Safety of Barbecue Food and Its Improvement Measures

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Abstract. Barbecue is popular as a considered delicious food, but its safety is questionable. The researchers found that the process of making barbecues could produce harmful carcinogens, and they advised people to eat barbecues less often. With the improvement of people's living standards, consumers pay more attention to healthy diet, and hope that food delicious and health coexist. It has not met the needs of today's consumers just relying on reducing the number of barbecue times to avoid causing harm to the human body. It has become an urgent problem to be solved how to make people enjoy the delicious barbecue while improving its safety. This paper starts with the influence of the barbecue cooking method on food, and deeply studies the changes of food materials and the possible harmful substances in the process of barbecue. In view of the influencing factors of barbecue safety, some feasible measures to improve barbecue safety are put forward, so as to help consumers and businesses reference.

Keywords: Barbecue; Resistant starch; Nitroamines.

1. Introduction

As a traditional cooking method, barbecue has a long history. Since the beginning of the third millennium BC, barbecue has been recorded in the history of human civilization. However, the development of barbecue in the next thousands of years was slow, due to the limitations of cooking utensils. In addition, people only learned to cook food with fire, rather than to season food. Then, the finding of salt contributed to the varieties of flavorings and new barbecue product taste. With the progress of science and technology and the improvement of people's cooking methods, a variety of barbecue methods have gradually derived, from smoking, and baking to curing, iron roast, bonfire roast, bamboo roast, diverse methods are popular in the world. However, regardless of the type of barbecue, the taste that is presented when properly chosen ingredients are cooked, substantially spiced, and well-seasoned is unquestionably a huge temptation and attractiveness for people. Likewise, the continued advancement of food science technology continually gives barbecues a new lease on life, and a variety of technical tools also support and ensure wholesome nutrition and delectable food.

Nowadays, barbecue has evolved into a rich and diverse barbecue culture, and each has its own characteristics due to different regions. For example, American people prefer to barbecue in their own yards for welcoming friends. In the various large supermarkets in the United States, barbecue equipment has a place, which is in an obvious position for people to choose from. Therefore, Americans are fond of barbecue, and they are always happy to use barbecue to get close to nature, entertain relatives and friends, and make new friends, demonstrating American’s active, outgoing, and friendly character. Korean barbecue has high protein and less greasy characteristics. The raw meat used is mostly pork belly, rich in protein, phospholipids and other substances with brain health function. In the long-term historical development process, Korean barbecue highlights the national characteristics of healthy eating and advocating nature, and reflects the characteristics of Korean introverted and traditional personality. Different from other countries, Brazilian barbecue only sprinkles some salt on the surface of the meat, which then melts and permeates Using the pine charcoal fire, the effects of oil oozing and brown surface are achieved and fresh tender products are obtained. The rough style and the original flavor of the campfire can be found in the Brazilian barbecue. Contrary to the version of Korean barbecue, Brazilian barbecue shows a full Latin style. In China, the simple folk customs of the people in northeast China have brought the fire to the "Zibo barbecue", triggering a national barbecue craze. Zibo barbecue is characterized by the affordable price,

good taste, and variety, so it is loved by consumers. In addition to the traditional beef and mutton kebabs, there are eggplant, corn, potatoes, leeks and other vegetables to choose from [1].

At the same time, however, the safety of the barbecue has also attracted widespread attention. It is assumed that barbecue may cause cancer, while there are some controversies. In the overwhelming situation of the barbecue boom, it is also an urgent problem to be solved how to improve the safety of barbecue and make the beloved barbecue healthier, greener and more secure.

This paper starts with the influence of the barbecue cooking method on food, and deeply studies the changes of food materials and the possible harmful substances in the process of barbecue. In view of the influencing factors of barbecue safety, some feasible measures to improve barbecue safety are put forward, so as to help consumers and businesses with reference.

2. Chemical Changes During Barbecue

2.1. Protein Oxidation

An important component that affects the nutritional value and flavor of meat products is protein oxidation, which can result in changes to the protein main chain and amino acid residue side chains. As a result, the flavor of food is impacted by the loss of amino acids that are precursors to the flavor of meat products [2].

Fresh fish meat makes up 15% of the muscle's protein composition, whereas chicken meat makes from 10% to 20%. It is one of the basic foods for people and a good source of energy and vital amino acids. Some essential amino acids, such as methyl sulfate and lithium acid, among others, will undergo oxidative alteration as a result of protein oxidation. Essential amino acids are lost as a result of oxidation modification, sometimes even forming hazardous compounds, including heterocyclic amines, acrylamide, etc. [3].

