# Effect of Phosphate Salts on the Pasting Properties of Korean Instant-Fried Noodle

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**ABSTRACT**

Up to 15% modified potato starch (MPS) is often added into Korean instant noodle formulas to improve the cooking and eating quality. However, the addition of MPS leads to higher raw material costs. The effect of phosphate salts (PS) on Korean instant-fried noodle pasting properties was investigated in this research. When 33% of total MPS in the regular Korean instant noodle formula was substituted by a small amount of PS (≤0.3%), the results clearly indicated that all the PS improved the pasting properties of noodle dough and ground instant-fried noodle powder, especially the peak viscosity of the Rapid ViscoAnalyser (RVA) curves. However, the pasting temperature was affected little by PS except that tripotassium phosphate increased it significantly. The RVA results showed that the pasting properties of ground instant noodle powder were significantly improved when 33% of MPS was substituted by 0.300% dipotassium phosphate. Meanwhile, the pasting properties were close to those of the regular formula ground instant noodle powder when 33% of MPS was substituted by 0.030% monosodium phosphate or 0.300% disodium phosphate. Therefore, we suggest that MPS used in Korea instant-fried noodle could be partially substituted by the blends of selected PS.

Asian noodles are the major wheat-based products in the Asian diet, accounting for ≈40% of total flour usage in Asia. There are many types of Asian noodles including fresh noodle, dried noodle, steamed noodle, boiled noodle, frozen boiled noodle, and instant noodle (Hou 2001; Fu 2008; Hou et al 2010).

Asian noodles are prepared mainly from three basic ingredients: flour, water, and salts. They exist in two distinct categories based on the presence or absence of alkaline salts (mainly $Na_2CO_3$ or $K_2CO_3$) (Hou 2001). Instant-fried (steamed and deep-fried) noodles have a distinctive flavor and texture due to unique processing steps such as steaming and frying, and to residual oil in noodles. They should have a porous spongy structure as well as pregelatinized starch through the steaming process (Park and Baik 2004). Instant-fried noodles are partially cooked by steaming and further cooked and dehydrated by a deep-frying process (Cheung et al 2008). During the frying process, many tiny holes are created as water is quickly dehydrated and replaced by oil on the surface of noodles, serving as a channel for water to migrate during cooking (Hou 2001). Steaming and frying processes enable instant-fried noodles to be quickly rehydrated and served, and both the formulation and processing parameters are important in governing the eating quality of instant-fried noodles.

Starches and their derivatives from different sources have been utilized to improve the cooking and eating quality of instant noodles (Huang and Lai 2010). Up to 15% (total flour-starch blend weight) of modified potato starch (MPS) is often added in Korean instant noodles because MPS could increase flour pasting viscosity and improve the eating quality of noodles. However, the addition of MPS leads to higher raw material costs. Previous research has shown some minor ingredients (salt, alkaline reagents, starch, oils, improvers, and preservatives) might be responsible for large differences in pasting viscosity (Shih and Daigle 1999; Mouquet and Treche 2001; Fitzgerald et al 2003; Ral et al 2008), while information on the effect of phosphate salts (PS) on instant noodle flour pasting properties remains largely unreported in the scientific literature.

Many researches have been conducted using the RVA to study Asian noodle properties (Yuan et al 1996, 2008; Ral et al 2008; Sandhu et al 2010). In our previous study (Zhou et al 2009), we discovered that many PS have the ability to increase the pasting peak viscosity and trough of instant noodle formula dry mix (without MPS) at lower addition levels (0.05–0.1%, flour weight). At higher levels (0.2–0.3%), however, some PS continued to raise these viscosities, while others began to reduce them. The results suggested that each phosphate salt had an optimal level that gave the most swelling of starch granules in instant noodle dough. These results suggested that different properties of PS ought to be considered when they are selected in noodle product application. Peak viscosity of noodle flour has correlated positively with the cooked alkaline noodle smoothness and negatively with alkaline noodle hardness by sensory evaluation (Miskelly and Moss 1985; Batey et al 1997).

