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EFFECTS OF PROLONGED HEATING ON QUALITIES OF LOW FAT EMULSIFIED MEATBALLS

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Background:

Emulsified meatball, called 'Kung-wan' in Taiwanese, is a popular meat product in Taiwan and related Chinese communities. As part of a series of studies in developing low fat Kung-wans, edible gum-hydrates were used to replace fat. Since Kung-wans are usually consumed in hot soup. Its qualities after prolonged heating are important and deserved further studied.

Objectives:

The aim of this study is to compare the effects of 13 different gum-hydrate fat substitutes on diameter, texture, color and sensory qualities of the low-fat Kung-wans after subjected to prolonged heating.

Methods

Leg muscle tissues and back fat of market-size hogs were purchased from a local meat packer. The tissues were ground with a meat chopper fitted with a plate of 15-mm diameter holes. The ground meat was packaged in double plastic (Nylon/PE laminated film) bags, 0.5 kg each, and stored at -20 ℃ until used within two months. The emulsified meatballs were manufactured according to a previous paper (Hsu and Chung, 1999) and were boiled at 98.5 ℃ for 75 minutes. A one-way randomized complete block design was adopted for this study (Anderson and McLean, 1974). As shown in Table 1, the experimental design consisted of three controls and 13 edible gum-hydrate formulae. The 13 edible gum-hydrate formulae included: κ-carrageenan (Newgelin TWD-100, Chuo Kasei Co., Ltd.) (Kcarr), κ-carrageenan with KCl (KcKCl), κ-carrageenan with dietary salt (KcSal), sodium alginate (Satialgine®S550X, SBI Bio-industries) (Algin), sodium alginate with $CaCO_3$ (AlgCa), agar (Huei-Gong agar, Yi-Liang Chem. Ingredient Co., Ltd., Taipei, Taiwan, R.O.C.) (Agar), konjac (KM grade) (Konja), konjac premixed with $Ca(OH)_2$ (KonOH), curdlan gum (CurdG), gellan gum (Xelcogel®) (GellG), locust bean gum (Viscogum™ BE, SBI Bio-industries) (LBG), guar gum (Lotus gum-India) (GuarG) and xanthan gum (Satiaxane™ CX 90, SBI Bio-industries) (XantG). The Tasty Enterprises Ltd. (Taipei, Taiwan, R.O.C.) provided all gums except for the agar. The compositions of the other ingredients were fixed as specified in Table 1. All percentages specified in these formulations used the hog leg muscle tissues as a basis. Three replications of each treatment combination were randomly assigned to different meat samples. Total number of specimens was 48. After boiling, the product samples were kept in 80 ℃ water bath during the following quality analyses. Texture profile analyses indices and Hunter-Lab values were measured according to a previous paper (Hsu and Chung, 1999). An experienced Kung-wan maker also judged the colors, odor, taste, texture and overall acceptance of each sample based on a five-point hedonic scale. A higher score signifies better preference. Product diameter was measured with a caliper. The mean of three measurements was taken for each datum.

Results & Discussions

As shown in Table 2 through 4, most textural quality indices and sensory test results indicated that replacing fat with water decreased product qualities. But most of the differences became insignificant ($p < 0.05$), which were different from what were observed in the unheated products (Hsu and Chung, 1999). Hardness and Hunter-a value of the products decreased due to swelling and becoming more transparent when subjected to prolonged heating (Table 2 and 3) (Hsu and Chung, 1999). Nine gum-hydrates, which included all but Konja and XantG, produced low fat Kung-wans with similar or higher texture profile analyses indices to the fat control (ConFa) (Table 2). Addition of $Ca(OH)_2$ greatly increased hardness and brittleness of Konjac (Table 2). Significantly lower Hunter-a values were observed in Kcarr, KcKCl and GellG while significantly higher Hunter-b values could be detected in the alginate group (Algin and AlgCa), LBG and GuarG (Table 3). Sensory test results showed that all low fat gum products were inferior to the fat control (ConFa) in their odor and taste (Table 4). Sensory odor and taste scores increased while sensory color,

texture and acceptance scores decreased when the products were heated (Table 4) (Hsu and Chung, 1999). That indicated that fat played an important role in Kung-wans flavor especially when the products were served hot. That also caused inferior low fat products to the fat control in their overall acceptance except for agar. Agar had better texture than ConFa (Table 4), which were opposite before heated (Hsu and Chung, 1999). KcKCl and KcSal were inferior to Kcarr in their taste due to the bitter taste of KCl. Konja was also inferior in its taste and that partially caused its lower acceptance by the sensory panel.

