THESIS

SPECIAL-FED VEAL: SEPARABLE COMPONENTS, PROXIMATE COMPOSITION, AND NUTRIENT ANALYSIS OF SELECTED RAW AND COOKED, WHOLESALE AND RETAIL CUTS

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ABSTRACT

SPECIAL-FED VEAL: SEPARABLE COMPONENTS, PROXIMATE COMPOSITION, AND NUTRIENT ANALYSIS OF SELECTED RAW AND COOKED, WHOLESALE AND RETAIL CUTS

Nutritional qualities of consumer foods are of great importance in improving health. The American obesity epidemic and resulting government recommendations for the decrease in the consumption of foods with high fat and sodium content resulted in an increase in consumer awareness of nutrition. In 2010, the Food Safety Inspection Service published the final rule "Nutrition Labeling of Single-Ingredient Products and Ground or Chopped Meat and Poultry Products" (75 FR 82148) requiring nutrient facts for individual retail cuts be labeled, effective January 1, 2012, under revisions to the Code of Federal Regulations (CFR) for "Nutrition labeling of meat and meat food products" (9 CFR 317.300). Veal products are included in the section regarding the "Identification of major cuts of meat products", which specifies cuts required to have a nutrition label, including veal (9 CFR 317.344). In order to supply veal producers and retailers with nutritional label information, and therefore provide consumers with accurate nutritional information, it is necessary to analyze modern and prevalent veal retail cuts for nutrient content. Ten raw and cooked special-fed veal cuts from six different suppliers of United States-sourced veal were analyzed for nutrient contents.

Veal has improved in many aspects of nutrient composition compared to values used in the current United States Department of Agriculture (USDA)-Agriculture Research Service (ARS) Nutrient Database Standard Reference 26 (SR-26). According to USDA federal

regulations (9 CFR 317.362), leg cutlets, loin chops, and shank cross-cuts (osso buco) can be labeled under the USDA classification of "Extra Lean" with less than 5g total fat, 2.5g or less of saturated fat, and less than 95mg of cholesterol. Additionally, shoulder blade chops were considered "Lean", having less than 10g fat, less than 5 g of saturated fat, and less than 95 mg of cholesterol per 100 g. The American Heart Association "Heart Check" requirements are met by leg cutlets, loin chops, and shank cross-cuts. Compared to SR-26 data, cholesterol levels declined by 30%. Veal provides an "excellent" source of: Vitamins B2, B3, B6, B12; selenium, zinc, phosphorus, and copper. Additionally, veal is a "good" source of Vitamin D, iron, and potassium.

These results provide nutrition facts for consumers to use in conjunction with common cookery methods like grilling- which currently is not an option for veal when searching for foods on the current SR. Additionally, values for choline and Vitamin D are now available for veal. Vitamin D levels in veal from these data showed that raw and cooked ground veal fulfill the requirements to be labeled as a "good source" of this anti-carcinogenic nutrient, containing more Vitamin D than fortified milk and having close to the same levels of eggs and fish. Veal is a lean, complete protein choice for consumers, providing "excellent" and "good" amounts of protein, vitamins, and minerals.

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CHAPTER I

INTRODUCTION

Nutritive qualities of consumer foods are a relevant topic for all segments of the food supply chain. The sale of red meat products affects all contributors to the meat industry. Relevant and available data is socially mandatory in today's highly technological world, especially with the ease of public access to information. It is of great pertinence that nutritional information on labels be current and relevant to the products being sold at the retail market. Veal products at the retail setting lack current, relevant nutrient information for buyers to make sound decisions when purchasing proteins.

Nutritional qualities of consumer foods are of great importance to the public. The American obesity epidemic and resulting government recommendations for the decrease in the consumption of foods with high fat and sodium content resulted in an increase in consumer awareness of nutrition. In 2010, the Food Safety Inspection Service published the Final Rule (FR) "Nutrition Labeling of Single-Ingredient Products and Ground or Chopped Meat and Poultry Products" (75 FR 82148) requiring nutrient facts for individual retail cuts be labeled, effective January 1, 2012, under revisions to the "Nutrition labeling of meat and meat food products" (9 CFR 317.300). Veal products are included in the section regarding the "Identification of major cuts of meat products" specifying which cuts are required to have a nutrition label (9 C.F.R. 317.344).

The implementation of nutrition labeling requirements for veal cuts caused the veal industry to realize the potential for an update in available data. Nutritional data for veal was originally published in the Foods Agriculture Handbook 8-17, and most recently updated and

published in 1989. The handbook contained data from the work of Ono et al. (1986), and was the last journal-published research for veal nutrient contents. Handbook 8 data was incorporated into the currently used USDA National Nutrient Database for Standard Reference (SR), Release 11 in 1996. The most recent, non-published contribution of veal nutrient information was regarding information on breast and shank cuts was conducted by Dr. Denis Buege at the University of Wisconsin, and submitted for contribution to the SR Release 12 in 1998 (USDA, ARS, 1998). Although there is other research on nutritive qualities of veal (Faustman et al., 1992; Young et al., 1983; Riss et al., 1983), these data were not incorporated into the USDA Nutrient Database SR. Nutrient data reflective of the current supply of veal is nonexistent, and new data may show differences and improvement in nutritive content. Special-fed veal product is a "red" meat and originates from young beef (bovine) animals, but comparisons of veal proteins to beef products may be inaccurate due to the vastly different diets for special-fed veal compared to conventionally raised beef. Special-fed veal milk-replacer diets are different than all other cattle feeding systems, as they are never fed roughages or grains, and the majority of veal-calf operations house calves indoors. Veal calves are fed solely a milk-replacer liquid formula until they reach 18 to 20 weeks of age or are approximately 226 kg live weight (AVA, 2011).

Special-fed veal occupies approximately 75% of the U.S. veal market, and is the most common type of veal sold to the general public (NCBA, 2014). Veal per capita consumption in 2000 was 0.23 kg, and has since declined to 0.14 kg as reported by USDA in 2010 (USDA, ERS, 2012). Consumer selections of protein indicate a disfavor for red meat particularly due to the generalization of it being "unhealthy" in terms of total fat and saturated fat content (IFICF, 2009). However, recent data shows that over 20 USDA-classified "lean" cuts of beef exist and there are lean red meats available for purchase (USDA-ARS, 2013). In order to supply veal

producers and retailers with nutritional label information, and therefore provide consumers with current nutritional information, it is necessary to analyze prevalent veal retail cuts for relevant data on nutrient composition.

REVIEW OF LITERATURE

Red meat options, particularly from bovine, are considered unhealthy partially due to historically high total fat, saturated fat, and sodium content in cuts compared to other complete and incomplete proteins sources in the diet. Outdated nutrition information encouraged generalizations of all red meat having high-fat and sodium content. As a result, shifts in the USDA Dietary Guidelines have occurred such that red meat is no longer specifically recommended as a sound choice in protein. The USDA Dietary Guidelines in the 70's trended toward a low-fat, high-carb consumption to improve American health. However, this diet could be the reason why the prevalence of obesity for adults aged 20 and over in the United States has increased from 19.4% in 1997 to 29.0% in 2013 (CDC, 2014). The 2010 Dietary Guidelines for Americans focused on the importance of reducing consumption of total fat, saturated fat, trans fat, sodium, refined grains, sugar, and alcohol. Accuracy of current nutritional information is vital in offering Americans healthy, nutrient-rich foods with essential vitamins and minerals, and highly bio-available complete proteins.

Lipids

Lipids are a group of simple molecules and compounds that have numerous essential functions in the body. Classifications of lipids are dependent on solubility and functionality. Simple lipids include fatty acids, acylglycerols, and waxes. Fatty acids can have the following sub-types: non-esterified, saturated, unsaturated, and *trans.* Compound lipids include, but are not limited to glycolipids, lipoproteins, and phospholipids. Broadly speaking, these lipids contribute to cell membrane structure, transport of fat-soluble Vitamins, cell signaling, energy storage, and solubilization of both aqueous and non-aqueous compounds. Consumption of fat is important in

obtaining essential lipids for many needs. The 2010 Dietary Guidelines for adult Americans recommends consuming 20 to 35% of total calories from fat.

Saturated Fatty Acids

Saturated fatty acids (SFA) are a hydrocarbon chain linked together with a single covalent bond with a carboxylic acid group and a methyl group at opposing ends. The 2010 Dietary Guidelines recommends that adult Americans consume less than 10% of total calories per day from saturated fatty acids due to associations with coronary heart disease (CHD) and instead consuming polyunsaturated and monounsaturated fatty acids. Lauric (C10:0), myristic (14:0), and palmic (C16:0) acids have been shown to increase LDL serum levels (Micha et al., 2010). Stearic acid (C18:0) however, is a fat which is either neutral or depressive in total cholesterol and LDL serum concentrations (Kris-Etherton and Yu, 1997). Additionally, newer data has shown SFA not being directly associated with an elevated risk of CHD (McNeill et al., 2012).

Unsaturated Fatty Acids

An unsaturated fatty acid has a hydrocarbon chain with at least one double bond placed between two carbons. There are monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs). Two unsaturated fatty acids are known to be essential in the human diet since they cannot be synthesized de novo: linoleic and alpha-linolenic. These two fatty acids are referred to as omega-6 and omega-3 fatty acids, respectively. It is recommended that American adults consume the majority of fat as MUFAs or PUFAs due to their positive attributes to human health in reducing total and LDL cholesterol levels (Kris-Etherton &Yu, 1997; USDA & USDHH, 2010). Omega-3 fatty acids are beneficial in cognitive development and decreasing CHD risk. The RDI for adults ranges from 250 to 500 mg/d (USDA & USDHH, 2010).

Conjugated Linoleic Acids

Conjugated linoleic acids (CLA) is a term in which isomers of linoleic acid (C18:2) are grouped due to their conjugated double bonds not being separated from a methylene group. In ruminants, partial hydrogenation of a few fatty acids occurs due to bacterial isomerases (Williams et al., 1983). Research has shown that CLA's are beneficial, with improvements in the immune system, and prevention of cancer and hypertension (Bhattacharya et al., 2006; Dilzer & Park, 2012). The two main isomers found naturally in animal products are trans-9, cis-11, and cis-10, trans-12.

Cholesterol

Cholesterol levels are measured by the ratio of low density lipoproteins (LDL) to high density lipoproteins (HDL) in the blood. Blood cholesterol levels in individuals are affected by dietary intake of animal products (Brown and Goldstein, 1986). Suppression of endogenous synthesis of cholesterol via an increase in dietary cholesterol and the negative feedback regulation of HMG-CoA reductase reaction is only relatively effective in suppression of liver production of cholesterol, and not in intestinal synthesis cessation (Prospective Studies Collaboration, 2007). Dietary cholesterol is derived from animal sources. Cholesteryl esters are the key contributors to plaque formation and atherogenic arteries.

Protein

Proteins and peptides are built using 20 amino acids linked together via a peptide bond to form chains. Protein has numerous functions such as transportation of nutrients, mobility, metabolism and body regulation, body structure, and is involved in immune system functions. Collagen, actin, myosin and hemoglobin contribute approximately 50% of the human body's proteins. Severe body system degradation can occur when protein levels are not maintained.

Many renal, hepatic, and gastrointestinal organ diseases become prevalent, including cancer formation and acceleration. The human body uses proteins at a high rate of turnover in metabolic processes, producing free amino acids which are divided into two groups: essential or nonessential. There are 20 common amino acids, each having an amino group, a side chain, a hydrogen, and a carboxylic acid group. Side chains program the specific properties of the amino acid, including solubility, polarity, and size.

To maintain homeostasis of protein needs, the recommended allowance for dietary protein is 0.8g/kg of body weight per day (NAS-IOM, 2005), or 46g for woman and 56g for men daily with alterations to these levels with body health status. To obtain the adequate levels, the quality of protein consumed is vital, as food sources can vary in protein digestibility and are classified as complete or incomplete based on amino acid content. Incomplete amino acids are derived from plant sources, mainly legumes and grains, and need a complementary protein to aid in fulfillment of the body's requirements. Meat diets supply the human body with complete proteins, as meat contains all the indispensable amino acids in adequate amounts. Digestibility of meat is approximately 95%, whereas vegetables such as split peas are 70% digestible (Smith and Gropper, 2013). The 2010 Dietary Guidelines for Americans recommends that 10 to 30% of calories should be obtained from protein.

Major and Trace Minerals

Major mineral functions are numerous and varied, and are vitally important in body health. Key major minerals include calcium, phosphorus, and magnesium. These minerals play roles in body fluid osmotic pressure, bone and teeth integrity. Trace minerals are elemental in nature and are important in numerous body functions, but in relatively small amounts; less than 100 mg/day (Smith and Groper, 2013).

Selenium

Functionally, selenium works to protect against damage from free radicals and hydrogen peroxide as a cofactor. Deficiencies include myalgia, cardiac myopathy, poor growth, and abnormal sulfur metabolism. The RDA for selenium for adult males and females is 55µg (USDA & USDHH, 2010). Levels for selenium in red meat, particularly beef are high, and beef is considered an "excellent" source (Acheson, 2003).

Zinc

Zinc is a mineral involved in nutrient metabolism, collagen formation, sexual maturation, and the replication and growth of cells. A lack of zinc in the diet can result in decreased growth ability, limited healing from injuries, and abnormal sense of taste and smell. The recommended daily allowance for adults is 8 mg for females and 12 mg for males (NAS, 2006). Beef is the best source of zinc, having on average 3.3mg/100g (Cotton et al., 2004).

Iron

Iron has two stable aqueous states in the body and in food: ferric (Fe^{3+}) and ferrous (Fe^{2+}), in the role of oxygen metabolism and transport. Heme iron is found in hemoglobin and myoglobin in meat. Non-heme iron is derived from plant sources and dairy products; however, dairy contains very little iron and is not considered a good source. The recommended dietary iron intake is 12 milligrams for women and 8 milligrams for men aged 19 to 50 years (NAS, 2006). Deficiencies in iron can result in anemia, fatigue, and immuno-compromised health.

Vitamins

Vitamins are organic compounds essential for body regulation and metabolism of carbohydrates, fat, and protein. In maintaining health, vitamins function in blood clotting, red blood cell synthesis, bone health, energy production, growth development and reproduction,

immune function, and as coenzymes and antioxidants. Without dietary vitamins, significant diseases and disorders can occur. However, effects from vitamin deficiencies may be reversible if vitamins are consumed at adequate levels and in absorbable forms. Unless the body has deficiencies due to cell-receptor defects, dietary vitamins are capable of preventing cardiovascular diseases as well as microcytic hypochromic anemia, beriberi, pellagra, and other disorders. Both water-soluble and fat-soluble Vitamins are vital in human health and nutrition. Fat-soluble Vitamins include Vitamins A, D, E, K and can be stored in the liver, kidneys, and fat. Water-soluble Vitamins are Vitamin C and the B Vitamins, and must be consumed daily as they are stored only in minimal levels in the body. Red meat contains relatively high levels of niacin, thiamin, pantothenic acid, Vitamin B6, B12, and K compared to other protein sources (Smith and Groper, 2013).

