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8 Effects of reheating methods on the product quality of Hongsu
9 chicken dish

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24 E-mail: min@jiangnan.edu.cn25 **Abstract**26 Hongsu chicken dish is a very popular commercially cooked, ready for home and
27 office consuming meat product in Yangzhou city, China. Effects of different reheating

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28 methods including hot water boiling, steaming, microwave heating and oven roasting
29 on the product quality attributes of Hongsu chicken dish were investigated. The
30 results showed that the microwave reheated samples had the best sensory scores, least
31 weight loss, the taste and texture were close to that of the freshly cooked meat, with
32 attractive color and aroma. To reach the required center temperature of 72 °C, the
33 sample should be microwave heated at 480 W for 3.2 min. This research suggested
34 that the microwave treatment was a quick and convenient method for reheating
35 Hongsu chicken dish.

36 **KEYWORDS:** Hongsu chicken dish, water boiling, steaming, microwave heating,
37 oven roasting, product quality

38
39 **Practical Applications:** This study compared the effects of different reheating
40 methods including water boiling, steaming, microwave and oven roasting treatment
41 on the quality attributes (including water content, weight loss, color, texture, sensory
42 evaluation, flavor and taste) of Hongsu chicken dish. The results showed that
43 microwave heating at 480 W for 3.21 minutes was able to reach the sample center
44 temperature of 72 °C. Compared with other reheating methods, microwave reheated
45 samples had the best sensory scores, least weight loss, and the taste was close to that
46 of the freshly cooked meat. Therefore, this technique might have met consumers'
47 requirements of convenient, quick and high quality reheated Hongsu chicken dish.

50 1 | INTRODUCTION

51 Hongsu chicken dish is one of the traditional and famous dishes of Yangzhou
52 city in China. It is a commercially prepared dish sold under refrigerated environment
53 to extend shelf-life. The Hongsu chicken dish needs to be reheated before human
54 consumption and the reheating process will further improve the product eating quality
55 such as flavor, taste and appearance etc. The reheating process will also inhibit
56 microbes to ensure food safety (Kerry, Kerry, & Kerry, 2011). The traditional main
57 heating methods for meat products are steaming, smoking, frying and roasting which
58 mainly rely on heat conduction and convection to transfer energy (Sun, 2005). By
59 using these methods, when the meat center temperature reaches the required safe
60 temperature, the surface meat are generally overcooked (Wills, DeWitt, Sigfusson, &

61 Bellmer, 2006), which could result in nutritional and sensory quality losses. To meet
62 consumers' requirements for high quality meat products, it is very important to
63 explore alternative techniques to alleviate the disadvantages of traditional heating
64 methods (Schellekens, 1996).

65 Microwave is an electromagnetic wave with a frequency ranging from 300 MHz
66 to 300 GHz. Microwave heating is very quick, because the electromagnetic waves can
67 penetrate into the interior of the samples and convert into heat energy in a short time
68 (Pu, Song, Song, & Wang, 2017), which has the advantages of safe and easy
69 operation, high energy efficiency, time saving and low maintenance (Salazar-
70 Gonzalez, San Martin-Gonzalez, Lopez-Malo, & Sosa-Morales, 2012; Zhang, Tang,
71 Mujumdar, & Wang, 2006). Comparing with the traditional heating methods,
72 microwave heating can maintain the nutritional and sensory quality of food to a
73 higher level (Vadivambal & Jayas, 2010).

74 Although the application of microwave heating in fresh meat cooking has been
75 extensively investigated (Ji, Xue, Zhang, Li, & Xue, 2017; Kondjoyan et al., 2014;
76 Liu & Lanier, 2016; Lorenzo, Cittadini, Munekata, & Dominguez, 2015), little is
77 known about the comparison between microwave heating and traditional heating
78 techniques on the quality of prepared meats. Therefore, the aim of this study was to
79 evaluate the effects of reheating methods (including hot water boiling, steaming,
80 microwave heating, roasting) on the product quality of Hongosu chicken dish. This
81 research may have provided useful information in selection of appropriate reheating
82 method before consumption of Hongosu chicken dish, and might be applicable for
83 reheating of other prepared meat products.