Conclusions:

Kcarr, Algin, AlgCa, Agar and KonOH appeared to be good fat substitutes for making low fat emulsified meatballs when the product were served in hot soup. Within these, Agar had lower cost and better heating qualities and so was a better fat substitute.

Pertinent literature:

Anderson, V.L. & McLean, R.A. (1974). "Design of experiments-A realistic approach", Chap. 4, Marcel Dekker, Inc., New York.

Hsu, S.Y. & Chung, H. -Y. (1999). Comparisons of 13 edible gum-hydrate fat substitutes for low fat Kung-wan. Journal of Food Engineering (Accepted).

TABLE 1. Formulae of Three Controls And 13 Different Edible Gum-Hydrates

Notation	*Ingredients*
ConFa	Positive control; added 20 % pork back fat.
ConWa	Negative control; added 20 % water.
ConPS	Starch control; added 5 % potato starch and 20 % water.
Kcarr	1 % κ-carrageenan; hydrated with 20 % water.
KcKCl	Kcarr (above) and substituted 1.276% KCl for 1% of NaCl
KcSal	Kcarr (above) and replaced 3 % NaCl with 3 % dietary salt, which contains 19% Na, 25% K and 52% Cl.
Algin	1 % sodium alginate; hydrated with 20 % water.
AlgCa	1 % sodium alginate; premixed with 0.072% $CaCO_3$ and hydrated with 20 % water.
Agar	1 % Agar; hydrated with 20 % water.
Konja	1 % Konjac; hydrated with 20 % water.
KonOH	1 % Konjac; premixed with 0.03% of $Ca(OH)_2$ and hydrated with 20 % water.
CurdG	1 % Curdlan gum; hydrated with 20 % water at 55℃.
GellG	1 % Gellan gum; hydrated with 20 % water.
LBG	1 % Locust bean gum; hydrated with 20 % water at 80℃.
GuarG	1 % Guar gum; hydrated with 20 % water.
XantG	1 % Xanthan gum; hydrated with 20 % water.

The other ingredients were lean pork (100%), 5% sugar, 0.3% polyphosphate, and 3% NaCl unless specified above.
All hydration were made at room temperature unless specified.

TABLE 2. Comparisons on Texture Profile Analyses Indices of Low Fat Kung-Wans Made of Different Food Gums and Boiled for 75 Minutes

Treatment	*Hard*	*Adhe*	*Brit*	*Visc*	*Cohe*	*Elas*	*Chew*	*Gumm*
ConFa	438 bc	0.0 b	596 abc	0 b	0.04 a	0.18 a	1 a	3 a
ConWa	408 bcd	0.0 b	503 abcd	0 b	0.17 a	0.34 a	12 a	16 a
ConPS	361 cd	0.0 b	364 cd	0 b	0.05 a	0.11 a	1 a	3 a
Kcarr	409 bcd	0.0 b	641 abc	0 b	0.09 a	0.36 a	5 a	7 a
KcKCl	388 bcd	0.0 b	772 ab	0 b	0.02 a	0.19 a	0 a	1 a
KcSal	429 bcd	0.0 b	750 ab	0 b	0.03 a	0.26 a	1 a	2 a
Algin	407 bcd	7.2 a	485 bcd	6 a	0.00 a	0.08 a	0 a	0 a
AlgCa	376 bcd	0.0 b	532 abcd	0 b	0.06 a	0.15 a	1 a	4 a
Agar	422 bcd	0.0 b	833 a	0 b	0.01 a	0.27 a	0 a	1 a
CurdG	444 b	0.0 b	455 bcd	0 b	0.04 a	0.12 a	0 a	3 a
GellG	392 bcd	0.0 b	557 abcd	0 b	0.06 a	0.24 a	1 a	4 a
Konja	358 d	0.0 b	373 cd	0 b	0.03 a	0.05 a	0 a	2 a
KonOH	548 a	0.0 b	819 a	0 b	0.11 a	0.31 a	10 a	10 a
LBG	371 bcd	0.0 b	398 cd	0 b	0.03 a	0.06 a	0 a	2 a
GuarG	375 bcd	0.0 b	458 bcd	0 b	0.03 a	0.21 a	0 a	2 a
XantG	254 e	0.0 b	249 d	0 b	0.13 a	0.24 a	1 a	6 a