Before conducting this research, we determined the RVA profiles of 25 commercial instant-fried noodles from 10 countries. These noodle samples were ground into powder using a falling number grinder and passed through a 0.83-mm sieve. The results showed that four noodle brands (three from Korea and one from China) that contained MPS had peak viscosities of 217.6–227.5 RVU, much higher than those of other noodle brands (12.7–128.8 RVU). These four noodle brands also had much higher trough (149.7–175.8 RVU), final viscosity (351.9–385.0 RVU), and setback values (188.8–225.3 RVU) than other noodles, which were 13.1–119.5, 34.1–308.4, and 18.2–182.4 RVU, respectively. Preliminary descriptive sensory evaluation of the cooked instant-fried noodles confirmed that these four noodle brands had much springier, smoother, more elastic, and chewier texture than others. These results suggested that RVA profiles of instant-fried noodles could be a useful noodle texture indicator. The objective of this research was to investigate the effect of PS on the pasting properties of Korean instant-fried noodle formula dry mix containing MPS and ground instant-fried noodle powder.

## MATERIALS AND METHODS

### Materials

Hard white wheat flour was milled at the Wheat Marketing Center (Portland, OR) on a pilot-scale mill (Miag-Multomat, Buhler-Miag, Switzerland). The moisture, protein, and ash contents were 12.6, 10.0 (14% mb), and 0.4% (14% mb), respectively. Modified potato starch (MPS) with a moisture content of 14.92% was purchased from National Starch Food Innovation. All other chemicals used were purchased from VWR (West Chester, PA) and were of analytical grade.

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Phosphate salts (PS) were supplied by the ICL Performance Products LP (St. Louis, MO). Based on the preliminary screening results, we selected seven PS for this research: monosodium phosphate (MSP), disodium phosphate (DSP), dipotassium phosphate (DKP), tripotassium phosphate (TKP), sodium acid pyrophosphate (SAPP), calcium acid pyrophosphate (CAPP), and sodium trimetaphosphate (STMP).

### Measurement of Pasting Properties by RVA

The RVA parameters of the Korean instant-fried noodle formula dry mix or ground instant-fried noodle powder were determined according to the procedure reported by Batey et al (1997) with the RVA-4 (Perten Instrucments, Springfield, IL). Briefly, the instant noodle formula dry mix or ground noodle powder and water were stirred at 960 rpm for 10 sec, and then at 160 rpm for the remainder of the test. The temperature profile was held at 60°C for 2 min, heated to 95°C at 5.83°C/min over 6 min, held at 95°C for 4 min, cooled to 50°C at 11.2°C/min over 4 min, and held at 50°C for 4 min.

The regular formula dry mix of Korean instant-fried noodle dough (control, 85:15 flour to MPS ratio) contained flour (2.930 g), MPS (0.517 g), sodium chloride (0.0517 g), potassium carbonate (0.003 g), and sodium carbonate (0.0007 g). The modified formula dry mix of instant-fried noodle dough (90:10 flour to MPS) with additional PS was flour (3.078 g), MPS (0.342 g), sodium chloride (0.0517 g), potassium carbonate (0.003 g), and sodium carbonate (0.0007 g), and 0.1–1.2 mmol of each of seven PS.

### Preparation of Korean Instant-Fried Noodle

Based on the RVA pasting properties of the modified Korean instant-fried noodle formula dry mixes, three PS (DKP, DSP, and MSP) were selected to partially substitute MPS in Korean instant-fried noodle dough for noodle making. DKP and DSP at 0.6 mmol (equivalent to 0.300%) and MSP at 0.01 and 0.06 mmol (equivalent to 0.005 and 0.030%, respectively) gave the maximum peak viscosities. The modified formula dry mixes of instant noodle dough with varying amounts of MPS and PS are listed in Table I. Sodium chloride, alkaline salts (sodium carbonate and potassium carbonate), and PS were predissolved in water. Wheat flour and MPS were weighed, thoroughly mixed in a plastic bag, and placed into a pilot-scale FR-E700 noodle dough mixer (Tokyo Menki, Tokyo, Japan) and the correct amount of salt-alkaline-PS solution (34%) was added. Instant-fried noodles were prepared on a pilot-scale noodle line following the procedure described by Hou (2010). Briefly, the dry mix and water were mixed for 5 min at 110 rpm, followed by mixing for 14 min at 60 rpm. The final thickness of the noodle dough was 1.25 ± 0.03 mm after sheeting for six steps on a pilot-scale noodle making machine (WR8-100, Tokyo Menki). The noodle dough was then slit into 1.2 × 1.7 mm (thickness × width) strands with a #18 square type slitter (1.7-mm width) and waved. After steaming for 5 min at 100°C in a tunnel steamer (model LB-20, Electro-Steam Generator, Alexandria, VA), the noodles were cut and folded in half to form blocks (125 ± 5 g). At last, the noodle blocks were loaded into the frying basket and deep-fried for 1 min at 140°C in a 4.8 gal (18.2 L) gas fryer (model SG14, Pitco Frialator, Concord, NH). Each noodle production was duplicated on two different days.

