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ORIGINAL ARTICLE

Effects of pure starter cultures on physico-chemical and sensory quality of dry fermented Chinese-style sausage

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Abstract Dry fermented Chinese-style sausages prepared in laboratory inoculating with *Lactobacillus casei* subsp.*casei*-1.001, *Pediococcus pentosaceus*-ATCC 33316, *Staphylococcus xylosus*-12 and without starter culture randomly sampled at 0, 3, 10, and 24 days of ripening were analyzed for physico-chemical and sensory qualities. A significant ($p<0.05$) decrease in moisture content of sausage during ripening was observed, whereas other major chemical parameters remained unchanged. The microbial fermentation resulted in decreased pH and nitrite but increased non protein nitrogen and total volatile basic nitrogen in the products. Starter cultures except *P. pentosaceous*-ATCC 33316, used in the sausage failed to suppress rancidity in ripened product as indicated by a significant ($p<0.05$) rise in thiobarbituric acid. The lightness (L) and yellowness (b) in the colour of all sausages decreased with ripening time, meanwhile the redness (a) increased significantly ($p<0.05$) in sausages inoculated with cultures *L. casei* subsp.*casei*-1.001 and *S. xylosus*-12. The texture profile of sausages was almost similar except for *P. pentosaceous*-ATCC 33316, which showed significantly ($p<0.05$) lower hardness and gumminess. Based on the sensory and physico-chemical quality criteria, *S. xylosus*-12 could be used as a starter culture to produce dry fermented Chinese-style sausage of high quality.

Keywords Dry fermented Chinese-style sausage · Starter culture · Physico-chemical · Sensory quality

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Introduction

Chinese style sausage is one of the most popular traditional meat products in China. It is prepared by mixing ground pork with curing ingredients and incubating at 2–5°C for 1–2 days stuffing in pork casing and is finally sun or electric oven dried at 50–55°C for 8 to 24 h (Huang and Lin 1993, Sun et al. 2000, Lin and Chao 2001). These sausages are 'semi-dry' or 'short-time fermented sausage', which differ from Western-style dry fermented sausages in terms of manufacturing process, ingredients, bacterial ecology and flavour (Guo and Chen 1991). Some common ingredients of Chinese type sausages are minced pork with larger particle size, sugar, rice wine, garlic and typical Chinese spices (Yu and Chou 1997, Sun et al. 2000, Lin and Chao 2001).

Lactic acid bacteria (LAB) and *Staphylococci* species are widely used in all types of dry fermented sausages. LAB are reported to accelerate ripening time, improve colour and flavour profile, inhibit pathogenic and spoilage bacteria by producing lactic acid and bacteriocin, thereby improving the overall quality and keeping quality of products (Bacus 1986, Con and Gökalp 2000, Erkkilä et al. 2001, Amézquita and Brashears 2002, Fadda et al. 2002). *Staphylococci*, on the other hand, have nitrite reductase, catalase positive, lipolytic, proteolytic and amine oxidase characteristics (Miralles et al. 1996, Gardoni et al. 2002, Mauriello et al. 2002), which could produce important volatiles to generate flavour components in such dry fermented sausages (Søndergaard and Stahnke 2002, Olesen et al. 2004).

Normally Chinese-style sausages are naturally fermented and pure cultures are rarely used for fermentation, while meat starters are widely used in Western type of dry sausages. Additionally, much information is not available at present on the quality characteristics of dry fermented Chinese-style sausages. Therefore, the objective of present study was to find out the effect of different starter cultures on the physico-chemical and sensory qualities of dry fermented Chinese-style sausage.