Heterocyclic amines are carcinogenic and mutagenic compounds produced in the process of high temperature heating of food. A large number of epidemiological studies have shown that the intake of heterocyclic amines increases the risk of colon cancer, gastric cancer, oesophageal cancer, pancreatic cancer and other cancers. The chemical structure is a heterocyclic primary amine, which is very common in fried and barbecued meat products. Heterocyclic amines are formed by precursor substances such as creatine, free amino acids, and hexoses when heated at high temperatures ranging from 150 to 300 ℃. The heterocyclic amines generated by thermal processing temperature of 100~250 ℃ are mainly aminoimidazole nitrogen and aromatic hydrocarbons; at the temperature above 250 ℃, protein or amino acids undergo pyrolysis to produce thermal decomposition heterocyclic amines, mainly aminocarlinines.

Acrylamide is a common toxic and harmful substance produced by Maillard reaction during hot processing of food. Acrylamide disrupts the nervous system by inhibiting neuroblastoma and glioblastoma cell differentiation in humans. Reducing sugars (glucose and fructose) condense with amino acids (mainly aspartate) to produce n-glycosides. N-glycosides are recombined into glucosamine reproducts, which then undergo a series of reactions to produce melanin. Then melanin further decarboxylation of Schiff bases leads to the formation of acrylamide [4].

2.2. Lipid Oxidation

Algae, ketones, and low-fat acids are examples of lipid oxidants that can give meat products their distinctive flavors; nevertheless, lipid peroxidants may degrade the flavor of meats and produce some poisonous molecules.

The oxidation of animal lipids has a direct impact on the ingredients that give meat products their distinctive flavors. In the heating process, such as high-pressure cooking, microwave heating, baking, grilling, and other processes of lipid thermal degradation reaction to produce lipid derivative chemicals, processed meat mostly produces volatile molecules. These molecules make up the flavors of meat [2].

However, after being heated for a long time, preoxidation will occur in lipids, resulting in a rising number of some harmful substances, including Tran's fatty acids, polycyclic aromatic hydrocarbons, etc. The risk of Tran's fatty acids is related to the daily intake. Every 2 percent increase in dietary Tran's fatty acids has a 25 percent increased risk of heart disease. Polycyclic aromatic hydrocarbons can enter the human body through the respiratory tract, skin and mucosa, and contaminated food. In the human body, through the action of aromatic hydrocarbon hydroxylase, its metabolism is activated into polycyclic aromatic hydrocarbon epoxide, and combined with DNA, RNA, protein and other macromolecular substances to induce mutations and tumors.

The fat tissue of ruminants (cattle and sheep), as well as milk from cows and goats, is where natural Trans fatty acids are found. Tran's fatty acids are created when oil is heated to a high temperature, and cis fatty acids undergo isomerization under the effects of temperature, metal ions, etc.

During the heating process, fatty acids in lipids can be converted cyclically into PAHs, and they can also mix with highly lime-soluble PAHs to produce PAH-rich groups. At the same time, there are a lot of polycyclic aromatic hydrocarbons in the smoke coming from the barbeque. This serves as motivation for companies to increase the distance between the meat and the smoke source in order to lower the amount of PAHs in their goods [4].

2.3. Resistant Starch (RS)

People occasionally choose foods like potatoes, which are high in starch, when having a BBQ. The primary source of energy in the human diet is starch, a polymer that is renewable, easily biodegradable, and can be employed as a material for energy storage. Amylose and amylopectin, two macropolymers, make up the majority of natural starch. According to recent research, the spatial conformation of amylose molecules in starch bends into a helical type because of their internal hydrogen bond, and the interior hydrophobic cavity can join with substances like lipids to form a single helical complex, which is resistant starch [5].

Healthy individuals' stomachs and small intestines do not digest and absorb RS. Intestinal flora can ferment it after it reaches the large intestine to create short-chain fatty acids (SCFAs), H2, CO2, and CH4. The physiological maintenance of human and intestinal health depends heavily on SCFAs [6].

2.4. Nutritional Substance in Vegetables

Customers will not only be exposed to meat and grain products during the barbecue process, but certain new barbecues will also broaden the selection of barbecue dishes by roasting a variety of vegetables, including eggplant and mushrooms, as well as corn and green veggies. These veggies contain a variety of vitamins, phenolics, anthocyanins, zeaxanthin, and other healthy compounds. Since barbecue is a form of thermal processing, certain items will be impacted.