Values in a column not followed by a same letter are significantly different ($p < 0.05$, n=3).

TABLE 3. Comparisons on Hunter-Lab Indices of Low-Fat Kung-Wans Made of Different Food Gums and Boiled for 75 Minutes

Treatment	*L*	*A*	*B*
ConFa	66.6 ab	0.1 a	8.9 cd
ConWa	68.6 ab	-1.1 b	10.3 ab
ConPS	68.0 ab	-0.5 ab	9.3 bcd
Kcarr	69.2 ab	-1.2 b	8.9 cd
KcKCl	67.6 ab	-1.1 b	9.3 bcd
KcSal	68.9 ab	-0.5 ab	9.0 cd
Algin	67.5 ab	0.2 a	10.7 a
AlgCa	66.2 b	-0.3 ab	10.4 ab
Agar	68.7 ab	-1.0 ab	9.5 bcd
CurdG	67.0 ab	-0.7 ab	9.1 cd
GellG	66.4 ab	-1.1 b	9.7 abcd
Konja	68.3 ab	-0.8 ab	10.0 abc
KonOH	68.0 ab	-0.8 ab	10.0 abc
LBG	69.9 a	-0.7 ab	10.7 a
GuarG	69.2 ab	-0.9 ab	10.3 ab
XantG	66.9 ab	-0.7 ab	8.6 d

Values in a column not followed by a same letter are significantly different ($p < 0.05$, n=3).

TABLE 4. Comparisons on Diameter and Sensory Quality Indices of Low-Fat Kung-Wans Made of Different Food Gums and Boiled for 75 Minutes

Treatment	*Diameter (cm)*	*Color*	*Odor*	*Taste*	*Texture*	*Acceptance*
ConFa	3.3 a	3.0 ab	5.0 a	5.0 a	3.0 abc	3.7 ab
ConWa	3.0 a	3.0 ab	3.7 bc	4.0 abc	2.7 bc	3.3 ab
ConPS	3.3 a	4.0 a	3.7 bc	3.7 abcd	3.7 ab	3.7 ab
Kcarr	3.2 a	3.7 ab	4.3 ab	3.7 abcd	3.0 abc	3.0 ab
KcKCl	3.1 a	3.3 ab	4.0 ab	2.7 cde	3.3 abc	3.0 ab
KcSal	3.2 a	3.3 ab	3.3 bcd	2.7 cde	2.7 bc	2.7 bc
Algin	3.1 a	3.3 ab	4.0 ab	4.0 abc	3.3 abc	3.3 ab
AlgCa	3.2 a	3.0 ab	4.3 ab	4.3 ab	3.3 abc	3.3 ab
Agar	3.1 a	3.3 ab	3.7 bc	3.7 abcd	4.0 a	4.0 a
CurdG	3.0 a	3.3 ab	4.0 ab	3.7 abcd	2.3 c	3.0 ab
GellG	3.1 a	2.7 ab	4.0 ab	3.7 abcd	3.0 abc	3.0 ab
Konja	3.1 a	3.0 ab	4.0 ab	3.3 bcd	2.7 bc	2.7 bc
KonOH	3.1 a	3.0 ab	4.3 ab	4.0 abc	3.0 abc	3.3 ab
LBG	3.2 a	2.7 ab	4.0 ab	3.7 abcd	2.7 bc	2.7 bc
GuarG	3.1 a	2.3 b	2.3 d	2.0 e	2.7 bc	1.7 cd
XantG	3.1 a	1.0 c	2.7 cd	2.3 de	1.0 d	1.0 d

Values in a column not followed by a same letter are significantly different ($p < 0.05$, n=3).