84

85 **2 | MATERIALS AND METHODS**

86 **2.1 | Meat Materials**

87 Hongosu chicken dish was prepared by using boneless chicken drumsticks and
88 skinless pork belly as main raw materials. The pork belly was firstly processed into
89 ground meat, and mixed uniformly with ginger, scallion and other seasonings in a
90 vacuum roller kneading machine. The boneless chicken drumsticks were steamed and
91 then covered with a layer of the mixed ground meat. Then the dish was steamed, fried,
92 and brined to obtain the final product. The prepared Hongosu chicken dish was
93 provided by Yangzhou Yechun Food Production & Distribution Co. Ltd. (Yangzhou
94 city, Jiangsu province, China) under refrigerated conditions on the same day of

95 cooking. The meat was aseptically cut into chunks (13 ± 0.5 cm in length, 4 ± 0.5 cm
96 in width and 1.5 ± 0.5 cm in thickness) with weight about 50 ± 5 g each, vacuum
97 packed, and kept in a refrigerator at about $4 \text{ }^\circ\text{C}$ for 2 days before reheating.

98

99 **2.2 | Heating Treatment**

100 The samples were divided into five groups (6 samples in one group) for
101 reheating treatments, namely untreated (control), hot water boiling, steaming,
102 microwave heating, and oven roasting. The initial temperature of the Hongsu chicken
103 dish was $4 \pm 2 \text{ }^\circ\text{C}$ before the treatments.

104

105 **2.2.1 | Water boiling**

106 The sample was wrapped with a polyethylene bag and then slowly placed into
107 the boiling water of a stainless-steel water bath. A fiber-optic temperature sensor
108 (FISO Technologies Inc., Quebec, Canada) was inserted into the center of the sample
109 and the sample was cooked until the temperature reached at $72 \text{ }^\circ\text{C}$.

110

111 **2.2.2 | Steaming**

112 The sample was put on a plate, and then placed in a stainless-steel household
113 steamer (Zhejiang Supor Co., Ltd., Hangzhou, China), and steamed at $100 \text{ }^\circ\text{C}$. The
114 fiber-optic temperature sensor was inserted into the center of the sample and heated to
115 $72 \text{ }^\circ\text{C}$.

116

117 **2.2.3 | Microwave**

118 The sample was placed in the center of a microwave oven (P70F20L-DG (S0),
119 2450 MHz Galanz microwave oven, Guangdong, China). The output power of the
120 microwave was 480 W. The sample was also heated to the center temperature of
121 $72 \text{ }^\circ\text{C}$.

122

123 **2.2.4 | Oven roasting**

124 The sample was heated in a convection oven pre-heated at $180 \text{ }^\circ\text{C}$. The center
125 temperature of the sample was measured at regular intervals and heating was
126 terminated when reached $72 \text{ }^\circ\text{C}$.

127

128 **2.3 | Measurements**

129 **2.3.1 | Moisture content analysis**

130 The Hongsu chicken dish was ground into meat batter. The moisture content was
131 measured gravimetrically in triplicate by drying 5 ± 0.5 g samples at 103 ± 2 °C until
132 constant weight (GBT 9695.15-2008, National Standard of China).

133 **2.3.2 | Weight loss**

134 After each heating treatment, the samples were cooled at room temperature for
135 30 min and wiped with blotting paper to calculate weight losses as follow (Chang et
136 al., 2011).

$$137 \text{Weight loss} = [(m_b - m_a)/m_b] \times 100\%$$

138 Where m_a and m_b are the weight (g) of the sample before and after heating
139 respectively.

141 **2.3.3 | Color parameters analysis**

142 The surface color of Hongsu chicken dish was measured by using a colorimeter
143 (Chroma Meter CR-400, Konica Minolta Inc., Tokyo, Japan). The colorimeter was
144 calibrated with a white standard board before testing. L^* represents lightness (100 is
145 total white, 0 is total black), a^* represents redness (positive value represents red,
146 negative value represents green), and b^* represents yellowness (positive value
147 represents yellow, negative value represents blue). Three randomly selected points of
148 the meat surface were measured individually, and the average results were calculated.
149 The total color difference (ΔE) was calculated as:

$$150 \Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

152 **2.3.4 | Texture profile analysis (TPA)**

153 Texture properties of Hongsu Chicken dishes were measured as described by
154 Bourne (1978) using Texture Profile Analysis (TPA) model of a texture analyzer