Each of the final instant noodle products was ground to pass through a 0.83-mm sieve using a falling number grinder (Perten Instruments, Springfield, IL) and tested for pasting properties by the RVA-4 as described previously.

### Sensory Evaluation

The expert panel consisted of five noodle specialists from noodle manufacturers in South Korea. The sensory evaluation was according to the method described by Hou et al (2010). Briefly, the three instant noodle cakes (including the control noodle) were cooked in boiling water simultaneously for 4 min and then the noodles were poured into 1200-mL bowls and 600 mL of hot water (90–95°C) was added. The panelists were instructed to evaluate the noodles within 4 min for appearance, mouthfeel, and bite texture in comparison to the control noodle according to the scoring sheet. The remaining noodles were kept in hot water for another 5 min and evaluated again for texture stability. The total noodle sensory score included the cooked noodle appearance, mouthfeel, bite texture, and texture stability (holding for 5 min in hot water after cooking).

### Statistical Analyses

All tests were run at least in triplicate in a completely randomized design. Results are expressed as mean ± SD. Data were analyzed by one-way analysis of variance (ANOVA) with the Student Newman-Keuls posthoc test. Statistical significance was set at the 5% significance level.

## RESULTS AND DISCUSSION

### Effect of PS on Pasting Properties of Different Noodle Formula Dry Mixes Containing MPS

The pasting viscosities of different instant noodle formula dry mixes with or without the addition of PS were determined by RVA, and the results are shown in Fig. 1 and Table II.

For the "85:15" blend (regular formula dry mix of Korean instant noodle containing 15% MPS of total flour/MPS weight), the peak viscosity (PV), trough, breakdown, final viscosity (FV), and setback were 308.96, 154.54, 154.42, 303.17, and 148.62 RVU, respectively. They were significantly higher than those of the "90:10" blend (modified formula dry mix of Korean instant noodle containing 10% MPS of total flour/MPS weight), which were 268.71, 135.04, 133.67, 276.50, and 141.46 RVU, respectively. The PV and FV values decreased by 40.25 (13.03%) and 7.16 (8.80%) RVU, respectively, as the MPS content was reduced from

**TABLE I**
**Formulas (g) of Korean Instant-Fried Noodle Groups**

| Group Ingredient[a] | 85:15 | 90:10 | DSP | DKP | MSP-1 | MSP-2 |
|---|---|---|---|---|---|---|
| Flour | 850 | 900 | 900 | 900 | 900 | 900 |
| MPS | 150 | 100 | 100 | 100 | 100 | 100 |
| Water[b] | 340 | 340 | 340 | 340 | 340 | 340 |
| Salt | 15 | 15 | 15 | 15 | 15 | 15 |
| Alkaline salts[c] | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 |
| Phosphate salt | 0 | 0 | 3.00 | 3.00 | 0.05 | 0.30 |

[a] MPS, modified potato starch; MSP, monosodium phosphate; DSP, disodium phosphate; DKP, dipotassium phosphate. 85:15, regular formula of Korea instant fried noodle dough containing 15% MPS of total flour/MPS weight; 90:10, modified formula of Korean instant-fried noodle dough containing 10% MPS of total flour/MPS weight; DSP, modified formula "90:10" with additional 0.300% DSP; DKP, modified formula "90:10" with additional 0.300% DKP; MSP-1, modified formula "90:10" with additional 0.005% MSP; MSP-2, modified formula "90:10" with additional 0.030% MSP.
[b] Salt, alkaline salts, and phosphate salt predissolved in water.
[c] Alkaline salts were 80% potassium carbonate and 20% sodium carbonate.

15% to 10%. These findings were consistent with previous reports that MPS could increase the flour PV value (Kim et al 1996; Fu et al 2008).

PV values increased for all PS with addition of 0.01 mmol (Fig. 1A). This result confirmed an earlier finding where phosphorus was able to increase the PV value (Kanazawa et al 2008). As to DSP and DKP, the PV values increased with increasing amounts. With the addition of DSP at 0.9 mmol, the PV reached its highest value of 299.83 RVU. For DKP, the highest PV was 301.46 RVU at addition of 1.2 mmol. Both DSP and DKP showed a dramatic improvement in PV value over the control sample. For the other five PS (MSP, SAPP, STMP, CAPP, and TKP), PV increased as the additions were <0.06 mmol, but they decreased as the additions were >0.06 mmol. One notable example was MSP, whose PV value was ≈300 RVU with addition of 0.06 mmol, then decreased sharply with addition >0.06 mmol. These results were in agreement with our previous research (Zhou et al 2009), which reported some PS increased the PV of instant noodle formula dry mix at lower addition levels and began to reduce the PV values at higher addition levels.