Vitamin B12

Cobalamin, or Vitamin B12, is found in food as cyanocobalamin and as an active form called methylcobalamin. B12 functions to convert amino acids skeletons to succinyl CoA in the Krebs cycle in post-deamination. The absence of B12 in the diet has a direct effect on folate concentrations, as B12 removes the methyl group of folic acid to its active form. The resulting folate deficiencies can cause fetal development problems, megaloblastic anemia and homocystiene effects, or vessel stiffening, in the cardiovascular system. Symptoms of B12 deficiencies can occur in strict vegetarians and vegans after approximately 10 to 20 years (Smith and Groper, 2013). The RDA for Vitamin B12 is 2.4 µg (USDA & USDHH, 2010).

Riboflavin

Riboflavin is a three ring structure with a sugar-alcohol side chain, and serves as the base for the coenzymes flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD), which

act as electron transporters in metabolic processes for energy production in the Krebs cycle and the electron transport chain. Deficiencies can result in symptoms of ariboflavinosis, chellosis, and glossitis. A lack of riboflavin in the diet can also limit the levels of other B Vitamins if low (Smith and Groper, 2013). The RDA for riboflavin is 1.1 mg (USDA & USDHH, 2010).

Niacin

Niacin, or Vitamin B3, has two active forms: nicotinic acid and nicotinamide. Both can convert to nicotinamide adenine dinucleotide (NAD) or nicotinamide adenine dinucleotide phosphate (NADP). Niacin functions as a coenzyme in electron transfer oxidation and reduction reactions, aids in glucose, protein, and fat metabolism, protein synthesis, and has a role in immune responses. Deficiencies can include the development of pellagra, a disease which causes the "Four D's": dermatitis, diarrhea, dementia, and ultimately, death. The bioavailability of niacin in plant foods is reduced compared to animal sources (Smith and Groper, 2013). The RDA for niacin in adult males and females is 14mg (USDA & USDHH, 2010).

Thiamin

Thiamin, or Vitamin B1, in an active form is thiamin pyrophosphate. Vitamin B1 participates in the transmission of nerve functions, produces adenosine triphosphate (ATP) during glycolysis, creates pentoses in DNA and RNA synthesis, and converts branched-chain amino acids to acetyl CoA. Deficiencies in thiamin causes a condition called Beriberi, wherein weight loss, confusion, muscle weakness, edema, chronic heart failure, muscle wasting, and nerve degeneration occurs (Smith and Groper, 2013). The RDA for thiamin in adult males and females is 1.1 mg (USDA & USDHH, 2010).

Vitamin B6

There are three forms of Vitamin B6; two forms, pyridoxamine and pyridoxal are from muscle sources and the latter converts to the active form of pyridoxal phosphate (PLP). The PLP form is stored mainly in muscle, and little in the liver. Vitamin B6 functions as a coenzyme, mainly for protein metabolism, and is directly involved in the transamination of essential amino acids to non-essential amino acids. In glycogeolysis and gluconeogenesis, B6 has a role in carbohydrate metabolism (Smith and Groper, 2013). In addition, B6 has hematopoetic properties and aids in immune system functions. The RDA of Vitamin B6 for adult males and females is 1.3mg (USDA & USDHH, 2010).

Vitamin E

Vitamin E has eight different vitamers, with two classes: tocopherols and tocotrienols. Alpha-tocopherol is the active form of Vitamin E and acts as an antioxidant in maintaining membrane vigor by preventing the oxidation of unsaturated fatty acids. The compound reduces non-lipid and lipid peroxyl radicals by supplying a hydrogen during the reaction. Vitamin E is found in most tissues in the body, with a great amount being stored in adipose tissue and cell walls (Smith and Groper, 2013). The RDA of Vitamin E for adult males and females is 15 mg of alpha-tocopherol (USDA & USDHH, 2010).

Vitamin D and 25-Hydroxy Vitamin D

Vitamin D has multiple forms, including provitamins ergocalciferol (D2) and cholecalciferol (D3). The main form of Vitamin D is 25-Hydroxy-cholecalciferol (calcidiol) and is used to determine levels in the body and is formed in the liver when D3 is hydroxylated. Vitamin D3 is produced in the skin and is derived from animal products. Vitamin D2 is from plants and is used in dietary supplements. The active form of Vitamin D is 1, 25

dihydroxycholecaliferol (calcitriol D3), which functions similar to a steroid hormone to regulate bone mineral metabolism, blood calcium homeostasis, and cell differentiation, proliferation, and growth. In particular to cell health, Vitamin D directly contributes to anti-carcinogenic activity (Welsh, 2012). Vitamin D has shown to prevent cancer, type I diabetes, heart disease, and osteoporosis (Holick, 2004). Obtaining adequate levels of Vitamin D in nutrition are vital to decrease risk of breast (Krishnan et al., 2012) and colorectal cancers. The RDA of Vitamin D for adult males and females is 15 to 20 µg (600-800 IU) (NAS, 2011).

The current USDA SR-26 does not have values for Vitamin D in veal reports, and it has only been recently made a priority to include analysis of foods for Vitamin D, including specifically calcitriol D3, which has shown recently to be important in countering carcinogenesis (Holick, 2004).

Nutritional Labeling of Retail Cuts

In 2010, the Food Safety Inspection Service published the final rule "Nutrition Labeling of Single-Ingredient Products and Ground or Chopped Meat and Poultry Products" (75 FR 82148) to include nutrient facts for individual retail cuts. For veal, this includes: arm blade chops, shoulder blade chops, rib roasts, loin chops, and leg cutlets.

The USDA has different requirements for labeling claim classifications of consumer foods. According to 9 CFR 317.362, Products that are "lean" must have less than 10 g fat, less than 5 g of saturated fat, and less than 95 mg of cholesterol per 100g (USDA, 2010). Furthermore, to be USDA "extra-lean", products must have 5 g or less of fat, 2.5 g or less of saturated fat, and less than 95 mg of cholesterol per 100 g (USDA, 2010). Additionally, the American Heart Association has a "Heart-Check" food certification program with nutritional requirements for different categories of foods. For "Extra Lean" meat and seafood, standards per

100 g are: less than 5 g total fat, less than 2g saturated fat, less than 0.5 g trans-fat, less than 95 mg cholesterol, less than 360 mg sodium, and 10% or more of the Daily Value of 1 of 6 nutrients (Vitamin A or C, Iron, Calcium, protein, or dietary fiber) (AHA, 2014). According to 9 CFR 317.354, the use of labeling claims such as "excellent source of", "high", and "rich in" requires 20% or more of the dietary reference intake (DRI) or the daily reference value (DRV) per reference amount customarily consumed (RACC). Furthermore, to be labeled a "good source", the product must contain 10-19% of the DRI or DRV per RACC (USDA-FSIS, 2013).

Special-Fed Veal Calf Diets and Production Systems

Dairy calves are the main source of U.S. veal, particularly male calves which cannot enter into the dairy herd for milk production. There are three types of veal: bob veal, special-fed, and "non-special-fed" or pasture-raised veal. Special-fed veal calves receive a milk-replacer formula diet, that is comprised of either soy or milk products until they reach a live weight of approximately 226 kg (500 pounds) and are usually 20 to 22 weeks of age (AVA, 2011). The nature of the animal being young and fed a liquid diet maintains the status of the pseudo-monogastric digestive tract, wherein the rumen is not further developed due to an absence of grains and forage feeds. The calf's system continues to bypass the rumen via the esophageal groove, to only utilize the abomasum for digestion of fats, carbohydrates, and proteins (Wise et al., 1984). The lack of grains and forages, and relatively lower iron content in milk-replacer diets, compared to traditional ruminant diets, for veal contributes to the opaque, pale-pink color of veal products (Miltenburg et al., 1992).

Vitamin D requirements by preruminant calves is 318 IU/d (NRC, 2001), however commercial milk replacer supplies on average 2,650 IU/d and reasoning for this amount is incomplete (Nonnecke et al., 2009). No additional hormones are used in the production of veal.

Antibiotics such as tetracycline may be used for preventing and treating illness (USDA-FSIS, 2012).

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CHAPTER III

SPECIAL-FED VEAL: SEPARABLE COMPONENTS, PROXIMATE COMPOSITION, AND NUTRIENT ANALYSIS OF SELECTED RAW AND COOKED, WHOLESALE AND RETAIL CUTS

MATERIALS AND METHODS

Experimental design

Special-fed veal product sampling was intended to be representative of the majority of products merchandized in U.S. retail stores. Six suppliers provided product, located in the Northeastern region in the U.S. where veal calves are harvested and where the demand for veal products is at its highest. Suppliers were randomly paired to form three composites pertaining to each cut. Cut is defined as the cut type and the status of being raw or cooked. Assays analyzed on a three-composite level had a pair-wise comparison design based on the cut type since there were no other factors in this study, aside from supplier. Nutrient composition of cuts were compared to each other only for assays performed on a three-composite level; this includes fat, ash, protein, moisture, cholesterol, minerals, and fatty acids.

Product Procurement

Veal cuts (Table 1) were supplied from six different slaughter establishments across the U.S. derived from special-fed, non-bob veal U.S. calves. Product was procured and shipped in retail packaging, with the exception of whole loin roasts and whole shanks which were vacuum-packaged wholesale. Grade of veal was not considered as a variable in selection; however, 98% of veal sold at the retail level is graded “Good” (American Veal Association, 2011).

For each cut, four packages per supplier were obtained. All retail packages were vacuum sealed in original packaging. Per each supplier, four wholesale whole loins and four whole shanks were received for raw analysis. Retail packages of loin chops contained two pieces; one chop was selected for raw dissection, the other for cooked analysis. Shank-cross-cuts were variably packaged as one single cut or had two cuts per package, thus two cuts were randomly selected for raw dissection, and two for cooked analysis. Leg cutlets were packaged with 4 cutlets per package. One random cutlet from each package was extracted for raw analysis; another cutlet was randomly selected for cooked analysis. Shoulder blade cross-cuts (blade chops) had one cut per package, therefore two blade chops were randomly selected for raw analysis, and two for cooked analysis. Four packages of retail ground veal was received from each supplier and varied in weight from 226 g to 454 g. Two ground veal packages were randomly selected for raw analysis and two for cooked analysis.

Cooking of Retail Cuts

Retail cuts designated for cooking (Table 1) were tempered in a single layer on racks at 0 to 4°C for 24 or 48 h. For possible surface moisture build-up removal from thawing, each individual cut was blotted with a paper towel and weighed to the nearest 0.1 g, and raw temperature was recorded. Cuts were cooked using 1 of 3 cooking methods: grilling, roasting, or pan-grilling.

Grilling

Leg cutlets, loin chops, and shoulder blade chops were grilled. A Salton two-sided electric grill (Model GRP99, Salton Inc., Lake Forest, IL) was pre-heated for approximately 10 min to insure a minimum surface temperature of 195°C was established before cooking. Individual cuts were placed on the grill surface and the cooking start time of each was recorded

individually. Different cut types were cooked on separate grills. All start and end cook times were recorded. Leg cutlets were placed on the grill, and due to their thinness, they were flipped after 0.5 minutes and cooked for approximately 1.5 min until the internal temperature reached 70°C on the grill; then allowed to peak once removed and temperature was recorded. For the loin chops and blade chops, each steak was cooked individually and the steaks were flipped to guarantee even cooking after 4 min or when the internal temperature reached 35ºC. Digital thermocouple thermometers (Digi-Sense; Cole Parmer, Vernon Hills, IL) were used for temperature monitoring. Once an internal temperature of 70°C was obtained, individual cuts were removed from the grill surface and the internal temperature was allowed to peak. Then, the internal off-temperature and cooked weight (to the nearest 0.1 g) were recorded. All cooked cuts were placed on wire racks and allowed to chill uncovered directly following cooking, at refrigeration temperatures (0 to 4°C) for at least 12 h before dissection.

Braising

Braising was used to cook shank cross-cuts. A 6-quart covered non-stick dutch oven (Calphalon Corp., Toledo, OH) was used to hold each individual cut and distilled, deionized water was added until it covered the cut and the volume was recorded. Ovens were pre-heated to 120°C. Entry and exit time was recorded for each cut, and cuts were cooked for a set time of 150 min due to the large amount of bone present on this cut. This protocol for braising was previously approved for use with beef during completion of the Nutrient Database Improvement study (Martin et al., 2013). Stainless steel tongs were used to remove the shank cross-cut and cuts were placed in a colander and allowed to cool for 10 min. The remaining liquid was poured into the colander and then into a graduated cylinder for measuring and the volume was recorded. Weights of all recovered meat were recorded. All cooked cuts were placed on wire racks and

allowed to chill uncovered directly following cooking, at refrigeration temperatures (0 to 4°C) for at least 12 h before dissection.

Pan-Grilling

Ground veal was cooked by pan-grilling. Each retail package was cooked individually on a non-stick anodized aluminum skillet pan (Calphalon Corp., Toledo, OH). Pans were pre-heated to a surface temperature of 195°C and monitored with an infrared thermometer. The ground veal pre-cook temperature was recorded using a digital thermocouple thermometer (Digi-Sense; Cole Parmer, Vernon Hills, IL) and placed in a pre-heated pan. A stainless steel spatula was used to break apart and stir the ground veal in the pan for even cooking. An infrared thermometer was used to monitor product temperature, and when the average reached a minimum of 71°C, the pan was removed from the heat source and the product placed in a stainless steel colander to cool for 10 min. Final weight of the ground veal was recorded to the nearest 0.1 g and then packaged in a large whirl-pak bag, placed on wire racks and allowed to chill, at refrigeration temperatures (0 to 4°C), for at least 12 h before cooked dissection.

Cut Dissections

Dissection of raw and cooked cuts were conducted following standardized methods requiring the recording of internal temperatures and start and end times for dissection of each individual cut. Raw samples were tempered in a single layer at 0 to 4^{o}C for 24 to 48 h. Cooked samples were tempered after cooking 12 to 24 h. All dissection procedures were completed in with limited exposure to direct light and powder-free gloves were worn at all times. Separable component weights were recorded for individual samples which included initial cut weight before dissection, separable lean, refuse, external fat, and seam fat. A yield tolerance range (97 to 101%) for weigh-back of the sample was set, and any samples not meeting this standard were

removed from the study and replaced with an extra sample from that cut. Samples that were of the same cut and cooking specification, and came from the same supplier were combined for homogenization. Seam and external fat from the raw and cooked samples were frozen and homogenized separately at a later time.