155 (TA-XT2i, Stable Micro Systems Ltd., Surrey, England) . The samples were balanced
156 at room temperature for 3 h, and then cut into cubes (1×1×1 cm) along the muscle
157 fiber direction. The conditions of TPA were as follows: P/36R flat cylindrical probe,
158 pre-test speed 2.0 mm/s, test speed 1.0 mm/s, post-test speed 2.0 mm/s, trigger force 5
159 g, and two consecutive cycles at 30% compressions separated by a 5 s interval. The
160 TPA parameters including hardness, springiness, cohesiveness, gumminess, and
161 chewiness were computed. Six measurements were done for each sample and
162 averages were reported.

163

164 **2.3.5 | Sensory analysis**

165 The Hongsu chicken dishes were evaluated by 10 trained and experienced
166 sensory evaluation panelists (five males and five females) with the age of 23–27 (Liu,
167 Zhang, Xu, Fang, & Zheng, 2015). The appearance, odor, taste and texture of the
168 chicken meat were evaluated using nine-point hedonic rating scales from 1 (dislike
169 extremely) to 9 (like extremely), where 7-9 = good, 4-6 = moderate and 1-3 = poor.
170 The criteria for sensory evaluation of Hongsu chicken are present in Table 1.

171

172 **2.3.6 | Flavor parameters analysis**

173 The flavor parameters of the heated and unheated Hongsu chicken samples were
174 measured by using an electronic nose (Isenso Intelligent Technology Co. Ltd.,
175 Shanghai, China), each sample was fully chopped and mixed in advance. The
176 electronic nose system consists of a gas sampling system, a chemical sensor array, a
177 signal preprocessing circuit, a pattern-recognition software and odor expression. The
178 sensor array had 14 different metal oxide gas sensors which respond to different
179 flavor compounds (Table 2). About 5 g of samples was taken into a glass tube fitted

180 with plastic cap and equilibrated at 25 ± 2 °C for 60 min. The detection time of each
181 sample was 120 s, and the sensors were cleaned for 120 s before another measurement.

182

183 **2.3.7 | Taste parameters analysis**

184 An electronic tongue (TS-SA402B, Intelligent Sensor Technology Inc.,
185 Kanagawa, Japan) consisting of an automatic sampler, a selective sensor array of 8
186 sensors (sourness, bitterness astringency, umami, richness saltiness, richness,
187 aftertaste-A, aftertaste-B), a signal acquisition instrument and a pattern recognition
188 software was used to analyze the sample taste. The Hongsu chicken dish was mixed
189 with distilled water (1: 4) g/mL and ground for 1 min by using a meat grinder. The
190 mixture was moved into 50 ml centrifuge tubes and centrifuged (Sigma 3-18 K, Sigma,
191 German) at 4,000rpm for 5 min. The supernatant was filtered through three layers of
192 gauze and the clear liquid was poured into the special beaker of the electronic tongue,
193 and then analyzed at room temperature. The taste signals were collected for 120 s for
194 each sample, and the sensors were cleaned using distilled water before another
195 measurement.

196

197 **2.3.8 | Data analysis**

198 Except of specifically stated, all experiments and measurements were repeated
199 three times. The experimental data were averaged and expressed as mean \pm standard
200 deviation. One-way analysis of variance (ANOVA) was performed using SPSS 20.0
201 software (IBM, Chicago, IL, USA), and mean values were identified as significantly
202 different when $P < 0.05$.

203

204 **3 | RESULTS AND DISCUSSION**

205 **3.1 | Moisture contents and reheating time**

206 To reach the center temperature of Hongsu chicken dish of 72 °C, only 3.21 min
207 was needed for microwave heating, while this for water boiling, steaming and

208 roasting was 21.12 min 12.71 min and 12.27 min respectively (Table 3), indicating
209 the reheating time by conventional methods was much longer than that of microwave
210 heating.