A high PV was a result of swelling of starch granules. However, under shearing at a temperature as high as 95°C, the greatly swollen granules disintegrated due to crowding and mutual pressure, resulting in dramatic decrease in viscosity following the PV (Collado and Corke 1999). The results showed the trough increased with addition of DSP, DKP, or STPP (Fig. 1B), and there was also a positive relationship between the trough and addition of three PS. This may be due to the short-chain starch molecules cross-linking with PS and then increasing the trough (Wang et al 2000). However, the troughs of MSP, SAPP, and TKP decreased sharply as additions were >0.12 mmol; for CAPP, the viscosity decreased as the addition was >0.02 mmol. It is speculated that the PS first cross-linked with starch and resulted in high viscosity when contents were at lower levels. However, at higher levels, PS might unfold the protein chains and combine with them, resulting in slight increased viscosity.

Breakdown is regarded as a measure of the degree of disintegration of granules or paste stability (Dufour et al 2009). At breakdown, the swollen granules disrupt further and amylose molecules will generally leach out into the solution (Zhang et al 2008). During the holding period of the test, the sample was subjected to a period of constant high temperature (typically 95°C) and this period was commonly associated with a breakdown in viscosity. Thus, starch granules were easily broken down by the shear force, which increased the swelling power (Zaidul et al 2007). Comparing to the "90:10" instant noodle formula dry mix without PS, all other noodle formula dry mixes with additional PS had lower breakdown values (Fig. 1C) and higher PV values (Fig. 1A). This