According to studies, the vitamin C content of sweet corn gradually decreased as the heating time increased and the heating temperature increased. The actual barbecue process generally does not take a long processing time, so the decrease of vitamin C content is not obvious [7].

Anthocyanins are naturally occurring, water-soluble pigments that are frequently found in plant-based foods. Anthocyanins are highly unstable and sensitive to changes in temperature, pH, oxygen, and metal ions, and heat processing is the most likely to result in fading and degradation. It is shown that the higher the temperature, the less stability of pH is in the range of 3 to 6. Thus, barbecue can decrease the anthocyanins in vegetables [8].

Carotenoids with significant health benefits, including beta-carotene, lycopene, and lutein, are abundant in dark green and orange-yellow vegetables. Carotenoids are most effectively preserved during rinsing and brief cooking times, followed by steaming and microwave steaming. However, while stewing and frying or baking, the preservation rate considerably drops, and fat-soluble loss occurs [9].

Zeaxanthin is natural pigments present in plants, algae, light, and bacterial metabolites. Caaxin protects vision, prevents senile macular degeneration and cataract, prevents cancer, enhances body

immunity, prevents potential cardiovascular and cerebrovascular diseases, protects against inflammatory and oxidative stress responses, and protects against oxidative retinal damage and growth in diabetic rats. However, it is shown that the content of zeaxanthin was reduced by 55% under the optimal conditions of 30 min, the baking temperature of 190 ℃ and 75% water was added [10].

3. Measures to Make Barbecue Healthier

3.1. Instruments

The barbecue oven used in traditional barbecue shops is generally charcoal oven, whose advantages lie in the short processing time, and at the same time, there are also disadvantages such as difficult to operate, large smoke emissions, small water content of baked food, easy to cause pollution to food. With the development of science and technology, more new ovens came out, making up for the shortcomings of traditional carbon ovens through technological innovation.

Some technicians use the thermoelectric conversion of food heating devices in the original old barbecue furnace to convert the heat from the charcoal into electricity and drive the small fan rotation, introducing a lot of oxygen into the barbecue furnace so that the charcoal combustion occurs more fully, in order to solve the issues with the existing technology [11,12].

Or, the addition of steam in a high-temperature oven can alter the state of heat transfer in the cavity, alter the structural properties of food substances, lessen the appeal of barbecue, and improve the health and safety of meat by reducing oil and salt and the production of harmful substances [13].

3.2. Raw Materials

3.2.1. Marinate Ahead of Time

As is shown in Table 1 below, curing antioxidant meat ingredients, including star anise, clove, onion, garlic, fennel and coriander, can help reduce the production of nitroamines. So businesses can reduce the content of nitroamines by pickling before barbecue [14].

Table 1. NDMA in Chinese sausagewith different inhibitory stuff (ug / kg) [14].

Group	Time (week)		
	0	2	4
1 Control Group	75.69±5.67a	76.35±4.81a	80.74±5.51a
2 anise essential oil	----	8.66±4.19d	10.53±4.88d
3 clove essential oil	9.36±4.93de	13.75±5.86de	16.48±4.29de
4 anise extract	23.87±4.48cf	25.38±4.96cef	28.65±3.80ce
5 clove extract	15.23±5.76def	18.08±4.72def	19.47±4.51ed

Note: a, b, c, d, e, f, g, h in the same column letter, the same indicates the difference is significant, the difference is not significant ($P < 0.05$)

3.2.2. Red Yeast Pigment Instead of Nitrite

Red yeast pigment is a pure natural red pigment created by fermenting, cultivating, and concentrating a variety of key raw ingredients, including rice, soybeans, and others. It is a healthy food supplement. Another red pigment is acidity; most light and some common materials are fairly stable, heat resistance is good, and it has a good antioxidant effect. As a result, the red pigment is coloring, and preservatives are frequently used in meat products and preserved products as food additives, not only because they can lower human sodium nitrite intake but also because they can increase the consumption of meat products and inhibit the growth of some microorganisms [15].

3.3. Tableware

For barbecue, it is better to use iron prods than bamboo prods. Meat ingredients need a long time to be cooked, so the use of wooden prods makes it easy to bake black. At the same time, the thermal

conductivity of the metal is strong; with the same heat, the use of iron prods can cook faster and can reduce the adhesion of meat and products.

For barbecue shops, a large number of products are needed every day. The smooth surface of iron products is not easy to hide dirt, it is easier to clean and keep for secondary use, and the environmental protection is stronger.