211 Water plays an important role in food, and is closely related to meat tenderness
212 and juiciness (Van Oeckel, Warnants, & Boucque, 1999). After reheating, the
213 moisture contents in all samples were decreased significantly, especially in the oven
214 roasting ones (Table 3), which could be attributed to its higher temperature and longer
215 treatment time. The moisture content in the microwave heated sample was higher than
216 the oven roasted sample, which was mainly because of the shorter time of microwave
217 heating. However, the water boiling and steaming treated chicken dishes had
218 relatively higher moisture contents than the oven roasting and microwave heating
219 samples. This is understandable since these two methods were using water as heating
220 media.

221 Weight loss is a negative attribute of prepared meat products from an aesthetic
222 and economic perspective (Selby et al., 2006). The oven roasting sample had the
223 highest ($P<0.05$) weight loss (13.73 %), followed by water boiling sample (10.46 %)
224 (Table 3), while there were no significant differences between the steaming and
225 microwave heating samples. Weight loss was caused by the loss of water and muscle
226 fragments, the volatilization of fat and partial free fatty acids during the heating
227 process (Liu et al., 2015). Barge et al. proposed that the loss of water was the main
228 cause of weight loss (Barge, Destefanis, Toscano, & Brugiapaglia, 1991).

229

230 **3.2 | Color attributes**

231 A survey of consumer behavior reported that consumers generally believe that
232 food color significantly correlate with its quality (Eagerman 1978). In the present
233 study, both microwave heating and oven roasting significantly ($P<0.05$) decreased L^*
234 value but increases a^* and b^* values (Table 4), showing that the oven and microwave
235 heating resulted in a bright and golden color, therefore the samples might be more
236 attractive in terms of the appearance. When comparing total color difference (ΔE), no
237 significant differences were detected between the reheating methods of water boiling
238 and steaming. However, ΔE was significantly higher ($P<0.05$) for oven roasted
239 sample than that of water boiling, steaming and microwave heating ones (Table 4).
240 This was because the surface of the roasted sample was accumulated with a lot of oils,
241 which contributed to the bright and golden color. The ΔE had no significant

242 difference in samples reheated with water boiling, steaming and microwave methods
243 (Table 4), suggesting the sample color differences might be minimal.

244

245 **3.3 | Texture profile**

246 Texture is another important attribute to assess the quality and acceptability of a
247 food product (Sikora, Juszczak, Sady, & Krawontka, 2003). The shear force is
248 negatively correlated with the meat tenderness (Boleman et al., 1997; Koohmaraie,
249 Kent, Shackelford, Veiseth, & Wheeler, 2002). Table 5 demonstrates that the
250 hardness, chewiness and shear force of water boiling, steaming and microwave
251 heating samples were decreased, suggesting these techniques improved the texture
252 property and possibly eating quality. In addition, microwave heated samples had the
253 highest springiness value than other samples. During the heating process, rupture of
254 muscle fibers may cause damage to the integrity of space structures, and the collagen
255 in the meat connective tissue was hydrolyzed into gelatin. These reactions will soften
256 the meat samples and increase the tenderness (Yang & Dong, 2009; Zu et al., 2016).
257 However, there was no significant difference in hardness, tenderness and shear force
258 between the oven roasting sample and the control sample, probably because the
259 temperature in the oven was high and the water loss was severe from the product,
260 resulting tougher texture.

261

262 **3.4 | Sensory evaluation**

263 Sensory evaluation is an important method for evaluating the comprehensive
264 quality of food (Kang et al., 2014). As can be seen from Table 6, the oven roasting
265 sample had significantly ($p < 0.05$) lower taste score than the other samples, while the
266 other reheating methods did not significantly affect the taste of Hongsu chicken
267 dishes. The roasting sample had a unique aroma of Hongsu chicken dish. The samples
268 reheated with water boiling and steaming methods had a little unpleasant aroma. The
269 aroma of microwave heated sample was better than that of water boiling and steaming
270 samples, but was not as good as the oven heated one. Liu et al. (2017) also observed
271 that the lamb aroma reheated with oven was better than that of microwave heating. In
272 terms of color, the roasted sample had the highest color score with an attractive
273 golden color, which may increase the consumers' appetite (Table 6). The color score
274 of the microwave heated sample was lower, but it was higher than those of water
275 boiling, steaming and control samples. The microwave heated samples had no

276 significant difference with the control in the appearance score, while the other three
277 samples had lower appearance values, especially the steaming sample (Table 6). The
278 overall score of control (untreated samples), microwave, and oven roasting samples
279 were not significantly different, but the microwave heated sample was significantly
280 higher than the water boiling and steaming samples, indicating the microwave heated
281 dish might be more acceptable by the panelists and potentially consumers.