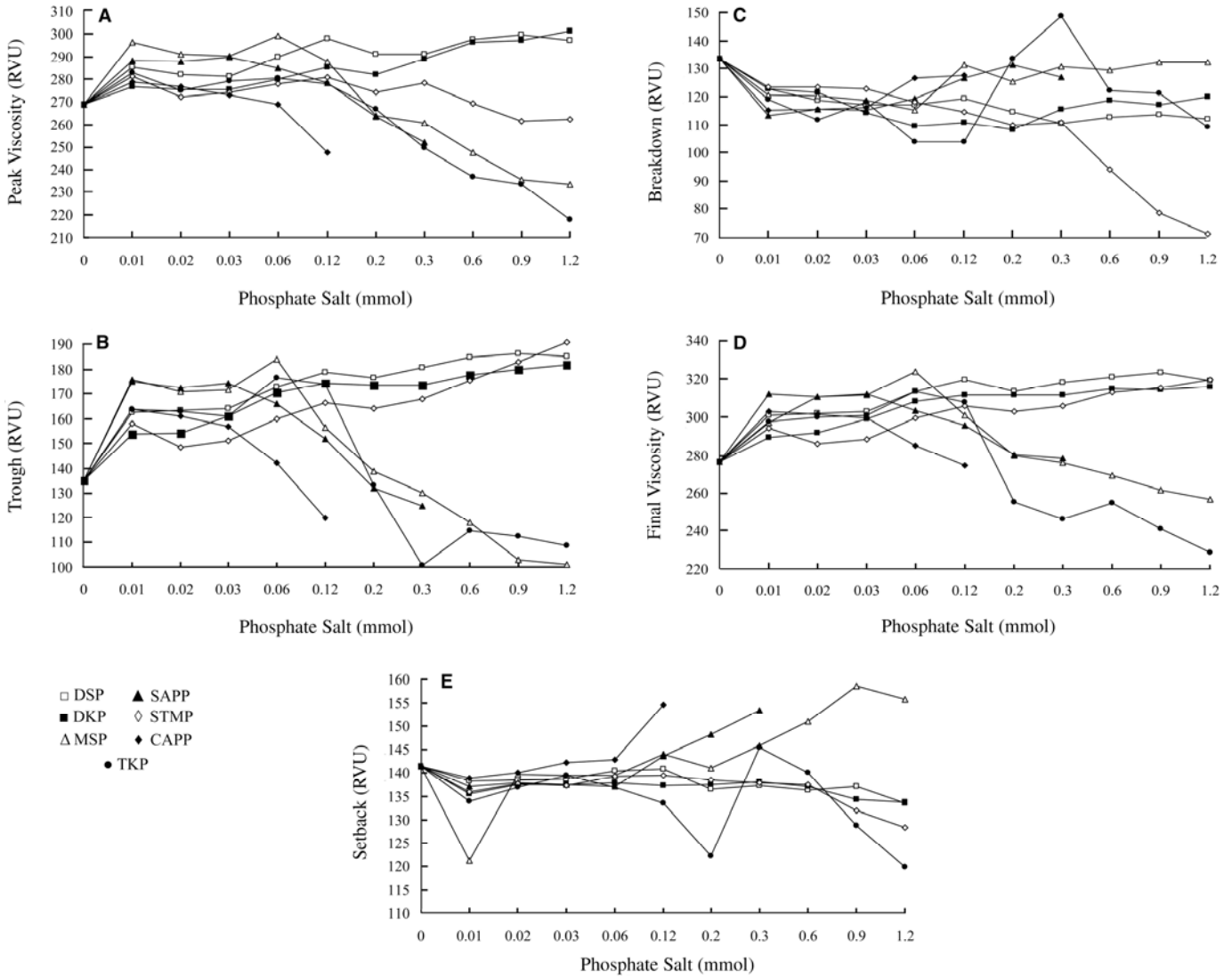


**Fig. 1.** Effect of phosphate salts on pasting properties of Korean instant-fried noodle formula dry mixes. **A,** Peak viscosity (PV); **B,** trough; **C,** breakdown value; **D,** final viscosity (FV); **E,** setback value. Abbreviations as in Table I.

observation disagreed with the previous reports in which higher breakdown was in association with higher PV (Zaidul et al 2007). The difference may be attributed to the fact that PS enhanced the intermolecular force of amylose and thus became more stable to the shear force during the 95°C holding period.

Subsequently, as the slurry cools, reassociation between starch molecules, especially amylose, will result in the formation of a gel structure and therefore FV values will increase. FV values decreased when the amount of MPS was decreased from 15 to 10%, which was contrary to previous reports in which FV of rice flour decreased with added corn starch (Wang et al 2000). The reason was the different kinds of starch used, in agreement with a previous report (Ragaee and Aal 2006). FV also showed the same trend as PV for the seven tested PS (Fig. 1D). For the DSP, DKP, and STPP, the FV increased significantly ($P < 0.05$).

The setback values were slightly changed for the Korean instant noodle formula dry mixes with all added PS except for MSP and SAPP (Fig. 1E). The setback resulted from rearrangement of excreted amylose molecules from the starch granules after swelling. The setback value revealed the gelling ability or retrogradation tendency of the amylose (Xu et al 2008). The higher setbacks were observed in the flour-MPS blends with added MSP, CAPP, or SAPP, at additions >0.06 mmol, suggesting that the higher amylose retrogradation occurred therein.

The pasting temperature of the "85:15" instant noodle formula dry mix was 65.6 ± 0.21°C (Table II). The pasting temperature of the "90:10" modified instant-noodle formula dry mix with or without PS was ≈1°C higher than that of the "85:15" group, which was attributed to 5% lower MPS in the modified noodle formula. All PS, except for TKP, had little effect on the pasting temperature of noodle dough.

### Effect of PS on Pasting Properties of Instant-Fried Noodle

Based on the RVA pasting results of modified instant noodle formula dry mixes containing each of the seven PS, three PS (DKP, DSP, and MSP) were selected and tested at optimal addition levels in Korean instant-fried noodle production to partially replace MPS in the formula. The RVA pasting parameters of the ground instant-fried noodle powder are presented in Table III. All six group noodles showed similar patterns of the pasting curves; however, the pasting curve of MSP-1 was slightly lower than others and that of DKP was higher than others (data not shown). Also, all six instant noodles had similar pasting temperatures.

No visible peaks could be found on the pasting curves for all six ground instant noodle powders (data not shown). The reason was perhaps that the pasting property of instant-fried noodles had been altered after steaming and frying that concurred with the previous findings (Ragaee and Aal 2006; Bui and Small 2007).

A survey of 25 commercial instant-fried noodle samples from 10 countries indicated four noodles that were much higher in RVA peak, trough, and final viscosities had springier, smoother, more elastic, and chewier texture. This suggests that improving RVA viscosities of instant-fried noodles with PS could have similar results on the cooked noodle textural characteristics.

### Sensory Evaluation of Instant-Fried Noodles

Three instant-fried noodles containing 15% MPS, 10% MPS, and 0.300% DKP, and 10% MPS and 0.300% DSP was evaluated by an expert panel from noodle manufacturers in South Korea. The panel noted that the latter two noodle samples containing 0.300% PS had higher texture stability scores than the first noodle sample (control noodle); while total noodle scores were similar.