Materials and methods

Preparation of inocula: A pure culture of *L. casei* subsp. *casei*-1.001 and *S. xylosus*-12 were obtained from Technological Centre of Shunghui Group, Henan, China, while *P. pentosaceus*-ATCC33316 was obtained from China General Microbiological Culture Collection Centre, Beijing. The LAB cultures were harvested by centrifugation at 10,000× g for 15 min at 4°C, washed twice with 20 mM phosphate buffer, pH 7.0, and finally resuspended in the same buffer (10% of initial volume) (Fadda et al. 2002). Likewise, broth containing *S. xylosus*–12 was centrifuged at 2,000× g for 10 min, washed with 0.85% sterile saline and finally resuspended in the same saline. The number of bacterial cells in each suspension was adjusted to reach 10^7 cfu/g meat by using spectrophotometer (Model WFZ-UV-2100, Unico™).The OD was measured at 660 nm for *S. xylosus*-12 (Guo et al. 2000) and at 680 nm for LAB (Fadda et al. 1998) and adjusted each OD at 2.0. The average corresponding bacterial viable cells per ml for each suspension (OD = 2.0) was 1×10^9, 4.4×10^9 and 1.3×10^9 CFU for *S. xylosus*-12, *P. pentosaceus*-ATCC 33316 and *L. casei* subsp.*casei*-1.001, respectively.

Preparation of sausage: Fresh, boneless pork and other ingredients were procured from local supermarket in Wuxi, China. Large connective tissues and external fat were trimmed off with a sterile knife and frozen overnight at about –10°C. Partially thawed meats were ground through a 9.5 mm plate meat mincer and mixed with other curing ingredients as follow: Pork lean (80 g), back fat (20 g), sugar (8 g), five spices powder (0.3 g), white pepper powder (0.1 g), common salt (2 g), monosodium glutamate (0.5 g), sodium nitrite (0.012 g), sodium erythorbate (0.05 g), potassium sorbate (0.2 g), Chinese rice wine (1 g), sodium tripolyphosphate (0.2 g) and chilled water (10 g).

Four different batches of sausage by inoculating *P. pentosaceus*-ATCC 33316 (CHS-PP), *L. casei* subsp.*casei*-1.001 (CHS-LC), *S. xylosus*-12 (CHS-SX) and a control CHS-CONT (without starter) were prepared. All the sausage batters were cured for 24 h at 4°C and then stuffed into edible collagen casing (3 cm diameter, Nalo Faser, Germany). Finally, the sausages were linked up manually (10–12 cm long and 45–50 g in weight) and kept inside a sanitized laboratory ripening cabinet (Zhujian, LRH-150-SII, China) for fermentation at 22°C (90–95% RH) for 3 days. Thereafter, the sausage was ripened in 2 stages; first ripening at 16 ± 1°C (80–85% RH) for 1 week and finally at 12 ± 1°C (75–80% RH) for 2 weeks. From each batch, 5 links of sausages were taken randomly at 4 stages of production: initially just before stuffing (0 day); after fermentation stage (3rd day); after 1 week of ripening (11th day) and after ripening (24th day). All the analyses were carried out in triplicates.

Chemical analysis: Each batch of sausage was analyzed for moisture, crude protein, crude fat and ash contents by AOAC (1997) method, salt content according to the method of Ranganna (1991) and pH by the method of Wang (2000). Volatile basic nitrogen (VBN) in ground sample was extracted in trichloroacetic acid according to the method of Yin and Jiang (2001) and quantitated by Conway micro diffusion technique (Pearson 1968). The residual nitrite content was determined following the method of AOAC (1997). Water activity (a_w) of the ground sample was measured by water activity meter (Rotronic Hygroskop DT, Switzerland). Thiobarbituric acid (TBA) value was determined according to Vasavada et al. (2003). The non protein nitrogen (NPN) was estimated by Kjeldahl method (Dierick et al. 1974).

Physical analysis: Three links of sausage samples were brought to room temperature (21°C) and each link was cut into half. The Hunter colour values L (lightness), a (redness) and b (yellowness) of each cross-section were measured by using colorimeter (Model TC –PII G, Beijing Optical Instruments Factory, China). The texture profile including hardness, springiness, cohesiveness and chewiness in sausage were determined according to Bourne (1978) and Lin and Chao (2001). A cube section (1cm) was cut from each link of sausage and then compressed twice using a texture analyzer (Model TAXT2i, Stable Micro System, England). A 25 kg load cell and P/25A adaptor with 2 mm/sec test speed and 70% compression strain were applied.