282

283 **3.5 | Electronic nose analysis**

284 The principal component analysis (PCA) is mainly used for data conversion and
285 dimension reduction of the eigenvector matrix of the sensor response values (Li, Deng,
286 Wang, Cui, & He, 2017). The linear classification of the eigenvector after reducing
287 the dimension is carried out, and the classification results are presented in the form of
288 scatter diagram. When the cumulative variance contribution rate is above 85%, it can
289 be considered that the selected principal components reflect the information of the
290 original index (Moreno-Rojas, Sanchez-Segarra, Camara-Martos, & Amaro-Lopez,
291 2010).

292 The PCA results of electronic nose analysis of Hongsu chicken dishes are
293 presented in Fig. 1. The ellipse represents the overall characteristic of a single sample,
294 and the distance of the graphic represents the odor difference between the samples.
295 The principal components PC1 and PC2 accounted for 70.88% and 18.98% of the
296 total variance respectively, and the cumulative contribution rate of PC1 and PC2
297 accounted for 89.86%, indicating they could reflect most of the information of the
298 original data. This also suggested that the samples with different reheating methods
299 can be distinguished well from the control group in terms of their flavor. The data of
300 water boiling sample and steaming sample were mixed up, which reflected that their
301 flavors were similar. The flavor characteristics of oven and microwave treated
302 samples were far away from those of the control, water boiling group and steaming
303 group, and the distance between each other was also far, which indicated that the
304 electronic nose could clearly distinguish the difference between oven, microwave
305 heated sample and other samples.

306

307 **3.6 | Electronic tongue analysis**

308 The taste data obtained by electronic tongue analysis were also analyzed by
309 principal component analysis (PCA), and the results are shown in Fig. 2. The smaller

310 the distance between samples, the closer their quality characteristics (Cong, Yi, &
311 Zheng, 2015). The contribution rates of PC1, PC2 and PC3 were 55.02%, 21.06% and
312 17.43% respectively, and the cumulative contribution rate was up to 93.51%, so the
313 three principal components can reflect the major information of the whole samples.
314 Fig. 2 also indicates that the distance between the microwave heating sample and the
315 unheated sample was relatively close, indicating the taste difference between them
316 was relatively small, which suggested that the microwave heating could maintain
317 most of the original taste of the Hongsu chicken dish.

318

319 4 | CONCLUSION

320 To investigate the effects of different reheating methods on the quality of
321 Hongsu chicken dishes, water boiling, steaming, microwave heating and oven
322 roasting techniques were applied. Compared with other methods, microwave heating
323 was quicker, resulted in meat sample with better color and taste, and lower weight
324 loss. Therefore, this technique could be used in reheating of Hongsu chicken dishes
325 and potentially for other prepared meats.

326

327

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425

426 **Figure captions**

427 Fig. 1 Principal component analysis plot of electronic nose sensor response signals for
 428 Hongsu chicken dishes using different reheating methods (λ: control; ▷: water boiling;
 429 ◇: steaming; Δ: microwave heating; +: oven roasting)

430 Fig. 2 Principal component analysis plot of electronic tongue sensor response signals
 431 for Hongsu chicken dishes using different reheating methods (×: control; Δ: water
 432 boiling; □: steaming; ○: microwave heating; ▣: oven roasting).