Dissection of Raw and Cooked Leg Cutlets

Raw and cooked leg cutlets were examined for any fat present, but due to the lean nature of the cut and absence of external fat and refuse, dissections were not conducted and nothing was separated from the cut. Therefore, leg cutlets did not contribute fat to seam and external fat samples for analysis. Weights and temperatures were recorded, and samples were cubed for homogenization purposes.

Dissection of Raw and Cooked Shoulder Blade Chops

Raw and cooked shoulder blade chops were dissected to yield the following components:

- Refuse (waste): defined as all bone and heavy, non-transparent, inedible connective tissue.
- Separable lean: included all muscle, intramuscular fat and any light connective tissue considered edible.
- External fat: defined as the adipose tissue located on the outer surface of the cut and above the bridge of the muscles.
- Seam fat: included all fat deposited between muscles in a cut.

Dissection of Raw Loin Roasts and Cooked Loin Chops

Raw loin roasts were cut into loin chops and the pieces were kept together. Raw loin roasts and cooked loin chops were dissected to yield the following components:

- Refuse (waste): defined as all bone and heavy, non-transparent, inedible connective tissue.
- Separable lean: included all muscle, intramuscular fat and any light connective tissue considered edible.
- External fat: defined as the adipose tissue located on the outer surface of the cut and above the bridge of the muscles.
- Seam fat: included all fat deposited between muscles in a cut.

Dissection of Raw Whole Shanks and Cooked Shank Cross-Cut Chops

Raw whole shanks were cut into cross-cuts to have smaller, dissectible cuts to work with, and pieces were kept together. Raw whole shanks and cooked shank cross-cuts were dissected to yield the following components:

- Refuse (waste): defined as all bone and heavy, non-transparent, inedible connective tissue.
- Separable lean: included all muscle, intramuscular fat and any light connective tissue considered edible.
- External fat: defined as the adipose tissue located on the outer surface of the cut and above the bridge of the muscles.
- Seam fat: included all fat deposited between muscles in a cut.

Dissection of Raw and Cooked Ground Veal

Ground veal was not dissected due to the nature of the product but initial weights and temperatures were recorded and product was sliced into 2.5-cm^3 pieces for homogenization.

Lean and Fat Homogenizing and Compositing

To conduct the nutrient analysis, individual cuts from six different suppliers were composited to form composites on a three-level and single national-level for varying assays (Table 2).

Homogenization

For the protection of samples from contamination, homogenization and aliquoting procedures were performed using powder-free nitrile gloves, and in the absence of direct light. Separable lean from cuts were homogenized directly after dissection. Samples that were of the same cut and cooking specification, and came from the same supplier, were combined in equal proportion for homogenization. Separable lean was cut into 2.5-cm^3 pieces and placed in a stainless steel bowl containing liquid nitrogen until the pieces became completely frozen. Frozen pieces were placed in a 7-quart (6.62-L) Robot Coupe BLIXER 6V (Robot Coupe USA Inc., Ridgeland, MS) and blended until the sample had a finely- powdered consistency. Samples were blended for approximately 10 s on low speed (1500 rpm) and 30 s on high speed (3500 rpm). After homogenization, sample was placed in whirl-pak bags: 60 g for proximate analysis, 100 g for proximate back-up, and 100 g for archive. If there were remnants, the sample bagged and stored. Raw and cooked seam and external fat samples were homogenized in a similarly to the lean samples. All samples were double bagged and stored at -80^{o}C for analysis and compositing. After homogenization of individual retail cuts, composites were formed for nutrient analysis.

Lean Compositing

For the three-level composite, separable lean tissue for each cut was composited by first randomly pairing the six suppliers to make three composites, with each supplier product contributing equal parts in weight. Proximate analysis (moisture, protein, fat, and ash), total

cholesterol, fatty acid composition, and ICP minerals (Ca, Mg, K, Na, Fe, Zn, Cu, Mn) were conducted on a three-level composite. A single, national composite was created by homogenizing equal parts of lean tissue for each cut from all 6 suppliers for the analysis of Vitamin E, B Vitamins, Vitamin D and 25-hydroxy Vitamin D, selenium, and choline. Samples for nutrient analysis were aliquoted into Whirl-Pak® bags in the presence of dry ice. Samples needing to be analyzed at off-site laboratories were shipped overnight on dry-ice.

Fat Compositing

Seam fat from all six suppliers and all cuts were combined to form one national composite, wherein all raw seam fat dissected was homogenized together. Additionally, all cooked seam fat was homogenized together for to obtain cooked fat data. The same protocol was used for external fat. Samples for nutrient analysis were aliquoted into Whirl-Pak® bags in the presence of dry ice. Samples needing to be analyzed at off-site laboratories were shipped overnight on dry-ice.

Nutrient Analyses

Nutrient analysis occurred at USDA-ARS approved labs that included Colorado State University (CSU) and external locations for varying analyses. Retail cuts varied for assays conducted (Table 2), as data from raw loin roasts can be used to derive information for raw loin chops, and the same follows for raw whole shanks and the corresponding raw shank-cross cut. Similarly, cook data for cooked loin chop was extrapolated for cooked loin roasts, and cooked shank-cross cuts for cooked whole shanks. Three-level composite samples had equal weight of homogenate from each of the three pairs of suppliers. Single-level composites contained equal aliquoted weights from all six suppliers. Duplicates were performed for all samples and nutrients.

Proximate Analysis

Proximate analysis was conducted to determine the percent fat, moisture, protein, and ash on the following samples for all cuts: three-level composite for raw and cooked lean, and the single-level composite for raw and cooked seam and external fat.

The AOAC oven drying method 950.46 (AOAC, 1995) was used for moisture analysis. Approximately 1 g from samples were weighed out and placed into aluminum tins and dried for 24 h at 100°C in a forced air drying oven. The percent moisture (%M) formula was: % M = [(wet weight – dry weight) / wet weight] x 100.

Ash content was determined using the AOAC 923.03 or 920.153 (1995). Approximately 1.0 g of sample was placed into a dry, pre-weighed crucible and then inserted into a Thermolyne box furnace at 600°C for 18 h. The percent ash formula used was: % Ash = (ash weight / wet weight) x 100.

Total lipid was extracted using the Folch method (Folch et al. 1957; AOAC, 2000). Approximately 1 g of sample was homogenized in 2:1 chloroform to methanol solution. The homogenized sample was placed on an orbital shaker at room temperature for 20 min. The homogenate was then filtered through ashless filter paper. Four ml of 0.9% NaCl was added to the filtered sample, and the sample was placed in a refrigerator for 24 h. When the filtrate separated into two phases, the low phase was then aspirated and placed into a pre-weighed scintillation vial. The vial was then dried under N_2 gas. Following the N_2 gas drying, the vial air dried under a hood for 2 h and was then placed in a forced air drying oven to dry for 12 h at 100^{o}C. The formula used for percent fat was: Percent Fat= [(Total volume of chloroform: methanol)/10 x final lipid weight)/sample weight] x 100.

Crude protein content was determined as described by the AOAC (2006) Official Method 992.15 in which a nitrogen determinator (Leco TruSpec CN or Leco FP-2000; Leco Corporation, St. Joseph, MI and Rapid N cube, Elementar, Hanau, Germany) was used. Percent protein was calculated by multiplying total percentage nitrogen by a factor of 6.25.

Fatty Acid Analysis

A full fatty acid analysis was performed on the following samples for all cuts: three-level composite for separable raw and cooked lean, and the single-level composite for raw and cooked seam and external fat. Fatty acid methyl esters (FAMES) were readied (Parks and Goins, 1994) and analyzed by liquid chromatography using an Agilent (Avondale, PA) Model 6890 Series II gas chromatograph-fixed with a Series 7683 injector and flame ionization detector. The instrument was equipped with a 100-m x 0.25-mm (id) fused silica capillary column (SP-2560 Supelco Inc. Bellefonte, PA). Percentages were calculated based on the total FAME analyzed.

ICP Mineral Analysis

The ICP minerals (Ca, Mg, K, Na, Fe, Zn, Cu, Mn, and P) were analyzed at the three-composite levels for raw and cooked separable lean, and a single-level composite for raw and cooked seam and external fat by CSU using the AOAC Official Method 985.35 and USDA wet ashing procedure. Phosphorus analysis was conducted using a colormetric method (AOAC Official Method 2.019, 2.095, and 7.098).

Cholesterol Analysis

Cholesterol analysis was conducted using standard methods (Dinh et al., 2008). This assay was performed on the following samples for all cuts: three-level composite for separable raw and cooked lean, and the single-level composite for raw and cooked seam and external fat.

Selenium Analysis

Selenium content was determined from a single-level composite, having an equally proportioned aliquot by weight contributing from each of the six suppliers per each cut, per raw and cooked status. Seam fat and external fat were from single-level composites, including fat from all suppliers and all cuts, per raw and cooked status. Selenium analysis was conducted by Covance Laboratory (Madison, WI) using AOAC 986.15 hydride-generation method (AOAC, 2005), with the quantitation limit of 30 ppb.

B-Vitamins (B12, B6, Riboflavin, Niacin, Thiamin and Pantothenic acid)

B-Vitamin samples were analyzed on a single-level composite, having equally proportioned aliquots from each of the six suppliers per each cut, per raw and cooked status. Seam fat and external fat were from single-level composites, including fat from all suppliers and all cuts per raw and cooked status. The B-Vitamins were analyzed by Covance Laboratories (Madison, WI). The AOAC methods utilized in the analysis of each Vitamin were: Vitamin B-12- AOAC 952.20 and 960.46; Vitamin B6- AOAC 961.15; Riboflavin- AOAC 960.46 and 940.3; Niacin- AOAC 944.13 and 960.46; Pantothenic acid- AOAC 945.74 and 960.46; Thiamin- AOAC 942.23, 953.17, and 957.17.

Total Choline

Samples for analysis were from a single-level composite having equally proportioned sample from each of the six suppliers, for the various cuts (Table 2). Raw and cooked seam fat and external fat were each from single-level composites, including fat from all suppliers and all cuts. Total choline and metabolites were measured on selected retail cut samples by the University of North Carolina, Chapel Hill via isotope dilution mass spectrometry as described by Koc *et al*. (2002).

Vitamin E

Samples for analysis were from a single-level composite having equally proportioned sample from each of the six suppliers for various cuts (Table 2). Raw and cooked seam fat and external fat were each from single-level composites, including fat from all suppliers and all cuts. Vitamin E content was measured by Craft Technologies (Wilson, NC) using HPLC with a normal phase column, and UV detection with external calibration, and internal standard recovery post analysis.

Vitamin D and 25-Hydroxy-Vitamin D

Samples for lean analysis were from a single-level composite having equally proportioned sample from each of the six suppliers for various cuts (Table 2). Raw and cooked seam fat and external fat were each from single-level composites, including fat from all suppliers and all cuts. Vitamin D2, Vitamin D3, and 25-hydroxy Vitamin D3 contents were determined. Vitamin D analyses were performed by Covance Laboratories (Madison, WI) using a liquid chromatography/mass spectrophotometry method described by Huang *et al.* (2009).

Statistical Analysis

For assays in which samples were analyzed on a three-level composite, statistical analysis was conducted to determine if significant differences were present between cuts. Least squares means with the probability difference procedure (PDIFF option) were computed using the MIXED procedure of the Statistical Analysis Systems Institute software (SAS; version 9.3, Cary, NC). The fixed effect was cut and composite was set as a random variable.

Quality Control

Quality control (QC) throughout nutrient analysis was performed in order to ensure precise and accurate data. Lab validation was performed using beef and chicken baby food standards, coming from the same lot of production from Beech Nut (Canajoharie, NY) obtained from the Food Analysis Laboratory Control Center (FALCC; Virginia Polytechnic Institute and State University, Blacksburg, VA). The National Institute of Standards and Technology SRM 1546 Meat Homogenate (MHA) (NIST, Gaithersburg, MD) was used as an additional standard for validation, as well as QC throughout the study for specific analyses (Montgomery, 2008). A pork and egg standard was used for Vitamin D and 25-hydroxy Vitamin D analysis (FALCC; Virginia Polytechnic Institute and State University, Blacksburg, VA) from validated works (Bilodeau et al., 2010). Throughout the following assays, MHA, beef baby food, and chicken baby food control materials were analyzed with each analysis group to ensure that values were within the acceptable range established by the FALCC: proximate analysis (protein, ash, fat, and dry matter), ICP Minerals, fatty acids, and total cholesterol. For Vitamin E, choline, selenium, and Vitamin B assays, beef and chicken babyfood were used as standards. Chemical analyses were considered valid by the USDA Nutrient Data Laboratory (NDL) when the SRM was within the standard error of the certified value. Each sample analysis was conducted in duplicate.

RESULTS AND DISCUSSION

Separable Components

Mean raw and cooked veal cut separable components can be found in Table 3, and Figure 1 demonstrates the vast difference in separable component percentages per cut. Dissections and separable component data are utilized by USDA-ARS to reconstruct muscle cuts in order to appropriately extrapolate their nutrient profile. All cuts were packaged at a retail ready level, with minimal external fat present. Leg cutlets are sold as a completely lean product, without external, seam fat, or refuse present and therefore only separable lean had a value other than zero. Ground veal was not dissected due to the nature of the comminuted product, a mixture of ground lean and fat. Raw whole shank and cooked shank cross-cut data show high percentages of refuse from a large portion of the cut being bone and heavy connective tissue which was removed as thoroughly as possible when dissected.

Cooking Yield

Mean cooking yield data can be found in Table 4. Historically, the type of cooking method and amount of external fat on a cut can affect yields, wherein higher levels of fat typically result in higher cooking yields (Jones, Savell, and Cross, 1992; Luchak et al., 1998; Wahrmund-Wyle, Harris, and Savell, 2000). Loin chops had the highest cooking yield of the five cuts, assumingly due to the presence of 6 mm (0.25 inch) external fat coverage on the cut. Additionally, shoulder blade chops had external fat presence at a maximum of 6 mm (0.25 inch), and therefore have a yield percentage similar to loin chops. Leg cutlets had zero external fat, bone, and heavy connective tissue, and consequently greater losses during cooking were likely

due to moisture loss. Pan fried ground veal and braised shank cross cuts had the greatest cook loss %.