Sensory evaluation: A 15-member trained panel was involved in sensory evaluation. The final products were evaluated for appearance, colour (red), flavour, sourness, sweetness, saltiness, rancidity, hardness and overall acceptability using a 6-point Hedonic scale, ranging from 0 for very low intensity to 6 for very high intensity (Moretti et al. 2004).

Statistical analysis: Data from triplicates were analyzed by one way ANOVA using SPSS (2002) software package and means were compared by Duncan's multiple range test. Pearson's correlation coefficient was also used to find out significant correlation, if any between the treatments.

Results and discussion

Effects on physico-chemical quality: The initial moisture content in all sausage batters was 62.9–63.2%, which declined to 24.2–27.1% in the final products (Table 1). Given a mild condition of 2 stages drying, a significant ($p<0.05$) reduction of moisture by approximately 2.5 times was observed. This pattern of moisture loss in Chinese-style sausages during ripening was very similar to other dry fermented sausage (Fanco et al. 2002). Additionally, fat, protein, ash and salt contents were close to the values reported elsewhere for similar types of products (Coppola 1997, Fanco et al. 2002, Moretti et al. 2004). However, a variation observed among treatments might be due to lack of uniformity in mixing of coarser type ground meat particles with other ingredients in sausage batters, which is a typical characteristic of Chinese-style sausages.

As with moisture content, a_w in all sausages significantly ($p<0.05$) decreased with ripening time (Fig. 1). Initially,

Table 1 Effects of starter cultures on chemical composition of dry fermented Chinese- style sausage during ripening

*Sausages	Ripening time, days			
	0	3	10	24
CHS-CONT				
Moisture	63.1 ± 1.68dA	53.4 ± 0.87cB	32.5 ± 1.30bA	24.5 ± 0.26aA
Protein	40.9 ± 1.53aA	40.7 ± 1.20aA	39.7 ± 1.03aA	39.7 ± 1.33aA
Fat	40.3 ± 2.14aA	40.1 ± 1.24aA	39.5 ± 1.81aA	37.9 ± 1.00aA
Ash	6.7 ± 0.34aA	6.5 ± 0.28aA	6.3 ± 0.12aA	7.1 ± 0.31aBC
Salt	4.0 ± 0.22aA	4.1 ± 0.36aA	4.1 ± 0.42aA	4.5 ± 0.19aA
CHS-PP				
Moisture	63.1 ± 1.51dA	49.3 ± 1.24cA	35.5 ± 0.47bA	27.1 ± 0.70aC
Protein	38.2 ± 1.25aB	39.8 ± 1.49bA	39.3 ± 1.16abA	41.5 ± 1.38bA
Fat	37.4 ± 0.66aA	37.7 ± 1.87aA	37.3 ± 2.11aA	36.4 ± 0.88aA
Ash	6.8 ± 0.06aA	6.6 ± 0.30aA	6.5 ± 0.33aA	6.7 ± 0.16aAB
Salt	3.8 ± 0.04aA	4.1 ± 0.52aA	4.0 ± 0.42aA	4.7 ± 0.17aA
CHS-SX				
Moisture	63.4 ± 1.67dA	50.3 ± 0.29cA	34.5 ± 0.47bA	24.8 ± 1.16aAB
Protein	36.8 ± 2.11aB	38.4 ± 2.42abA	40.3 ± 1.64bA	38.8 ± 1.17bA
Fat	38.7 ± 2.12aA	38.0 ± 1.96aA	37.8 ± 1.78aA	37.5 ± 1.26aA
Ash	6.7 ± 0.17aA	6.5 ± 0.38aA	6.4 ± 0.38aA	6.5 ± 0.16aA
Salt	3.9 ± 0.60aA	4.0 ± 0.16aA	4.2 ± 0.49aA	4.6 ± 0.26aA
CHS-LC				
Moisture	62.9 ± 1.07dA	50.2 ± 1.27cA	35.4 ± 2.90bA	26.1 ± 0.18aBC
Protein	39.9 ± 1.66aA	39.8 ± 1.30aA	40.3 ± 1.20aA	38.7 ± 1.66aA
Fat	36.9 ± 1.01aA	36.4 ± 2.57aA	35.9 ± 0.68aA	36.9 ± 0.90aA
Ash	6.5 ± 0.13aA	6.7 ± 0.37aA	6.9 ± 0.44aA	7.2 ± 0.21aC
Salt	4.2 ± 0.33aA	4.1 ± 0.21aA	4.1 ± 0.26aA	4.6 ± 0.16aA