433 Table 1 Criteria for sensory evaluation of Hongsu chicken dishes

Characteristics	Standard	Scores
Appearance	Complete shape, better to keep the original form of the meat	7-9
	A slight change in shape	4-6
	The shape dispersed, and damaged seriously.	1-3
Taste	Good viscoelasticity and juiciness, proper hardness, not greasy	7-9
	Low or high hardness, a little dryness and greasy	4-6

	Bad viscoelasticity and juiciness, very low or high hardness, greasy	1-3
	A strong smell of Hongsu chicken with no peculiar smell	7-9
Flavor	Lack of a strong aroma or slight peculiar smell	4-6
	no meat aroma, peculiar smell	1-3
	Attractive color and lustre	7-9
Color	Normal color and lustre	4-6
	Poor color and lustre	1-3

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Table 2 Sensors used and their main applications in the electronic nose

Sensor No.	General description	Reference
S1	Ammonia, used as sensor for aromatic compounds	Benzene
S2	Reacts on sulphur compounds, H_2S 1×10^{-4} g/L. Otherwise sensitive to many terpenes and sulphur organic compounds, which are important for smell, limonene, pyrazine	H_2S
S3	Mainly hydrogen, selectively, (breath gases)	H_2
S4	Organic acid esters and terpenes, aromatic compounds, less polar compounds	Propane
S5	Detects alcohol's, partially aromatic compounds, broad range	CO
S6	Sensitive to methane (environment) ca. 1×10^{-2} g/L. Broad range	CH_4
S7	Aromatics compounds, sulphur organic compounds	H_2S
S8	Very sensitive, broad range sensitivity, react on nitrogen oxides	NO_2
S9	Aliphatic hydrocarbons, aromatic compounds	Propane
S10	Hydrocarbons	CH_4
S11	Aromatic compounds	Toluene
S12	Alcohol, organic solvents	C_2H_5OH
S13	Alkenes, aromatic compounds, less polar compounds	Propane
S14	Reacts on high concentrations >0.1 g/L, sometime very selective (methane)	CH_4

436 Table 3 Heating time (to reach center temperature of 72 °C), weight loss and moisture content of
 437 Hongsu chicken dishes using different reheating methods

Reheating Methods	Time (min)	Weight loss (%)	Moisture content (%)
Control	N	N	68.83±0.18 ^a
Water boiling	21.12±1.07 ^a	10.46±0.28 ^b	66.63±0.35 ^b
Steaming	12.72±1.02 ^b	9.24±0.44 ^c	67.09±0.47 ^b
Microwave heating	3.21±0.32 ^c	9.47±0.22 ^c	64.21±0.43 ^c
Oven roasting	12.27±0.90 ^b	13.73±0.39 ^a	58.48±0.21 ^d

438 Data are mean ± standard deviation.

439 Values with different superscripts in the same column represent significant differences ($P < 0.05$).

440

441

Table 4 Color parameters of Hongsu chicken dishes using different reheating methods

Reheating methods	L*	a*	b*	ΔE
Control	68.14±0.15 ^a	2.37±0.35 ^c	16.02±0.45 ^c	
Water boiling	65.01±0.68 ^b	3.36±0.52 ^{bc}	17.14±0.39 ^c	3.96±0.51 ^b
Steaming	68.60±0.93 ^a	2.41±0.46 ^c	17.18±1.01 ^c	3.85±0.76 ^b
Microwave heating	64.56±0.35 ^b	3.47±0.11 ^b	20.65±0.64 ^b	3.99±0.70 ^b
Oven roasting	60.24±0.22 ^c	3.89±0.87 ^a	26.99±0.64 ^a	14.52±0.45 ^a

442

Data are mean ± standard deviation.

443

Values with different superscripts in the same column represent significant differences ($P<0.05$).

444

Table 5 The texture profile of Hongsu chicken dishes using different reheating methods

Reheating methods	Hardness	Springiness	Cohesiveness	Chewiness	Shear force (N)
Control	835.05±77.09 ^a	0.73±0.032 ^c	0.56±0.015 ^d	349.36±26.93 ^a	16.43±1.1 ^a
Water boiling	420.82±50.82 ^c	0.82±0.016 ^b	0.68±0.034 ^a	232.84±17.18 ^c	12.34±0.71 ^{bc}
Steaming	455.61±45.67 ^c	0.83±0.015 ^b	0.68±0.014 ^a	256.71±26.79 ^c	11.43±1.52 ^c
Microwave	599.22±36.31 ^b	0.87±0.011 ^a	0.63±0.019 ^b	307.96±24.85 ^b	14.02±0.93 ^b
Oven roasting	796.96±29.60 ^a	0.75±0.018 ^c	0.59±0.021 ^c	352.28±16.67 ^a	15.93±0.45 ^a

445

Data are mean ± standard deviation.