Proximate Composition

External and seam fat values for proximate analysis can be found in Table 5. Raw and cooked cut analyses of proximate data are represented in Table 6. Protein, fat, ash, and moisture levels are compared to the current Standard Reference Release 26 in Table 7. The results displayed are for separable lean content of cuts only, and do not include external and seam fat contribution to the complete nutritional composition of the cut. The USDA Nutrient Database Laboratory will use these results in their system to produce calculated values for an overall depiction of nutritional information for each cut. Seam and external fat was not statistically analyzed for differences as fat samples were comprised of fat from all cuts, and assays conducted on only one sample per raw or cooked status for external and seam fat.

Protein

External fat showed approximately double the amount of protein in cooked samples as opposed to raw samples of external fat (Table 5). In comparison to beef (10g protein cooked fat from retail cuts) (USDA-ARS, 2013), veal fat has higher levels of protein (16.6 g protein cooked external fat). The difference in protein content are most likely due to the lack of lipids present in veal adipocyte cells, which creates a skewed proportion of structural and sarcoplasmic proteins of adipocytes to lipid content when comparing filled adipocytes of more matured, finished beef animals (Swize et al., 1992). Seam fat showed little numeric difference between raw and cooked samples for protein.

Raw separable lean of cuts, and raw ground veal values for protein are compared to currently used SR-26 values in Table 7. Leg cutlets, loin roasts, and whole shanks increased in

protein content, whereas shoulder blade chops remained constant. Ground veal decreased slightly in protein content from 19.4% to 18.6%. When comparing raw and cooked cut values, cooked values are higher in protein due to a loss of moisture causing an increase in the concentration of nutrients (Wahrmund-Wyle et al., 2000; Smith et al., 2011).

From the 3-level composite proximate data (Table 6), raw and cooked cuts were compared for protein content. Raw cuts had statistically significant differences ($P<0.05$), wherein leg cutlets and loin roasts had higher protein values than whole shanks, shoulder blade chops, and ground veal. Amongst cooked cuts, no significant ($P<0.05$) differences were present for protein content. Trends relative to the current SR-26 show that raw cuts have increased in protein for all cuts based off of separable lean, except raw shoulder blade chops which stayed constant for protein content (Table 7). From the work of Martin et al. (2013), raw beef ribeye cuts ranged in mean protein content from 21.2 - 22.0 g/100 g lean tissue for all grades. The SR-26 values for raw, select grade, beef porterhouse steaks, separable lean only and trimmed to 1/8"fat (SR-26 ID# 13468: USDA-ARS, 2013) show protein content being 22.61 g/100 g lean tissue. Raw veal loin roast values are comparatively 21.9 g/100 g lean tissue, revealing that protein content for beef and veal are similar, with slight variation in content with differing cuts. Cooked veal is an "excellent" source of protein, providing 58.9 % for females and 48.4 % for males of daily required protein per an 85 g serving (3 oz.) for adults.

Fat

Both seam and external fat for raw and cooked cuts were similar in percentages (Table 5). Table 6 depicts fat percentages for raw cuts and raw ground veal. The three-level composite data for proximate analysis (Table 6) shows significant differences ($P<0.05$) in percent fat levels for raw and cooked cuts. Cooked leg cutlets had the least amount of fat ($P<0.05$), with loin roasts

and whole shanks being similar in content. As expected, ground veal had the highest ($P<0.05$) fat percentage among the cuts, as it is a comminuted product of lean and fat, whereas the other cuts had seam and external fat removed. Shoulder blade chops had the second-greatest amount of fat among cooked cuts, due to having the highest seam fat content. Seam fat lies between muscles and when cooked, is less likely to be lost during cooking (Jones et.al, 1992). Overall means for fat percentages were relatively low. Excluding ground veal, raw cuts had a peak level of fat at 2.9 %, and cooked cuts being at most 5.5 % of cut composition. Comparative values from the current SR-26 (Table 7) reveal fat percentages have decreased for raw shoulder blade chops, loin roasts, and whole shanks, but have increased in content for leg cutlets and ground veal. Comparing raw veal loin roast fat content (2.9 %) to the SR-26 values for raw, select grade, beef porterhouse steaks, separable lean only and trimmed to 1/8"fat (SR-26 ID# 13468: USDA, ARS, NDL, 2013) with 5.41 g/100 g lean tissue, veal appears have less fat content than beef for this cut. Based on fat levels only, veal cuts that could qualify for being labeled "Lean" are leg cutlets, loin chops, and shank cross-cuts. Additionally, shoulder blade chops could be labeled "Extra Lean" taking only fat content into account. Cooked ground veal contained an average of 11.8g fat /100g product, which, if made with a lower fat ratio, could be labeled as a "Lean" product.

Moisture

External fat and seam fat moisture percentages are represented in Table 5. There were differences in percent moisture ($P<0.05$) for raw cuts. As expected, moisture content varied inversely with fat percentage. The leanest cuts, including whole shank, leg cutlets, and shoulder blade chops, were among the highest for moisture content, while ground veal, which had the highest percent fat, had the lowest ($P<0.05$) moisture content (Table 6). For cooked cuts, ground veal had the lowest moisture content ($P<0.05$), while all other cuts had similar moisture content

(Table 6). Moisture content comparisons of current veal values in the SR-26 to these raw cut data are presented in Table 7, and show decreases in values for leg cutlets, shoulder blade chops, ground veal, and loin roasts. Whole shanks were the only cut to increase in moisture content. It should be noted that all heavy connective tissue was removed from the veal shanks in this study, which likely influenced the overall moisture content.

Ash

Ash values for external and seam fat can be found in Table 5, and ash values for cooked and raw cuts are presented in Table 6. Ash content did not differ for raw cuts ($P>0.05$); however, cooked leg cutlets has the highest ($P<0.05$) ash content when compared to all other cooked cuts. Ash percentages for cooked cuts showed significant ($P<0.05$) effects of cut differences for whole shanks (Table 6). Raw cuts did not have significant differences ($P<0.05$) in ash content. Ash content for separable lean of raw shoulder blade chops, loin roasts, and whole shanks were constant compared to current SR-26 data (Table 7). In comparison to SR-26 data, separable lean from raw leg cutlets decreased, whereas ground veal values increased in ash.

Fatty Acids

Fatty acid results for raw and cooked external and seam fat are represented in Table 8. Results of fatty acids for raw separable lean of cuts are in Table 9, and cooked data are represented in Table 10. The SR-26 currently has limited information regarding fatty acid content of veal, and comparisons of these data show increases in identification of fatty acid content, due to more accurate techniques in fatty acid analysis. In comparison to beef, separable lean of veal saturated fatty acid levels for raw loin roast cuts on average are lower than beef porterhouse steaks of select grade, with select grade chosen to mimic low intramuscular fat content of veal (SR-26 ID# 13468: USDA, ARS, NDL, 2013).

Fatty acid profiles for raw and cooked lean cuts are represented on a percent basis in Figure 2, with raw and cooked values being similar. Monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), conjugated linoleic acids (CLA), and stearic acid, together represent the majority of fatty acids at 68 % of the fatty acid profile for separable lean of both raw and cooked veal (Figure 2). Total saturated fat levels of cooked separable lean are on average 41 %, but of that 13 % is attributed by stearic acid, which is widely accepted as neutral or beneficial in health effects (Kris-Etherton and Yu, 1997). External and seam fatty acid percentages based on classifications are represented in Figure 3. Cooked seam fat contained numerically higher stearic (13.5 %) and PUFA (7.2 %) values compared to cooked external fat (10.98 % and 3.22 %). The CLA content in separable lean of veal as a percent of fatty acids is between 0.33 - 0.34 %, and beef retail cuts in comparison is 0.34 - 0.58 % of fatty acids (Acheson, 2013). In external and seam fat, CLA levels are numerically the same or higher than separable lean samples at levels between 0.30 and 0.72 % (Figures 2 & 3). The CLA found in veal cuts of isomers cis-9, trans-11 and trans-10, cis-12 has been shown to be beneficial to animal and human health (Bhattacharya et al., 2005; Dilzer & Park, 2012).

ICP Minerals (Ca, Fe, Mg, P, K, Na, Zn, Cu, Mn)

Raw and cooked external and seam fat mineral content are shown in Table 5. Results for raw analysis of cuts for minerals can be found in Table 11, and cooked results are in Table 12. When comparing these nutrients to the current SR-26 values for raw cuts on a separable lean basis, with the exception being ground veal having lean and fat intermixed for values, some changes in nutrient composition of veal are evident (Table 7). In comparison to values published in SR-26, values for iron, magnesium, sodium, and copper have increased for all raw veal cuts, whereas decreases in potassium and zinc in raw samples is evident. Cooked cut mineral values

were not compared to past values for cooked cuts due to the differing cooking methods of the cuts to these data.

The three-level composite data for raw separable lean of cuts, and raw ground veal mineral analysis shows significant differences ($P < 0.05$; Table 11) in mineral levels in mg/100 g basis for iron, manganese, potassium, and zinc content. Iron levels were highest for raw ground veal, while raw leg cutlets and raw loin roasts were lowest. On a raw veal basis, differences, although present for some minerals, were varied and an overall cut recommendation for selecting on a mineral basis is not clear. Cooked veal data resulted with significant differences ($P<0.05$) by cut for calcium, copper, iron, manganese, potassium, and zinc (Table 12). The increase in number of minerals having differences amongst cuts from raw to cooked could be attributed to cook-loss (Jones et.al, 1992). Cooked shoulder-blade chops and shank cross-cuts were consistently highest for calcium and zinc levels. Potassium and manganese levels were greatest for cooked leg cutlets, while the other cuts were statistically the same. Copper content of raw veal cuts has increased in mg/100g by an average of 0.2 mg compared to previous SR data (USDA-ARS, 2013). Beef values for copper are lower than veal, being on average 0.1 mg/100g compared to 0.3-0.5 mg/100g and could be attributed to differing feeding systems and diets.

From this data, certain cooked cuts can be labeled as “excellent” and “good” sources of minerals. All cuts are an “excellent” source of phosphorus. Leg cutlets, shank cross-cuts, and shoulder-blade chops are all excellent sources of zinc, while loin chops and ground veal are “good” sources of zinc. Shank cross-cuts are the only cut to provide enough iron to be named a “good” source. Iron content for veal is lower than levels found in beef which is likely due to the lower iron content in calf diets leading up to slaughter in order to maintain a light, pale colored lean, as well as lower levels of heme iron in circulation (Miltenburg et al., 1992). Leg cutlets

serve as a "good" source of potassium. Leg cutlets, shoulder blade chops, and ground veal serve as "excellent" sources of copper, while loin chops and shank cross-cuts provide a "good" source of copper.

Cholesterol

Cholesterol results for raw and cooked separable lean of veal cuts and ground veal are shown in Table 13. Based on the work of Faustman and others in 1992, cholesterol levels should be higher than comparable beef cuts due to the young age of the animal, having a higher ratio of membrane cholesterol to muscle content. However, when comparing cholesterol levels of raw separable lean of beef to veal, beef cuts have a range of 39-68mg/100g tissue (USDA-ARS, 2013) and are similar to these raw cut veal data having 49.0-62.3 mg/100g tissue. When comparing raw veal cut cholesterol levels to values currently in the SR-26 (Table 7), current veal cholesterol levels have decreased on average by 24.8 mg/100 g lean tissue. Significant differences *($P<0.05$)* in cholesterol content are reported for raw veal cuts (Table 13). Whole shanks and shoulder blade chops contain the highest mg of cholesterol per 100 g, while ground veal showed to have the least amount. Although ground veal has a greater amount of fat, and increased in fat content compared to previous data, cholesterol levels decreased. This is likely due to the decrease in proportion of muscle cell numbers to fat contributing to a decrease in cholesterol content derived from muscle cells (Swize et al., 1992; Chizzolini et al., 1999). Ground veal contained the highest fat percentage and the lowest cholesterol values. As reported by Hoelscher et al (1998), the cholesterol content in adipocytes and muscle cells vary based on cell membranes and storage components. Muscle cells contain 60-80% of cholesterol in the cell membrane, whereas adipocytes have 88-92% of cholesterol in the storage component of the cell Hoelscher et al., 1998). The loss of muscle from the product may have lowered the cholesterol

levels at such a magnitude as to outweigh the addition of cholesterol from an increase in fat content.

Cholesterol levels of veal compared to other cooked meat source data from SR-26 is shown in Table 14. When compared to pork top loin chops, veal leg cutlets had similar amounts of cholesterol per 100g of separable lean, while chicken breast contained the highest numeric level of cholesterol at 85 mg (USDA-ARS, 2013). Although the difference in cholesterol content for glycolytic (white) and oxidative (red) muscle fiber types has shown that fast-twitch white fibers contain lower levels of cholesterol than slow-twitch red fibers (Alasnier et al., 1996), these results indicate similar or lower levels of cholesterol for meat with higher levels of oxidative, red muscle fibers. However, the same research from Alasnier and others in 1996 also concluded that when phospholipid levels are made equal for glycolytic and oxidative muscle fibers, oxidative fibers have less cholesterol content. These data raise questions as to the muscle fiber composition of veal, as well as the need for further research on cholesterol content differences between red and white muscle fiber types, including cholesterol and phospholipid content differences between younger animal meat and matured animals.

Cooked separable lean cholesterol values are higher than raw samples mainly due to moisture loss, creating an increase in the concentration of all other components. Cholesterol content for cooked fat samples (Table 5), however, did not change greatly compared to raw values, due to a lesser amount of moisture available for loss in adipose tissue at 33 - 42%, compared to lean tissue having 66 - 77% moisture (Hoelscher et al., 1988).

Selenium

Selenium values for external and seam fat can be found in Table 5 and cooked cuts are represented in Table 15. Selenium values showed numeric increases for all raw cuts compared to

the current SR values (Table 7) for separable lean veal cuts and ground veal by an average of 44%. Selenium values from veal provide, on average, 30 % of the daily value needed by adults. All cooked veal retail cuts are an "excellent" source of selenium, which includes leg cutlets, loin chops, shank cross-cuts, shoulder blade chops, and ground veal. Similarly to veal, the beef retail cooked separable lean value for selenium is 21.3 µg/100g, delivering approximately the same daily value of selenium (USDA-ARS, 2013).