3.4. Auxiliary Diet

In recent years, researchers domestically and internationally have used natural products with flavonoid compounds, tea polyphenols, anthocyanins, VC, and other active ingredients to eliminate nitrite or prevent the creation of nitrosamines; the results are clear. The amount of nitrosamine was dramatically reduced when a team made natural compound juice from grapes, yellow lemons, green lemons, pomegranates, pineapples, and papayas. These studies have led people to the conclusion that when eating barbecued cuisine, some fruits rich in vitamins and flavonoids can significantly lower the nitrosamine hazards associated with the meat items [16].

3.5. Baking Time and Temperature

To improve the color and smell and regulate the dangerous ingredients in barbecue meals, baking time and temperature must be moderately controlled. Low baking temperatures cause certain sulfhydryl groups in animal proteins to oxidize and form disulfide bonds, eventually exposing the hydrophobic groups while minimizing water loss. Meat tightens up and improves in flavor. The meat is given a better color and flavor due to the Maillard reaction and lipid oxidation reactions occurring simultaneously. However, because of the excessively high baking temperature (220 °C) and longer baking time (20 min), the protein is severely degraded, the sulfhydryl group is continuously oxidized, the disulfide bond content keeps rising, and the extensive exposure of hydrophobic groups causes the aggregation of myofibrillin to cause a substantial reduction in water retention, water loss, taste hardening, and loss of elasticity. Maillard The flesh turns black and loses its sheen as a result of the reaction's aggravation, excessive oxidation, acidity of the lipids, and decline in flavor [17].

3.6. Restaurants

If possible, choosing bigger barbecue restaurants with fresher ingredients and cleaner surroundings is recommended.

Table 2. Qualified rate of large and medium-sized barbecue stalls [18].

Sample Species	Total number of sample colonies	Total number of bacterial colony(%)	colibacillus(%)	Staphylococcus aureus(%)
Pork	50	80	96	98
Beef	50	86	92	98
Mutton	50	78	96	94
Fish	50	70	82	90
Squid	50	72	92	96
In total	250	77.2	91.6	95.2

Table 3. Qualified rate of bacteria detection in small barbecue stalls [18].

Sample Species	Total number of sample colonies	Total number of bacterial colony(%)	colibacillus(%)	Staphylococcus aureus(%)
Pork	50	68	82	80
Beef	50	72	74	84
Mutton	50	78	72	82
Fish	50	70	74	76
Squid	50	60	74	78
In total	250	69.6	75.2	80

According to Table 2 and Table 3 above, the microbial indexes of both large and medium-sized barbecue restaurants and small barbecue stalls exceeded the national food safety and hygiene standards. Among them, the test of the total number of bacterial colonies shows that the qualified rate of large and medium-sized barbecue restaurants is 77.2%. In the samples of meat and aquatic products collected from small barbecue stalls, the qualified rate of the total number of bacterial colonies is less than 70%. The operation mode of small stalls makes the pollution of bacterial colonies, coliform group and Staphylococcus aureus more serious than that of large and medium-sized restaurants.

Therefore, when eating barbecue food, it is best to choose large and medium-sized restaurants, whose sanitary conditions are good. At the same time, the staff should strengthen health knowledge education and urge them to standardize their operation, so as to reduce pollution and protect the health of consumers [18].

4. Conclusion

As a thermal process, barbecue affects the nutrients in protein, oil, starch and vegetables. Meat products are rich in protein and grease. The nutritional value of protein at high temperature degeneration decreases; excessive oxidation of oil will combine with protein to produce substances harmful to the human body. After thermal processing, the starch spiral structure can combine with lipids to form resistant starch, as a dietary fiber to promote human gastrointestinal peristalsis and microflora growth. Besides, some nutrients in vegetables suffer a certain degree of loss, which is not conducive to the human body absorbing these beneficial components in vegetables.

In order to make the barbecue healthy, this paper proposes some feasible measures, such as improvements of the barbecue equipment. Reducing the nitrite content of raw materials of meat products selection of clean tableware, reasonable control of barbecue production time and temperature, etc.

By studying the change and generation of nutrients and harmful substances in barbecue, this paper explores the influencing factors affecting the safety of barbecue, and puts forward some practical measures for consumers and businesses to reference, so that consumers enjoy the food while taking into account the healthy diet, thus improving the quality of life.

With improved technology and improved food production and preservation methods, consumers will no longer need to worry about obesity, hypertension and cancer risks, but as an option to increase dietary diversity. In the future, barbecue is expected to develop and progress in a healthier, greener and more delicious direction.

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