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Values with different superscripts in the same column represent significant differences ($P<0.05$).

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Table 6 Sensory evaluation of Hongsu chicken dishes using different reheating methods

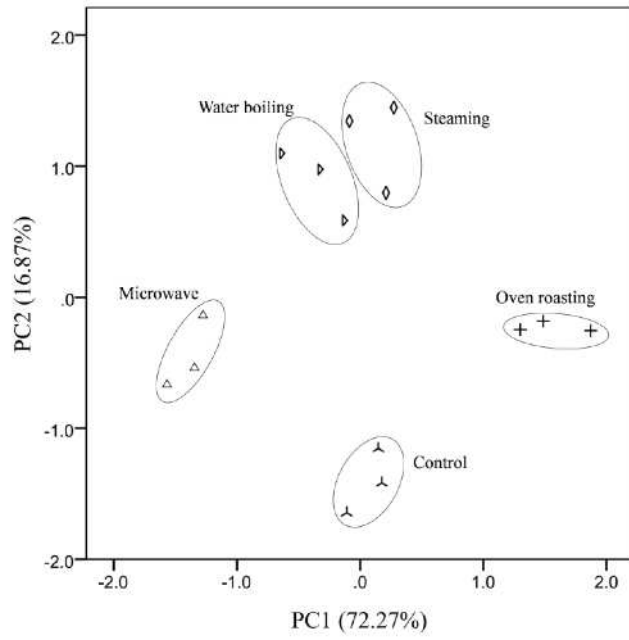
Reheating methods	Taste	Flavor	Color	Appearance	Overall
Control	6.01±0.87 ^{ab}	5.89±1.01 ^{bc}	6.09±0.37 ^c	8.8±0.82 ^a	6.57±0.66 ^{ab}
Water boiling	6.84±0.93 ^a	5.04±0.67 ^c	5.99±0.58 ^c	7.29±0.67 ^b	6.23±0.73 ^b
Steaming	6.78±0.85 ^a	5.82±0.58 ^{bc}	5.67±0.79 ^c	4.33±0.76 ^d	5.78±0.74 ^b
Microwave	7.49±0.65 ^a	7.15±0.61 ^b	7.11±0.37 ^b	8.49±0.41 ^{ab}	7.51±0.32 ^a
Oven roasting	5.01±0.44 ^b	8.46±0.63 ^a	8.14±0.51 ^a	5.84±0.58 ^c	6.84±0.51 ^{ab}

448

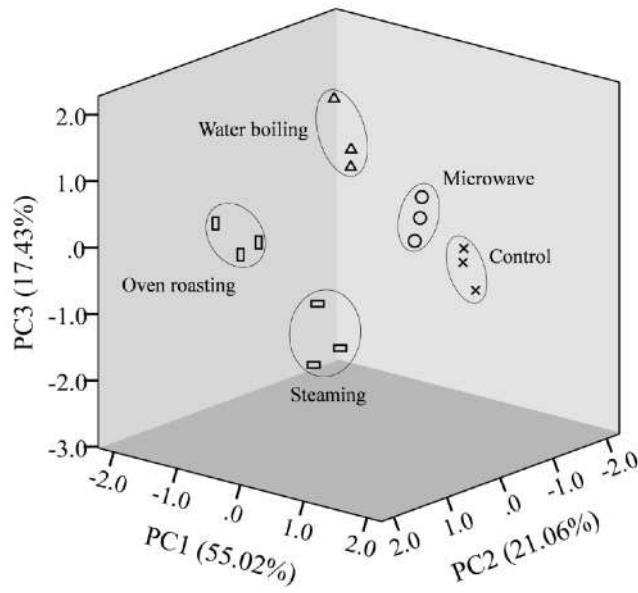
Data are mean ± standard deviation.

449

Values with different superscripts in the same column represent significant differences ($P<0.05$).



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