B-Vitamins (B12, B6, Riboflavin, Niacin, Thiamin and Pantothenic acid)

The Vitamin B content of raw ground veal and separable lean for leg cutlets, loin roasts, and shoulder blade chops show numeric increases compared to SR-26 data for Riboflavin (B_2), Vitamin B_6, and Vitamin B_{12} for (Table 7). Raw and cooked external and seam fat sample results for Vitamin B analyses can be found in Table 5. Results for raw separable lean of cuts and ground veal for Vitamin B are represented in Table 15, and cooked in Table 16. In general, beef is a "good" source of Riboflavin (B2), and an "excellent" source of B6, B12, and Niacin (B3) (Acheson, 2013). Similarly, veal cut results show that many cuts are an excellent source of B-Vitamins, based on percent Recommended Daily Intakes (RDI) on a 2,000 calorie diet for RDI values representing 97 - 98% of healthy adults (Table 17). Veal leg cutlets, shoulder blade chops, shank cross-cuts, and ground veal are "excellent" sources of Vitamin B2 (Riboflavin), while veal loin chops are a "good" source. Vitamin B3 (Niacin) and Vitamin B12 content allows for all veal retail cuts included in this study to be labeled as "excellent" sources. Results for veal do not qualify additional labeling for both Vitamin B1 (Thiamin) and Vitamin B5 (Pantothenic Acid), as RDI percentages were below 10 %.

Total Choline

Total choline results for some raw cuts of separable lean, and raw ground veal are represented in Table 15. Values for cooked separable lean of cuts, and cooked ground veal can be found in Table 16. External and seam raw and cooked amounts of total choline are in Table 5. Total isolated choline values in previously published veal research was not available, even where cholesterol oxidation was studied (Engeseth & Gray, 1992). However, there is a reference value for veal baby food, found in SR-26 which is 49.5 mg/100 g for choline (USDA-ARS 2013). Choline levels by for raw cuts were numerically highest for leg cutlets. There is not currently an established RDI for choline.

Vitamin E

Vitamin E is analyzed by the following sub-classes of nutrients: alpha-tocopherol, beta-tocopherol, gamma-tocopherol, and delta-tocopherol. The results for raw, separable lean leg cutlet and loin roast samples, as well as ground veal samples can be found in Table 15. Cooked ground veal and separable lean values for leg cutlets and loin chops are represented in Table 16. Specifically for alpha-tocopherol, which is used in Vitamin E requirements previous research evaluating veal providing alpha tocopherol levels for raw muscle were reported at 1.0 µg/g, and would indicate an increase in content for veal to a range of 2.7- 4.93µg/g (Engeseth et al., 1992). Additionally, when examining values based on SR-26, values reported in 1989 comparatively showed an increase in alpha-tocopherol for all raw cuts analyzed (USDA-ARS, 2013). Raw and cooked seam and external fat sample results for Vitamin E are shown in Table 5. Alpha-tocopherol levels were numerically highest for ground veal, as expected since Vitamin E is fat-soluble and can be found at higher levels in fat tissue than in lean muscle tissue. The current study indicates that common veal cuts provide less than 0.1 % of the RDI needed by adults.

Vitamin D (D2, D3, and 25-Hydroxy Vitamin D)

Vitamin D values are reported in Table 5 for raw and cooked external and seam fat samples, Table 16 for cooked separable lean of cuts and cooked ground veal, and Table 15 for raw separable lean of cuts and raw ground veal. Levels of Vitamin D in veal were high relative to beef, other muscle foods, and Vitamin-D-fortified 2% fat milk (Table 18). There are no data available from previous research as to Vitamin D levels in special-fed veal, and therefore, SR-26 does not have values for this nutrient. There are values, however, for veal baby food, which has a value of 0.65 mcg/100 g (USDA, ARS, NDL, SR-26 Food ID: 03005). This value grants a good base for estimating Vitamin D levels in whole cuts of veal; however, veal baby food does not specify the type of veal included in the product. Therefore, it is uncertain as to the type and source of veal product, and a comparison of feeding systems on Vitamin D contents in special-fed to pasture-raised veal may reveal a contribution to differing levels. Differences in cholesterol, iron, and zinc were found in research comparing red "pasture-fed" and white "special-fed" veal (Faustman et al., 1992). Leheska *et al.* (2008) reported comparisons of grass-fed beef to grain-finished beef, but Vitamin D levels were not reported.

Vitamin D levels in special-fed veal diets compared to conventional beef cattle feeding diets, as well as age of animals, and digestive tract physiology, contribute to differences identified in comparisons of Vitamin D levels in veal and beef. High concentrations of Vitamin D in milk-replacer formulas provided to veal calves are assumingly the contributor to very high levels of Vitamin D in veal muscle identified in this study.

From this data, ground veal qualifies for being labeled as a "Good Source" of Vitamin D, fulfilling 12.38% of the RDI value per RACC of 85 g (9 CFR 317.354). Additional cuts may be eligible for this labeling claim after including the external and seam fat values, in combination

with separable lean values. Since Vitamin D is fat-soluble and values for Vitamin D in external and seam veal fat are relatively high, it can be assumed the loin chop and blade chop retail cuts could be included as a "Good Source" of Vitamin D when the whole cut profile is reported by the USDA Nutrient Database Laboratory and released in the Standard Reference values for veal.

Labeling Claims

Veal cuts qualify for USDA classifications of "Extra Lean" and "Lean", and also fulfill the American Heart Association's "Heart Check" requirements (Table 14). Additionally, certain veal cuts are considered "excellent" and "good" sources of protein, vitamins, and minerals, as aforementioned in previous result sections.

CONCLUSIONS

Nutrient information for human foods has become a key factor in protein selection in the diet, particularly fat and cholesterol values. The findings of this research will update nutrient databases with current nutritional values for common veal cuts. Consumers, nutritionists, producer groups, regulatory bodies, and retailers will be able to utilize this information to make informed decisions based on the nutritive values of veal. These results supply society with nutrition facts when using common cookery methods for veal. This research also provides values for choline and Vitamin D which is not available in SR-26 for veal (USDA-ARS, 2013). The results contain accurate data and to use when formulating diets and making healthy choices at the meat counter and retail case.

Since the last update to the SR, compared to values that are used in the current USDA-ARS Nutrient Database Standard Reference 26 (USDA-ARS, 2013), veal has improved in many aspects of nutritive composition. Compared to nutritive data presented in SR-26, findings of the current research indicate that veal cholesterol levels have declined by 30%. Furthermore, fat content in separable lean decreased for shoulder blade chops, loin roasts, and whole shanks. Leg cutlets, loin chops, and shank cross-cuts can be labeled under the USDA classification of "Extra Lean" with less than 5g total fat, 2.5 g or less of saturated fat, and less than 95mg of cholesterol. Additionally, shoulder blade chops can be classified as "lean", having less than 10g fat, less than 5 g of saturated fat, and less than 95 mg of cholesterol per 100 g. The American Heart Association "Heart Check" requirements are met by leg cutlets, loin chops, and shank cross-cuts.

Protein content for beef and veal are similar with slight variation in content with differing cuts. As expected, fat content was the highest for ground veal. Consequently, the fat content of

ground veal aids in providing higher levels of fat-soluble vitamins including Vitamin D and Vitamin E. Fatty acid profiles for separable lean of the veal cuts in this study show favorable nutritive values, wherein 68% of fatty acids in veal cuts are polyunsaturated, monounsaturated, stearic, and conjugated linoleic acids- all of which are accepted as being beneficial or having a neutral in effects on health. When compared to the data presented in SR-26, mineral content for iron, magnesium, sodium, and copper have increased for all raw veal cuts, and decreases in potassium and zinc. On a raw veal basis, differences by cut, although present for some minerals, were varied and an overall cut recommendation for selecting on a mineral basis is not evident.

The finding of this research indicated that Vitamin D levels in veal justify being labeled as a "good source" of this nutrient. In the present study, veal contained a greater amount of Vitamin D than fortified milk as well as having comparable levels Vitamin D as eggs and fish. Obtaining high levels of Vitamin D in the diet is important in decreasing risk of cancer and other diseases, and maintaining good health. Overall, veal provides an "excellent" source of: Vitamins B2, B3, B6, B12; selenium, zinc, phosphorus, and copper. Additionally, veal is a "good" source of Vitamin D, iron, and potassium. At the retail setting, veal can be a lean, complete protein choice for consumers providing excellent and good sources of protein, vitamins, and minerals.

Table 1. Veal cuts, cooking assignment for analysis and corresponding IMPS code.

Name	IMPS Number	Analyzed as Raw, Cooked, or Both
Veal Chuck, Shoulder Blade Chops	1309A	Both
Veal Osso Buco, Foreshank	1312	Cooked
Veal Hindshank, Center Cut	337A	Raw
Veal Loin Chops	1332	Cooked
Veal Loins, Trimmed	332	Raw
Veal Cutlets, Boneless	1336	Both
Ground Veal	396	Both

Table 2. Compositing levels for separable lean[1] of veal cuts and ground veal to be analyzed per type of nutrient analysis.

Analysis	Composite Level	Cuts[3]
Proximates	3 (from 6 suppliers, paired)	Raw: Loin Roast, Leg Cutlet, Blade Chop, Whole Shank, Ground Veal Cooked: Loin Chop, Leg Cutlet, Shoulder Blade Chop, Shank-Cross Cut, Ground Veal
Fatty Acids	3 (from 6 suppliers, paired)	Raw: Loin Roast, Leg Cutlet, Blade Chop, Whole Shank, Ground Veal Cooked: Loin Chop, Leg Cutlet, Shoulder Blade Chop, Shank-Cross Cut, Ground Veal
Total Cholesterol	3 (from 6 suppliers, paired)	Raw: Loin Roast, Leg Cutlet, Blade Chop, Whole Shank, Ground Veal Cooked: Loin Chop, Leg Cutlet, Blade Chop, Shank-Cross Cut, Ground Veal
ICP Minerals	3 (from 6 suppliers, paired)	Raw: Loin Roast, Leg Cutlet, Blade Chop, Whole Shank, Ground Veal Cooked: Loin Chop, Leg Cutlet, Shoulder Blade Chop, Shank-Cross Cut, Ground Veal
Selenium	1(no replication)	Raw: Loin Roast, Leg Cutlet, Blade Chop, Whole Shank, Ground Veal Cooked: Loin Chop, Leg Cutlet, Shoulder Blade Chop, Shank-Cross Cut, Ground Veal
B-Vitamins (A): B12, B6, B2, B3	1(no replication)	Raw: Loin Roast, Leg Cutlet, Blade Chop, Whole Shank, Ground Veal Cooked: Loin Chop, Leg Cutlet, Shoulder Blade Chop, Shank-Cross Cut, Ground Veal
B-Vitamins (B): B1, B5	1 (no replication)	Raw: Loin Roast, Leg Cutlet, Blade Chop, Whole Shank, Ground Veal Cooked: Loin Chop, Leg Cutlet, Shoulder Blade Chop, Shank-Cross Cut, Ground Veal
Total Choline[2]	1 (no replication)	Raw: Loin Roast, Leg Cutlet, Ground Veal Cooked: Loin Chop, Leg Cutlet, Ground Veal
Vitamin E[2]	1(no replication)	Raw: Loin Roast, Leg Cutlet, Ground Veal Cooked: Loin Chop, Leg Cutlet, Ground Veal
Vitamin D[2]	1 (no replication)	Raw: Loin Roast, Leg Cutlet, Ground Veal Cooked: Loin Chop, Leg Cutlet, Ground Veal
25-Hydroxy Vitamin D[2]	1 (no replication)	Raw: Loin Roast, Leg Cutlet, Ground Veal Cooked: Loin Chop, Leg Cutlet, Ground Veal

[1]Cooked and raw external and seam fat was analyzed for all nutrients listed on a single-composite level containing equal-weighted aliquots from all six supplier products.

[2]Total Choline, Vitamin E, Vitamin D, and 25-Hydroxy Vitamin D analysis was not conducted on Raw and Cooked Shoulder Blade Chops, Raw Whole Shanks, or Cooked Shank Cross Cuts.

[3]Data from certain cuts can be extrapolated for values of similar cuts: raw loin roasts and cooked loin chops; raw whole shanks and cooked shank cross-cuts.

Table 3. Mean ± standard deviation of separable components dissection data for veal cuts.

Cut Type	Initial weight (g)	Separable Lean (g)	External Fat (g)	Seam Fat (g)	Refuse (g)
Raw					
Leg Cutlet[1]	55.2±13.4	55.2±13.4	0	0	0
Shoulder Blade Chop	450.0±95.4	307.4±78.7	8.8±3.4	26.6±11.5	99.9±15.2
Loin Roast	1494.7±327.4	858.9±221.4	83.1±36.4	82.4±26.4	440.7±86.4
Whole Shank	1270.1±56.5	586.8±72.1	7.2±3.1	25.7±10.6	616.6±40.6
Ground Veal[2]	357.2±80.2	-	-	-	-
Cooked					
Leg Cutlet[1]	43.5±11.0	43.5±11.0	0	0	0
Shoulder Blade Chop	352.4± 90.5	231.2±60.7	9.7±8.1	17.9±6.9	89.4±25.9
Loin Chop	152.9±23.0	93.5±14.9	6.6±1.6	4.5±1.5	47.1±13.0
Shank Cross-Cut	186.9±45.3	90.9±25.2	1.7±2.8	4.9±3.3	87.9±23.6
Ground Veal[2]	259.8±63.9	-	-	-	-

[1]Leg cutlets, raw and cooked, are sold at the retail level absent external fat, refuse, and visible seam fat.

[2] Ground veal was not dissected; initial weights were recorded.

Table 4. Cooking yields including mean separable components (%), individual cut proximate (% moisture, % protein, % fat, and % ash) values[1], and cooking information[2].

