same

freezer or refrigerator that has food for personal use. The refrigerator and freezer temperatures should be monitored all the time using a thermometer.

Each type of food has a different potential for cross contamination and should be kept separate. Each meat product should have its own clearly labeled cooler. For example, if you have a cooler for seafood, clearly label that cooler as "seafood cooler" to keep someone from accidentally storing beef in that cooler. Different species of meat, such as poultry or seafood, as well as raw and ready-to-eat (RTE) foods should be kept apart. Also, both raw and RTE meats should never be stored with fresh fruit and vegetables.

Most farmers markets happen outdoors, where dust and insects can get onto the food, so vendors should cover their booth at the market with an overhead tarpaulin or a tent.

Vendors and workers handling all of the types of food in the booth could be a source of cross contamination themselves, so every booth/vendor should have their own portable hand washing station according to local health department requirements. Typically, the hand wash stations approved by health departments consist of a five or more gallon tank full of potable (drinkable) water, a nozzle dispenser, and a basin. The hand wash station should also have soap, single use towels, and a trash can.

Labeling

All beef products sold at the farmer's market must have the appropriate USDA seal or mark showing that the products have been through federal inspection. Vendors are also required to tell customers safe handling instructions, a use by date, the product name (ribeye, shoulder etc.) weight, the name and address of the processor, and the date meat was packaged.

Sampling

Offering samples is one of the best ways to attract long lasting customers. While presentation and quality of the beef product are very important, food safety remains the most important thing of all. If you plan to offer samples, know that KDA requires samples to be cooked at the farmers' market location. This

means samples can be brought precut or could be cut at the farmers market, but proper storage temperatures still have to be maintained. Cold samples must stay at 41° or lower, and hot samples should be kept at 135° or above.

Vendors handing out cooked or processed samples should try to cook beef only when it will be eaten quickly instead of sitting out. If it still has to wait for customers, vendors should monitor the temperatures so cooked product or cold product are not at the temperature danger zone for a long time. KDA Farmers market guidelines state that samples should not be kept out more than 30 minutes. It is recommended that vendors bring refrigerated samples since thawing samples could be a problem and water from thawed meat could get on other foods. A calibrated food grade thermometer is a must to make sure beef is cooked to the minimum internal temperatures recommend by the USDA-Food Safety Inspection Services (FSIS) below. To provide quality samples that are safe, vendors should let the meat rest for three minutes before it is handed out as samples (Table 9-3).

Table 9-3. Cooking food safely.

Product	Minimum Internal Temperature & Rest Time
Beef Steaks, chops, roasts	145°F (62.8°C) and allow to rest for at least 3 minutes
Ground meats	160°F (71.1°C)

Source: USDA-FSIS.

Approved hand wash stations and three compartment sinks are required to ensure staff handling the samples are doing it in a sanitary manner. Utensils, cutting boards, knives, and other food contact surfaces should be thoroughly washed and sanitized periodically. If a vendor also sells fruits and vegetables, three separate sets of utensils should be kept: one each for raw meat, cooked meat, and fresh produce. Proper presentation also means making sure customers only touch or pick up the sample they are eating.

KDA has stringent guidelines when it comes to marketing, selling, and sampling meat at an approved farmers market. KDA issues two types of sampling certificates: one for processed and cooked samples and the other for raw samples. The former requires a completed application, while the raw samples, specifi-

cally fresh fruits and vegetables, requires a Kentucky produce Best Practices Diploma. Both certificates are valid for two years. For more detailed information on these two certificates and guidelines for marketing, selling, and providing cooked/processed meat samples at the farmers market read the KDA Farmers Market Manual at http://www.kyagr.com/marketing/documents/FM_2016-2017KDAFMMManual.pdf.

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