Several studies reported that starch pasting properties, including high peak viscosity (An and King 2009), high breakdown (Singh et al 2009), and swelling power (Noitang et al 2009) are responsible for superior noodle quality for Japanese and Korean type noodles. Starch is widely used as a texture-enhancing ingredient for instant noodles. The addition of the exotic starch improves noodle texture by conferring a smoother, more elastic, and chewy texture. Descriptive sensory evaluation of 25 cooked commercial instant-fried noodles also confirmed that the four noodle brands that contained modified potato starch had much springier, smoother, more elastic, and chewier texture than other noodles. Cooked noodle appearance is more appealing because the added starch yields noodles with a smooth, clean, and shiny surface.

## CONCLUSIONS

Our results clearly indicated that all the phosphate salts used in this research affected the pasting properties of Korean instant-fried noodle formula dry mix, with the RVA peak viscosity increasing as the addition amount of PS was <0.06 mmol. However, the PS had little impact on the pasting temperature except that it increased significantly with TKP. The RVA pasting profiles of ground instant-fried noodle powder demonstrated that the pasting properties of modified formula instant noodle containing 0.300% DKP were better than those of the regular formula instant noodle, and the pasting properties of modified formula instant noodle containing 0.300% DSP or 0.030% MSP were similar to those of regular formula instant noodles. Nevertheless, the mechanism of how PS modified the pasting properties of the wheat flour in the

**TABLE II**
**Effect of Phosphate Salts on Pasting Temperature (°C) of Korean Instant-Fried Noodle Formula Dry Mix[a,b]**

| Sample | Pasting Temperature |
|---|---|
| 85:15 | 65.60 ± 0.21a |
| 90:10 | 66.60 ± 0.10b |
| DSP | 66.46 ± 0.23b |
| DKP | 66.61 ± 0.34b |
| MSP | 66.07 ± 0.52b |
| TKP | 69.02 ± 1.85c |
| SAPP | 66.17 ± 0.31b |
| STMP | 66.50 ± 0.28b |
| CAPP | 66.22 ± 0.25b |

[a] Abbreviations and formulas as in Table I. Also TKP, tripotassium phosphate; SAPP, sodium acid pyrophosphate; CAPP, calcium acid pyrophosphate; STMP, sodium trimetaphosphate.
[b] Data expressed as mean ± SD ($n = 5$). Values followed by different letters are significantly different ($P < 0.05$).

**TABLE III**
**Pasting Properties (RVU) of Ground Instant-Fried Noodle Powder[a,b]**

| Sample | Peak Viscosity | Trough | Breakdown | Final Viscosity | Setback | Pasting Temp (°C) |
|---|---|---|---|---|---|---|
| 85:15 | 57.73 ± 1.42c | 57.65 ± 1.58d | 0.08 ± 0.21b | 135.30 ± 4.25d | 77.65 ± 2.78b | 82.58 ± 1.38ns |
| 90:10 | 51.25 ± 0.88a | 51.30 ± 0.84b | –0.06 ± 0.13a | 123.81 ± 2.05b | 72.50 ± 1.26a | 84.22 ± 0.38 |
| DSP | 53.78 ± 0.29b | 54.06 ± 0.13c | –0.28 ± 0.18a | 125.33 ± 1.40b | 71.28 ± 1.29a | 84.35 ± 0.22 |
| DKP | 63.31 ± 1.49d | 63.39 ± 1.54e | –0.08 ± 0.22a | 146.39 ± 2.29e | 83.00 ± 0.76c | 84.10 ± 0.22 |
| MSP-1 | 48.45 ± 0.89a | 48.53 ± 0.76a | –0.09 ± 0.14a | 118.25 ± 1.77a | 69.72 ± 1.02a | 84.87 ± 0.19 |
| MSP-2 | 53.81 ± 0.88b | 53.89 ± 0.97c | –0.08 ± 0.17a | 129.00 ± 1.72c | 75.11 ±0.82b | 84.10 ± 0.26 |

[a] Abbreviations and formulas as in Table I.
[b] Data expressed as mean ± SD ($n = 5$). Values in the same column followed by different letters are significantly different ($P < 0.05$); ns, not significant.

instant-fried noodle dough systems is still not fully understood. More study is needed to investigate the impact of PS on the instant-fried noodle microstructure and textural characteristics.


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