Separable components, proximate values, and cooking values	Cooked				
	Leg Cutlet	Shoulder Blade Chop	Loin Chop	Shank Cross Cut	Ground Veal[9]
Sample size	24	12	24	12	12
Cooking Information					
Pre-cooking raw weight, g	62.5	484.36	205.5	269.1	366.9
Hot cooked weight, g	45.9	374.7	165.3	188.4	259.8
Cooking yield[3], %	73.9	77.2	80.6	70.1	70.5
Separable components					
Pre-dissection cut weight[4], g	43.5	352.4	154.0	187.4	259.8
Separable lean[5],%	100	65.6	61.2	49.0	-
External fat[6],%	0	2.7	4.2	1.1	-
Seam fat[7],%	0	5.1	2.9	2.7	-
Refuse[8],%	0	25.4	30.8	46.4	-

[1] Values represent mean data from six suppliers contributing an equal number of samples per cut.
[2] Prior to cooked dissection, blade chops, loin chops and leg cutlets were grilled to an internal temperature of 70^{0}C using a clam-shell grill. Ground veal was cooked on a skillet until an average infrared thermometer reading of 71^{0}C was achieved. Shank cross-cuts were braised in covered non-stick dutch ovens with deionized water at 120^{0}C for 150 minutes.
[3] Cooking yield, %: (hot cooked weight/pre-dissection cut weight) x 100.
[4] Pre-dissection weights for cooked samples were obtained on samples chilled for 12-24 hours after cooking.
[5] Separable lean weight (g) includes lean scraped from the bone and any included intramuscular fat. Separable lean, %: [separable lean (g)/ pre-dissection cut weight (g)] x 100.
[6] Seam fat weight (g) includes any fat which lies between muscles. Seam fat, %: [seam fat (g)/ pre-dissection cut weight (g)] x 100.
[7] External fat weight (g) includes all fat located on the outer surface of the cut. External fat, %: [external fat (g)/ pre-dissection cut weight (g)] x 100.
[8] Refuse weight (g) includes all bone and heavy connective tissue, include the membrane covering external fat. Refuse, %: [refuse (g)/ pre-dissection (g)] x 100.
[9]Ground veal was not dissected, as fat and some connective tissue is incorporated in the product.

Table 5. Proximate and nutrient composition mean values of raw and cooked external fat and seam fat of veal cuts at a single-composite level[1].

Proximate values and nutrient, units	External		Seam	
	Raw	Cooked	Raw	Cooked
Proximate values, %				
Moisture	33.8	37.6	42.3	36.0
Protein	8.8	16.6	11.6	11.2
Fat	40.0	43.4	49.6	47.2
Ash	0.458	0.601	0.641	0.574
Nutrient, units/100 g of tissue				
Riboflavin (Vitamin B_2), mg	0.090	0.160	0.150	0.160
Niacin (Vitamin B_3), mg	2.780	4.160	3.810	2.840
Pantothenic Acid (Vitamin B_5), mg	0.260	0.390	0.880	0.360
Vitamin B_6, mg	0.154	0.214	0.227	0.203
Cholesterol, mg	86.15	85.24	82.91	82.31
Vitamin B_{12}, µg	1.35	1.61	1.56	1.62
Total Choline, mg	32.0	41.9	44.9	53.8
Total Betaine, mg	10.8	15.3	11.7	15.4
Vitamin D2, µg	<0.200	<0.200	<0.200	<0.200
Vitamin D3, µg	5.51	3.56	3.54	4.53
25 Hydroxy Vitamin D3, µg	0.943	0.828	0.667	0.850
Selenium, µg	5.2	9.8	8.0	9.7
Nutrient, units/g of tissue				
AlphaTocopherol, µg	2.99	4.46	6.75	5.21
BetaTocopherol, µg	0	0	0	0
Gamma Tocopherol, µg	0.55	0.67	1.82	1.22
Delta Tocopherol, µg	0.44	0.36	0	0.45
Vitamin B1, µg	0.349	0.533	0.411	0.949
Choline, nmol	148.5	157.1	205.0	215.1
P-Choline, nmol	149.7	181.1	178.3	193.3
Phosphatidylcholine, nmol	2050.8	2764.9	2962.8	3648.6
GP-Choline, nmol	204.4	233.5	215.8	229.5
Betaine, nmol	926.2	1305.5	997.2	1316.2
Sphingomyelin, nmol	522.3	688.5	745.5	879.4
Nutrient, mg/100g				
Calcium	31.0	57.6	29.7	42.6
Copper	0.517	0.258	0.270	0.324
Iron	0.73	1.09	0.87	1.15
Magnesium	19.2	25.5	23.4	24.5
Manganese	0.0074	0.0436	0.0141	0.0337
Phosphorus	133	168	150	152
Potassium	107	152	179	155
Sodium	88.9	103.2	88.9	87.1
Zinc	0.83	1.42	1.77	2.00

[1]Single national-level composite samples consist of fat from all 6 suppliers product from all dissected cuts, which does not include ground veal.

Table 6. Raw and cooked veal cut least squares means (n=3) for percent per 100 g lean tissue for proximate data on a three-composite level[1].

Veal Cut	Protein	Fat	Ash	Moisture
Raw				
Leg Cutlet	22.07[a]	2.07[b]	1.10	75.20[ab]
Loin Roast	21.85[a]	2.90[b]	1.04	74.79[b]
Whole Shank	19.77[b]	1.64[b]	0.98	77.97[a]
Shoulder Blade Chop	19.60[b]	2.88[b]	1.00	76.29[ab]
Ground Veal	18.58[b]	13.06[a]	0.93	66.16[c]
SEM	0.47	0.94	0.03	0.88
P-Value	0.0022	0.0001	0.0689	0.0001
Cooked				
Leg Cutlet	31.89	2.63[c]	1.47[a]	65.32[a]
Loin Roast	29.75	4.44[bc]	1.10[b]	64.65[a]
Whole Shank	29.12	4.51[bc]	0.96[b]	63.28[a]
Shoulder Blade Chop	27.33	5.53[b]	0.98[b]	66.44[a]
Ground Veal	25.83	11.78[a]	1.07[b]	59.87[b]
SEM	2.56	0.9364	0.11	1.17
P-Value	0.5450	0.0229	0.0145	0.0146

[1]Composite levels based on supplier pairing of samples: composite 1= suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6.

[a-c] Within a column, composite means without a common superscript differ ($P < 0.05$). Means without these superscripts are not significantly different.

Table 7. Selected veal nutrient mean values for raw cuts, compared to the current USDA-ARS Nutrient Database Laboratory Standard Reference Release-26 values.

	Leg Cutlet		Blade Chop		Loin Roast		Whole Shank		Ground Veal	
Nutrient, units/100g tissue	USDA NDL Value[1]	Data Value	USDA NDL Value[2]	Data Value	USDA NDL Value[3]	Data Value	USDA NDL Value[4]	Data Value	USDA NDL Value[5]	Data Value
Moisture, %	75.8	75.0	76.7	76.2	74.9	74.8	77.5	78.0	72.8	66.2
Protein%	21.3	22.1	19.6	19.6	20.2	21.9	19.3	19.8	19.4	18.6
Fat%	1.8	2.1	3.3	2.9	3.3	2.9	2.8	1.6	6.8	13.1
Ash%	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.0	1.0	0.9
Cholesterol, mg	78.0	55.6	90.0	59.7	80.0	54.6	75.0	62.3	82.0	49.0
Selenium, µg	9.1	16.0	8.1	15.8	8.8	18.0	8.0	13.0	8.1	13.1
Riboflavin, mg	0.280	0.340	0.310	0.430	0.260	0.310	0.270	0.390	0.270	0.280
Vitamin B_6, mg	0.470	0.599	0.370	0.466	0.560	0.683	0.440	0.430	0.410	0.670
Vitamin B_{12}, µg	1.51	2.08	1.86	2.88	1.18	2.65	1.37	1.92	1.34	3.66
Calcium, mg	5.0	5.0	23	22.6	17	10.6	20.0	13.7	15.0	15.5
Iron, mg	0.80	0.81	0.88	1.26	0.75	0.85	0.76	1.19	0.83	1.37
Magnesium, mg	27	32	23	32.8	25	35.7	21	33.7	24	30.7
Phosphorus, mg	223	212	204	209	211	237	192	212	203	197
Potassium, mg	372	273	295	211	324	283	316	185	315	198
Sodium, mg	64	81	97	138.1	91	93.1	85	119.7	82	118.4
Zinc, mg	2.34	1.97	4.42	3.38	2.49	2.15	4.02	3.86	3.06	2.51
Copper, mg	0.110	0.303	0.121	0.356	0.100	438	0.074	0.357	0.109	0.471
Manganese, mg	0.029	0.017	0.029	0.013	0.029	0.014	0.009	0.010	0.028	0.008

[1]USDA-ARS Standard Reference number 17099: Veal, leg (top round), separable lean only, raw
[2]USDA-ARS Standard Reference number 17131: Veal, shoulder, blade, separable lean only, raw
[3]USDA-ARS Standard Reference number 17107: Veal, loin, separable lean only, raw
[4]USDA-ARS Standard Reference number 17278: Veal, shank (fore and hind), separable lean only, raw
[5]USDA-ARS Standard Reference number 17142: Veal, ground, raw

Table 8. Fatty acid profile of external and seam fat from raw and cooked veal cuts[1] on a single composite level[2] shown as a percentage of total fatty acids (g/100g of fat).

Fatty acid	Common Name	External		Seam	
		Raw	Cooked	Raw	Cooked
10:0	Capric	0.0667	0.0327	0.0328	0.0788
12:0	Lauric	0.0718	0.0759	0.0761	0.0175
12:1		0.0312	0.0372	0.0373	0.0619
C14:0	Myristic	3.1439	2.8731	2.8817	2.3440
C14:1	Myristoleic	0.8181	1.0842	1.0874	0.5567
C16:0	Palmitic	23.9325	25.7330	23.7489	23.4849
C16:1	Palmitoleic	3.8064	4.6041	4.6180	3.4836
C17:0	Margaric	1.2290	1.1394	1.1428	1.1428
C17:1	Heptadecenoic	0.8808	1.0960	1.0993	1.0185
C18:0	Stearic	13.4860	10.9798	11.0128	13.5256
C18:1 trans-1		0.2650	0.1876	0.1881	0.3418
C18:1 trans-2		0.4473	0.4985	0.4786	0.3925
C18:1 trans-3		2.5752	2.2582	2.2650	2.8228
C18:1 t-vaccenic	Vaccenic	1.6399	1.7808	1.7861	0.6263
C18:1c9	Oleic	41.8226	41.3163	43.3648	40.2258
C18:1c11	Oleic	1.8076	1.9394	1.9453	2.0803
C18:2	Linoleic	2.8299	2.9905	2.8574	5.6276
C18:3	Linolenic	0.1317	0.1103	0.1107	0.1960
C20:0	Arachidic	0.0568	0.0445	0.0447	0.0497
unknown		0.1161	0.1233	0.1236	0.0981
C18:2c9t11	CLA	0.4591	0.6570	0.6590	0.2675
C18:2t10c12	CLA	0.0621	0.0610	0.0612	0.0000
C20:1	Eicosenoic	0.1976	0.2262	0.2268	0.0000
C20:2	Eicosadienoic	0.0054	0.0107	0.0108	0.0000
C20:4	Arachidonic	0.0875	0.1083	0.1086	1.3497
C20:5	Timnodonic (EPA)	0.0000	0.0000	0.0000	0.0000

[1]Ground veal did not contribute fat to this data, as fat is not removed during dissection.

[2]Single National-level composite fat samples consist of samples from all six suppliers and all cuts.

Table 9. Fatty acid profile of separable lean[1] from raw veal cuts at a three composite level[2] shown as a percentage of total fatty acids (g/100g of tissue).

Fatty acid	Common Name	Leg Cutlet	Shoulder Blade Chop	Loin Roast	Whole Shank	Ground Veal
10:0	Capric	0.0388	0.0742	0.0786	0.0410	0.0558
12:0	Lauric	0.0786	0.0829	0.0910	0.0792	0.0781
12:1		0.0244	0.0404	0.0398	0.0415	0.0379
14:0	Myristic	2.6714	2.4319	2.3914	2.5251	2.4706
14:1	Myristoleic	0.5645	0.5304	0.5076	0.4942	0.5008
16:0	Palmitic	23.8936	23.3345	23.2414	23.4531	22.9941
16:1	Palmitoleic	3.6241	3.2808	3.2205	3.1788	3.0968
17:0	Margaric	1.2583	1.2389	1.2482	1.2891	1.4226
17:1	Heptadecenoic	0.9937	0.9629	0.9586	0.9453	1.0338
18:0	Stearic	14.2457	14.6478	14.6529	15.0963	15.1555
18:1 trans-1		0.3834	0.3281	0.3464	0.4242	0.4565
18:1 trans-2		0.3813	0.3523	0.3646	0.4085	0.4497
18:1 trans-3		3.2958	2.6147	2.8072	3.3853	4.0531
18:1 t-vaccenic	Vaccenic	0.6652	0.6968	0.7354	0.7355	0.7656
18:1c9	Oleic	39.9648	40.6776	39.6857	39.0476	38.7083
18:1c11	Oleic	1.8452	1.9109	1.9367	1.7897	1.8669
18:2	Linoleic	4.3328	4.8438	5.5493	5.2735	5.1137
18:3	Linolenic	0.1810	0.1518	0.1688	0.1796	0.1777
20:0	Arachidic	0.0607	0.0538	0.0494	0.0592	0.0369
Unknown		0.0969	0.0980	0.1023	0.1105	0.1223
18:2c9t11	CLA	0.3152	0.2667	0.3247	0.3116	0.2952
18:2t10c12	CLA	0.0419	0.0195	0.0193	0.0104	0.0254
20:1	Eicosenoic	0.1829	0.0760	0.0271	0.1029	0.0656
20:2	Eicosadienoic	0.0076	0.0077	0.0077	0.0000	0.0000
20:4	Arachidonic	0.6892	1.0180	1.1596	0.8597	0.8482
20:5	EPA	0.0221	0.0445	0.0527	0.0116	0.0255

[1]Separable lean used for all cuts, except ground veal, wherein the nature of the product is both lean and fat.

[2]Three-level composite samples consist of samples from paired suppliers: composite 1=suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6.

Table 10. Fatty acid profile of separable lean[1] from cooked veal cuts at a three composite level[2] shown as a percentage of total fatty acids (g/100g of tissue).

Fatty acid[3], %	Common Name	Leg Cutlet	Shoulder Blade Chop	Loin Chop	Shank Cross Cut	Ground Veal
10:0	Capric	0.0310	0.0374	0.0484	0.0621	0.0773
12:0	Lauric	0.0816	0.0704	0.0937	0.0949	0.0902
12:1		0.0269	0.0417	0.0385	0.0458	0.0409
14:0	Myristic	2.7523	2.5910	2.6133	2.4367	2.4586
14:1	Myristoleic	0.6824	0.6513	0.5138	0.6643	0.6676
	Palmitic			23.884	23.145	23.230
16:0		23.6212	23.6606	5	0	1
16:1	Palmitoleic	3.8201	4.0484	3.4157	4.0442	4.0664
17:0	Margaric	1.2108	1.1992	1.2924	1.1258	1.1340
17:1	Heptadecenoic	0.9980	1.0586	0.9974	1.0317	1.0406
	Stearic			14.545	13.126	13.103
18:0		13.9640	13.3761	5	6	3
18:1 trans-1		0.3941	0.3442	0.3811	0.3316	0.3358
18:1 trans-2		0.3752	0.3602	0.3731	0.3778	0.3757
18:1 trans-3		3.2426	2.8507	3.0939	2.6073	2.6335
18:1 t-vaccenic		0.6610	0.7730	0.7239	0.6864	0.7466
	Oleic			39.528	40.505	40.456
18:1c9		40.4740	40.5288	0	6	2
18:1c11	Oleic	1.9249	1.9947	1.8331	2.1251	2.1025
18:2	Linoleic	4.0196	4.6977	4.8606	5.5346	5.4330
18:3	Linolenic	0.1633	0.1642	0.1619	0.1580	0.1605
20:0	Arachidic	0.0362	0.0313	0.0318	0.0309	0.0321
Unknown		0.1299	0.0818	0.1061	0.1027	0.0970
18:2c9t11	CLA	0.3354	0.2941	0.3011	0.3075	0.3108
18:2t10c12	CLA	0.0343	0.0237	0.0304	0.0229	0.0308
20:1	Eicosenoic	0.2214	0.0496	0.0496	0.0000	0.0000
20:2	Eicosadienoic	0.0162	0.0000	0.0000	0.0000	0.0000
20:4	Arachidonic	0.6284	0.9027	0.8980	1.2280	1.1797
20:5	EPA	0.0244	0.0104	0.0104	0.0000	0.0000

[1]Separable lean used for all cuts, except ground veal, wherein the nature of the product is both lean and fat.

[2]Three-level composite samples consist of samples from paired suppliers: composite 1=suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6.

[3] t = trans, c = cis

Table 11 . Raw veal cut least squares means (n=3) for mineral data in mg/100g lean tissue[1] on a three-composite level[2].

Nutrient, mg/100g	Calcium	Copper	Iron	Magnesium	Manganese	Phosphorus	Potassium	Sodium	Zinc
Leg Cutlet	5.1	0.304	0.81[b]	32.0	0.017[a]	211.9	273[ab]	81.0	1.97[b]
Loin Roast	10.5	0.438	0.85[b]	35.7	0.014[ab]	237.0	283[a]	93.1	2.15[b]
Whole Shank	13.7	0.357	1.19[ab]	33.7	0.010[b]	211.7	185[b]	119.7	3.86[a]
Shoulder Blade Chop[3]	22.6	0.356	1.26[ab]	32.8	0.013[ab]	208.9	210[b]	138.1	3.38[ab]
Ground Veal	15.5	0.471	1.37[a]	30.7	0.008[b]	196.9	198[b]	118.5	2.51[b]
SEM	4.74	0.05	0.13	2.14	0.002	19.12	19.84	25.47	0.41
P-Value	0.1536	0.1504	0.0497	0.5690	0.0260	0.6830	0.0239	0.5564	0.0477

[1]Raw separable lean was used in the assays to provide these results with the exception of ground veal, wherein the nature of the product contains both lean and fat.

[2]Three composite level used for proximates and cholesterol; composite samples were from paired suppliers: composite 1=suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6. Single national composite used for choline, B Vitamins, Vitamin E, Vitamin D, 25-hydroxy Vitamin D, and selenium; composites included samples from all 6 suppliers which contributed equal proportions to the composite.

[a-c] Within a column, composite means without a common superscript differ ($P < 0.05$). Means without these superscripts are not significantly different.

Table 12. Cooked veal cut least squares means (n=3) for mineral data in mg/100g lean tissue[1] on a three-composite level[2].

Nutrient, mg/100g	Calcium	Copper	Iron	Magnesium	Manganese	Phosphorus	Potassium	Sodium	Zinc
Leg Cutlet	6.2[b]	0.434[ab]	1.39[ab]	38.5	0.017[a]	284.8	369[a]	87.7	3.13[b]
Loin Chop	13.0[b]	0.316[b]	0.79[b]	33.3	0.012[b]	213.8	239[b]	103.1	1.83[b]
Shank Cross-Cut	20.6[a]	0.379[b]	2.06[a]	34.3	0.011[b]	218.0	205[b]	90.3	5.32[a]
Shoulder Blade Chop[3]	20.7[a]	0.572[a]	1.65[a]	34.1	0.009[b]	232.5	239[b]	105.5	4.55[a]
Ground Veal	17.7[ab]	0.470[ab]	1.50[a]	34.2	0.009[b]	231.1	245[b]	164.4	2.95[b]
SEM	2.32	0.05	0.22	2.75	0.001	22.74	27.73	22.63	0.46
P-Value	0.0100	0.0433	0.0265	0.6603	0.0194	0.2694	0.0234	0.2021	0.0019

[1]Cooked separable lean was used in the assays to provide these results with the exception of ground veal, wherein the nature of the product contains both lean and fat.

[2]Three composite level used for proximates and cholesterol; composite samples were from paired suppliers: composite 1=suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6. Single national composite used for choline, B Vitamins, Vitamin E, Vitamin D, 25-hydroxy Vitamin D, and selenium; composites included samples from all 6 suppliers which contributed equal proportions to the composite.

[a-c] Within a column, composite means without a common superscript differ ($P < 0.05$). Means without these superscripts are not significantly different.

Table 13. Raw and cooked veal cut least squares means (n=3) for mg/100g cholesterol of separable lean tissue data on a three-composite level[1].

Veal Cut	Cholesterol, mg/100g
Raw	
Leg Cutlet	55.61[ab]
Loin Roast	54.62 [ab]
Whole Shank	62.33 [a]
Shoulder Blade Chop	59.75 [a]
Ground Veal	49.00 [b]
SEM	2.56
P-Value	0.0350
Cooked	
Leg Cutlet	71.65
Loin Roast	78.23
Whole Shank	92.20
Shoulder Blade Chop	76.96
Ground Veal	76.72
SEM	6.91
P-Value	0.2819

[1]Composite levels based on supplier pairing of samples: composite 1= suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6.

[a-c] Within a column, composite means without a common superscript differ ($P < 0.05$). Means without these superscripts are not significantly different.

Table 14. USDA "Lean/ Extra Lean" and American Heart Association (AHA) "Heart Check" classifications of cooked veal and other cooked animal protein cuts based on total fat, saturated fat, cholesterol, *trans* fat, and sodium content.

Cut	Total fat g/100g	Saturated fat g/100g	Cholesterol mg/100g	*Trans* fat g/100g	Sodium mg/100g	USDA Classification	AHA Heart-Check?
Leg cutlet	2.6	1.087	72	0.121	88	Extra Lean	Yes
Loin chop	4.3	1.110	78	0.119	103	Extra Lean	Yes
Shoulder Blade chop	5.5	1.069	60	0.113	106	Lean	No
Shank cross-cut	4.5	1.046	92	0.104	90	Extra Lean	Yes
Ground Veal	11.8	1.048	77	0.106	167	None	No
Beef Top Round Steak[1]	3.8	1.556	86	0.191	75	Extra Lean	Yes
Beef Tenderloin Steak[2]	8.3	3.296	93	0.438	59	Lean	No
Beef Top round Roast[3]	3.8	1.383	77	0.170	67	Extra Lean	Yes
Beef Eye of Round Steak[4]	3.9	1.410	78	0.182	68	Extra Lean	Yes
95% lean ground beef patty[5]	5.9	2.698	76	0.150	71	Lean	No
Chicken breast-boneless, skinless[6]	3.2	0.992	104	0.010	58	None	No
Pork top loin chop[7]	4.6	1.784	69	0.017	87	Extra Lean	Yes

[a] Values presented as a weight percentage of fatty acids

[b] 9 CFR 317.362 USDA: Lean classifications per 100g include and are defined as 1) Lean: <10 g total fat, < 5g saturated fat, <95 mg cholesterol. 2) Extra Lean: < 5g fat, ≤2.5g saturated fat, <95mg of cholesterol

[c] American Heart Association (AHA) "Heart Check" requirements per 100g : <5 g total fat, < 2 g saturated fat, <95 mg cholesterol, <0.5 g Trans fat, <360mg Sodium.

[1]USDA-ARS, Standard Reference number 13491: Beef, round, top round steak, boneless, separable lean only, trimmed to 0" fat, all grades, cooked, grilled
[2]USDA-ARS, Standard Reference number 13442: Beef, loin, tenderloin steak, boneless, separable lean only, trimmed to 0" fat, all grades, cooked, grilled
[3]USDA-ARS, Standard Reference number 23378: Beef, round, top round roast, boneless, separable lean only, trimmed to 0" fat, all grades, cooked, roasted
[4]USDA-ARS, Standard Reference number 23381: Beef, round, eye of round steak, boneless, separable lean only, trimmed to 0" fat, all grades, cooked, grilled
[5]USDA-ARS, Standard Reference number 23559: Beef, ground, 95% lean meat/5% fat, patty, cooked, pan-broiled
[6]USDA-ARS, Standard Reference number 05747: Chicken, broiler or fryers, breast, skinless, boneless, meat only, cooked, grilled
[7]USDA-ARS, Standard Reference number 10181: Pork, fresh, loin, top loin (chops), boneless, separable lean only, cooked, pan-fried

Table 15. Nutrient composition mean values of raw separable lean[1] of veal cuts and ground veal at varying composite levels[2].

Nutrient, units	Raw				
	Leg Cutlet	Shoulder Blade Chop[3]	Loin Roast	Whole Shank[3]	Ground Veal
Nutrient, units/100 g of tissue					
Riboflavin (Vitamin B_2), mg	0.34	0.43	0.31	0.39	0.28
Niacin (Vitamin B_3), mg	9.28	4.61	7.25	5.37	5.52
Pantothenic Acid (Vitamin B_5), mg	0.58	1.05	0.69	0.66	0.446
Vitamin B_6, mg	0.599	0.466	0.683	0.403	0.67
Cholesterol, mg	55.6	59.7	54.6	62.3	49.0
Vitamin B_{12}, µg	2.08	2.88	2.65	1.92	3.66
Total Choline, mg	120.0	-	110.5	-	96.5
Total Betaine, mg	28.4	-	23.4	-	25.6
Vitamin D2, µg	<0.200	-	<0.200	-	<0.200
Vitamin D3, µg	0.575	-	1.190	-	1.280
25 Hydroxy Vitamin D3, µg	0.398	-	0.352	-	0.594
Selenium, µg	16.0	15.8	18.0	13.0	13.1
Nutrient, units/g of tissue					
AlphaTocopherol, µg	3.05	-	2.67	-	4.93
BetaTocopherol, µg	0	-	0	-	0
Gamma Tocopherol, µg	0	-	0.39	-	0.63
Delta Tocopherol, µg	0.24	-	0	-	0.39
Vitamin B1, µg	0.998	1.090	0.856	0.843	1.100
Choline, nmol	114.3	-	290.7	-	150.8
P-Choline, nmol	167.2	-	305.3	-	332.7
Phosphatidylcholine, nmol	9983.5	-	8640.7	-	7496.4
GP-Choline, nmol	491.4	-	670.9	-	604.0
Betaine, nmol	2424.6	-	1994.2	-	2184.1
Sphingomyelin, nmol	758.6	-	695.9	-	680.8

[1]Raw separable lean was used in the assays to provide these results with the exception of ground veal, wherein the nature of the product contains both lean and fat.

[2]Three composite level used for proximates and cholesterol and composite samples were from paired suppliers: composite 1=suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6. Single national composite used for choline, Vitamin E, Vitamin D, 25-hydroxy Vitamin D, and selenium and were samples from all 6 suppliers contributed equal proportions to the composite.

[3]Shoulder blade chops and whole shanks were not analyzed for choline, Vitamin E, Vitamin D, and 25-Hydroxy Vitamin D.

Table 16. Nutrient composition mean values[1] of cooked veal retail cuts at a varying composite levels[2].

Nutrient, Units	Cooked				
	Leg Cutlet	Shoulder Blade Chop[3]	Loin Chop	Shank Cross Cut[3]	Ground Veal
Nutrient, units/100 g of tissue					
Riboflavin (Vitamin B_2), mg	0.47	0.48	0.33	0.35	0.43
Niacin (Vitamin B_3), mg	10.10	5.14	7.94	3.77	7.90
Pantothenic Acid (Vitamin B_5), mg	0.650	0.435	0.550	0.480	0.508
Vitamin B_6, mg	0.761	1.180	0.691	0.177	0.880
Cholesterol, mg	71.7	59.7	78.2	92.1	76.7
Vitamin B_{12}, µg	2.08	3.66	2.89	1.88	3.53
Total Choline, mg	159.9	-	150.0	-	119.6
Total Betaine, mg	29.2	-	27.4	-	33.9
Vitamin D2, µg	<0.200	-	<0.200	-	<0.200
Vitamin D3, µg	0.587	-	0.802	-	1.380
25 Hydroxy Vitamin D3, µg	0.660	-	0.663	-	0.805
Selenium, µg	21.6	18.4	26.1	20.7	18.5
Nutrient, units/g of tissue					
AlphaTocopherol, µg	4.34	-	3.75	-	2.58
BetaTocopherol, µg	0	-	0	-	0
Gamma Tocopherol, µg	0.43	-	0	-	0.73
Delta Tocopherol, µg	0	-	0	-	0.45
Vitamin B1, µg	0.926	1.100	0.700	0.834	0.949
Choline, nmol	148.6	-	219.2	-	207.4
P-Choline, nmol	216.8	-	243.2	-	457.9
Phosphatidylcholine, nmol	13328.1	-	12276.0	-	9232.6
GP-Choline, nmol	388.6	-	492.0	-	556.8
Betaine, nmol	2494.4	-	2342.4	-	2895.6
Sphingomyelin, nmol	1263.4	-	1165.2	-	1025.7

[1]Raw separable lean was used in the assays to provide these results with the exception of ground veal, wherein the nature of the product contains both lean and fat.

[2]Three composite level used for proximates and cholesterol; composite samples were from paired suppliers: composite 1=suppliers 1 and 3; composite 2= suppliers 2 and 4; composite 3= suppliers 5 and 6. Single national composite used for choline, B Vitamins, Vitamin E, Vitamin D, 25-hydroxy Vitamin D, and selenium; composites included samples from all 6 suppliers which contributed equal proportions to the composite.

[3]Blade chops and shank cross cuts were not analyzed for choline, Vitamin E, Vitamin D, and 25-Hydroxy Vitamin D.

Table 17. Vitamin B percent Recommended Daily Intake (RDI) for cooked veal cuts based on Vitamin B values per 100g, with "excellent" and "good" source identification.

Nutrient, mg/100g	RDI[1]	Leg Cutlet	% RDI[2]	Shoulder Blade Chop	% RDI[2]	Loin Chop	% RDI[2]	Shank Cross-Cut	% RDI[2]	Ground Veal[3]	% RDI[2]
Vitamin B1, µg	1500	92.60	6.2	110	7.3	70	4.7	83.4	5.6	94.9	6.3
Vitamin B2, mg	1.7	0.47	27.6 [a]	0.48	28.2 [a]	0.33	19.4 [b]	0.35	20.6 [a]	0.43	25.3 [a]
Vitamin B3, mg	15	10.10	67.3 [a]	5.14	34.3 [a]	7.49	49.9[a]	3.77	25.1 [a]	7.9	52.7 [a]
Vitamin B5, mg	10	0.65	6.5	0.435	4.4	0.55	5.5	0.48	4.8	0.508	5.1
Vitamin B6, mg	2	0.76	38.1 [a]	1.18	59.0 [a]	0.691	34.6 [a]	0.177	8.9	0.888	44.4 [a]
Vitamin B12 µg	6	2.08	34.7 [a]	3.66	61.0 [a]	2.89	48.2 [a]	1.88	31.3 [a]	3.53	58.8 [a]

[1] Reference daily intakes (RDI) dietary allowance (RDA) is the daily intake level of a nutrient that is considered to be sufficient to meet the requirements of 97-98% of healthy individuals in the United States.

[2] % RDI: Percent Reference Daily Intake. The % RDI is based on a 2,000 calorie intake and is calculated as the average % DV across all cuts.

[3] Raw separable lean was used in the assays to provide these results with the exception of ground veal, wherein the nature of the product contains both lean and fat.

[a] Percentage qualifies the cut to be labeled as an "excellent source" of the vitamin, providing over 20% of the RDI.

[b] Percentage qualifies the cut to be labeled as a "good source" of the vitamin, providing between 10-19% of the RDI.

Table 18. Vitamin D nutrient analysis values for raw separable lean of veal cuts and raw ground veal, and SR-26 values for other raw proteins and known foods high in Vitamin D.

Units/100g tissue	Veal Data			USDA-ARS Standard Reference-26 Data						
	Raw Leg Cutlet	Raw Loin Roast	Raw Ground Veal	Veal Babyfood[2]	Beef Porterhouse Steak [3]	Ground Beef [4]	Ground Turkey [5]	Fortified Milk [6]	Canned Tuna[7]	Whole Egg
Vitamin D3										
µg	0.575	1.190	1.280	-	0.1	0.1		-	2.0	2.0
IU [a]	23[a]	47.6[a]	51.2[a]	-	4[a]	4[a]		-	80 [a]	80 [a]
D2 + D3[1]										
µg	-	-	-	0.7	0.1	0.1	0.4	1.2	2.0	2.0
IU	-	-	-	28 [a]	4[a]	4[a]	16 [a]	48[a]	80 [a]	80 [a]
25-Hydroxy D3										
µg	0.398	0.352	0.594	-	-	-	-	-	-	
IU [a]	15.92[a]	14.08[a]	23.76[a]	-	-	-	-	-	-	
Total Vitamin D										
µg	0.973	1.542	1.874	0.650 [a]	0.075 [a]	0.075 [a]	0.350 [a]	1.225 [a]	2.0 [a]	2.05 [a]
IU	39[a]	62[a]	75[a]	26	3	3	14	49	80	82

[1]USDA NDL uses values for D2+D3 in mcg form, and represent Vitamin D in IU and are meant to be equitable, however some additional conversion factors are not publicly known. Veal data results for Vitamin D2 were <0.200µg and as such are not reported in this table as exact numbers are not known.

[2]USDA-ARS Standard Reference number 03005: Babyfood, meat, veal, strained

[3]USDA-ARS Standard Reference number 13231: Beef, short loin, porterhouse steak, separable lean only, trimmed to 1/8"fat, choice, raw

[4] USDA-ARS Standard Reference number 23567: Beef, ground, 85% lean meat / 15% fat, raw

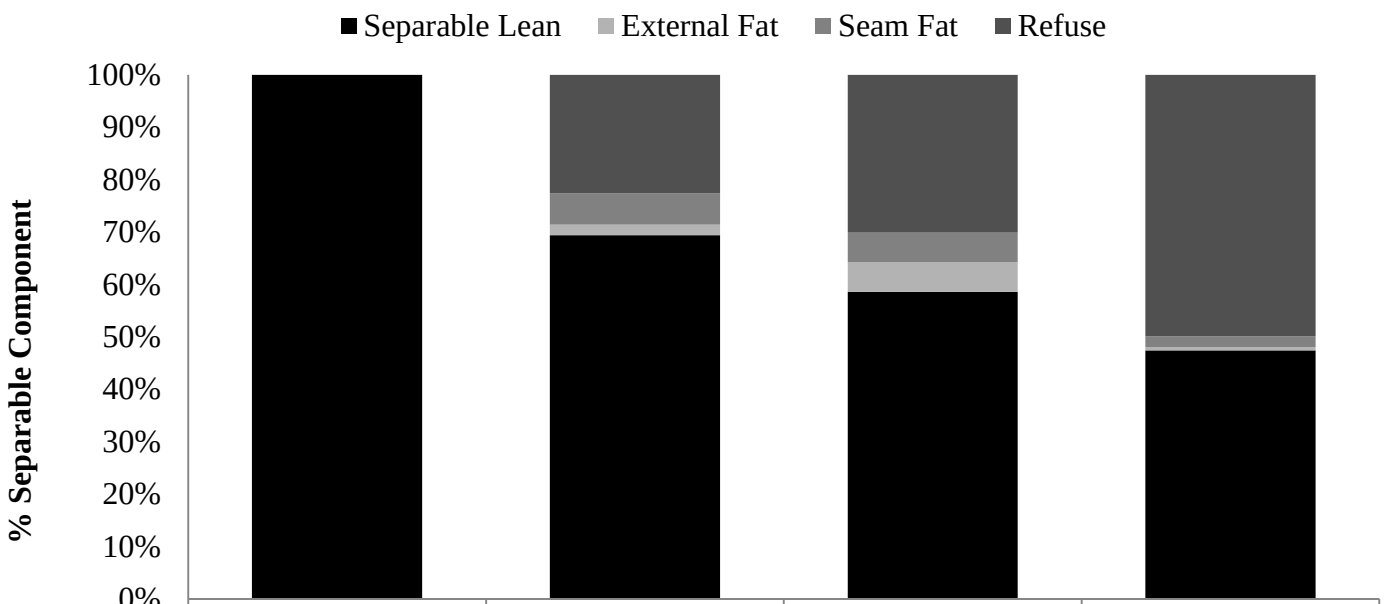
[5] USDA-ARS Standard Reference number 05668: Ground turkey, 85% lean, 15% fat, raw

[6] USDA-ARS Standard Reference number 01079: Milk, reduced fat, fluid, 2%, milkfat, with added Vitamin A and Vitamin D

[7] USDA-ARS Standard Reference number 15126: Fish, tuna, white, canned in water, drained solids

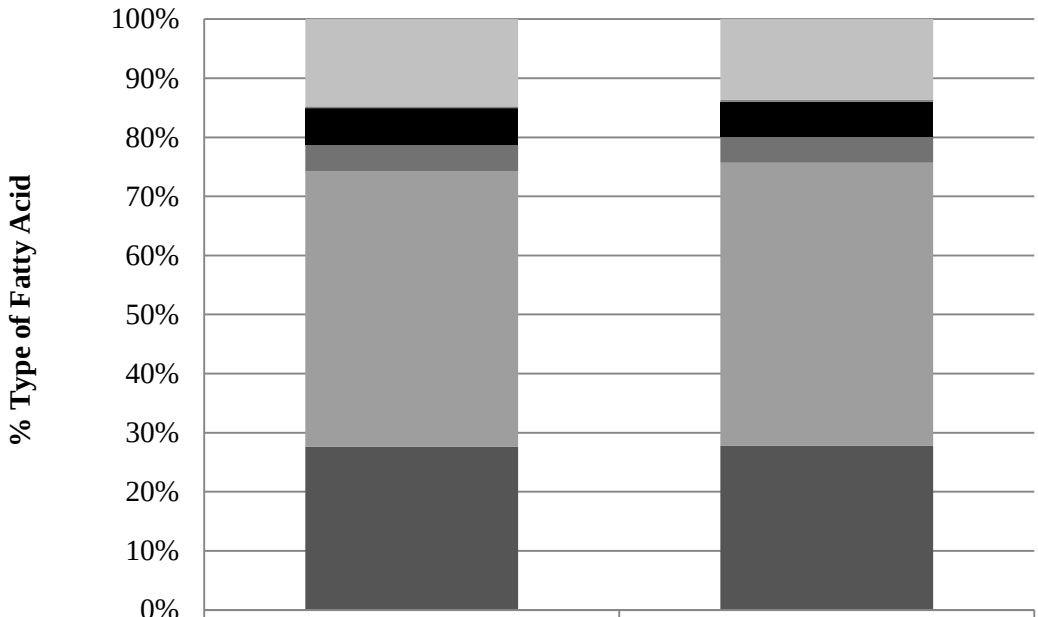
[8] USDA-ARS Standard Reference number 01123: Egg, whole, raw, fresh

[a] Values are converted based off of reported data from analysis. Conversion of units is on a 1mcg/40IU basis as used by USDA Nutrient Database Laboratory, SR-26 documentation (USDA ARS).



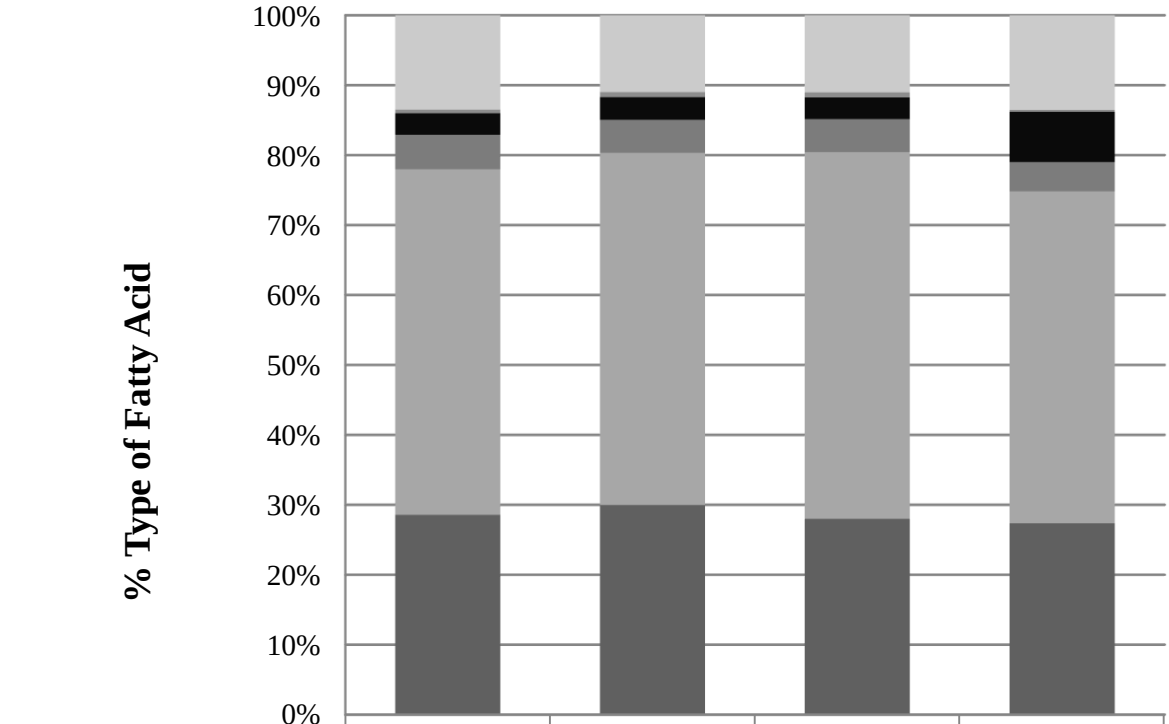
	Leg Cutlet	Shoulder Blade Chop	Loin Roast	Whole Shank
Refuse	0	22.2	29.5	48.5
Seam Fat	0	5.9	5.5	2.0
External Fat	0	2.0	5.6	0.6
Separable Lean	100	68.3	57.5	46.2

Figure 1. Raw separable component percentages for each cut from dissections, including separable lean, external fat, seam fat, and refuse.



	Raw	Cooked
Stearic	14.76	13.62
Conjugated Linoleic Acid	0.33	0.34
Polyunsaturated	6.15	5.87
Trans	4.48	4.39
Monounsaturated	46.66	47.83
Saturated	27.61	27.71

Figure 2. Percent fatty acid composition of fat derived from separable lean of raw and cooked veal cuts. Total Stearic Acid= 18:0. Total Conjugated Linoleic Acid = Σ 18:2 c9 t11 and 18:2 t10 c12. Total Polyunsaturated Fatty Acid = Σ18:2, 18:3, 20:2, 20:4, 20:5, 22:6. Total *Trans* Fatty Acid = Σ18:1 trans-1, 18:1 trans-2, 18:1 trans-3, 18:1 t-vaccenic. Total Monounsaturated Fatty Acid = Σ12:1, 14:1, 16:1, 17:1, 18:1c9, 18:1c11, 20:1. Total Saturated Fatty Acid = Σ10:0, 12:0, 14:0, 16:0, 17:0, 20:0, 24:0.



	Raw External Fat	Cooked External Fat	Raw Seam Fat	Cooked Seam Fat
Stearic	13.49	10.98	11.01	13.5
Conjugated Linoleic Acid	0.52	0.72	0.72	0.3
Polyunsaturated	3.05	3.22	3.09	7.2
Trans	4.93	4.73	4.72	4.2
Monounsaturated	49.36	50.30	52.38	47.4
Saturated	28.53	29.93	27.96	27.3

Figure 3. Percent fatty acid composition of raw and cooked external and seam fat dissected from veal cuts. Total Stearic Acid= 18:0. Total Conjugated Linoleic Acid = Σ 18:2 c9 t11 and 18:2 t10 c12. Total Polyunsaturated Fatty Acid = Σ18:2, 18:3, 20:2, 20:4, 20:5, 22:6. Total *Trans* Fatty Acid = Σ18:1 trans-1, 18:1 trans-2, 18:1 trans-3, 18:1 t-vaccenic. Total Monounsaturated Fatty Acid = Σ12:1, 14:1, 16:1, 17:1, 18:1c9, 18:1c11, 20:1. Total Saturated Fatty Acid = Σ10:0, 12:0, 14:0, 16:0, 17:0, 20:0, 24:0.

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