Mean ± SD with different letters with in the same row (a-d) and within the same column (A-C) are significantly different ($p<0.05$).
All the results are expressed in g/100 g of dry matter; n = 3
*Chinese sausage (CHS) without starter culture (CONT), with *Pediococcus*-ATCC 33316 (PP), *Staphylococcus xylosus* (SX) and *Lacobacillus casei* subsp *casei*-1.001 (LC)

there were no significant differences in a_w among all sausages but after 24 days of ripening decrease in a_w became significant ($p<0.05$) in control and in *S. xylosus*-12 inoculated samples. The final a_w found in Chinese-sausage was 0.79–0.83, which is lower than the value reported in Western type of dry fermented sausages (Beriain et al. 1993, Lizaso et al. 1999, Mauriello et al. 2002). The excessive loss in moisture during long ripening resulted in lower a_w in such dry sausages.

A rapid decline in pH was noticed during the first 3 days of fermentation in all products, which then remained almost same up to the end of ripening period (Fig. 1). The change in pH was significant ($p<0.05$) and lowest pH (4.2) value was in CHS-LC, while highest pH (5.3) was in CHS-SX. The decline in pH of all samples was rapid during first 10 days as reported by Fanco et al. (2002), which was associated with marked growth of LAB. Similar result for pH value has been reported in case of *S. xylosus* added (CHS-SX) sample (Bover-Cid et al. 2001, Olesen et al. 2004). Further decline in pH in sausage was slowed down due to production of NPN. However, the acidic pH of about 5 helped to stabilize the shelf life of fermented sausages (Fanco et al. 2002).

The TBA value in dry fermented Chinese-style sausage increased with ripening time (Fig. 1). The trend of TBA values in all samples gradually increased until 10 days of ripening, after which it increased rapidly over 1 mg malonaldehyde/kg (MDA/kg). The sample inoculated with *P. pentosaceous* ATCC 33316 (CHS-PP) showed the lowest TBA value (1.05), whereas control (CHS-CONT) showed the highest (1.46 mg MDA/kg). It has been reported that the rancid off-flavour could be detected when the TBA value rises above 1 mg MDA/kg (Ockerman and Kuo 1982). The results were correlated well with the sensory data and the detectable level of rancidity in all the products. Starter cultures except *P. pentosaceous*-ATCC 33316 (CHS-PP) didn't

show antioxidant effect on lipid oxidation. This could be due to the bacterial lypolysis during fermentation, which might have influenced lipid oxidation in sausages (Suriyaphan et al. 2001).

The NPN rapidly increased during the first 3 days of fermentation and slightly declined with further ripening time (Table 2). The increase in NPN was highest in CHS-SX sausage and lowest in CHS-CONT. The observation was similar to the finding of others (Bover-Cid et al. 1999a, 2001). The average NPN value (590 mg/100 g dry matter) in culture added sample was very close to the value reported for similar types of dry sausage (Beriain et al. 1993, Fanco et al. 2002). NPN is an indicator of degree of proteolysis in dry fermented sausage and could vary from one part to another and even diameter of the product (Bover-Cid et al. 1999b).

The VBN value for all dry sausage samples significantly increased ($p<0.05$) with ripening time (Table 2). Increasing trend of VBN value (7–18 mg VBN/100 g dry matter) in stored Chinese-style sausage has been reported (Lin and Lin 2002). There was a gradual increase in VBN during the first 10 days, which stabilized in later stage of ripening. The rate of increase in VBN was significantly higher ($p<0.05$) in CHS-CONT and lower in LAB inoculated sample which further confirmed the capability of LAB for neutralizing VBN by producing lactic acid and bacteriocin (Yin and Jiang 2001, Yin et al. 2002).

The residual nitrite content in any meat product is considered for the formation of carcinogenic n-nitrosamines (Fiddler et al. 1972, Sen et al. 1974). The nitrite level in all sausages significantly ($p<0.05$) decreased with ripening

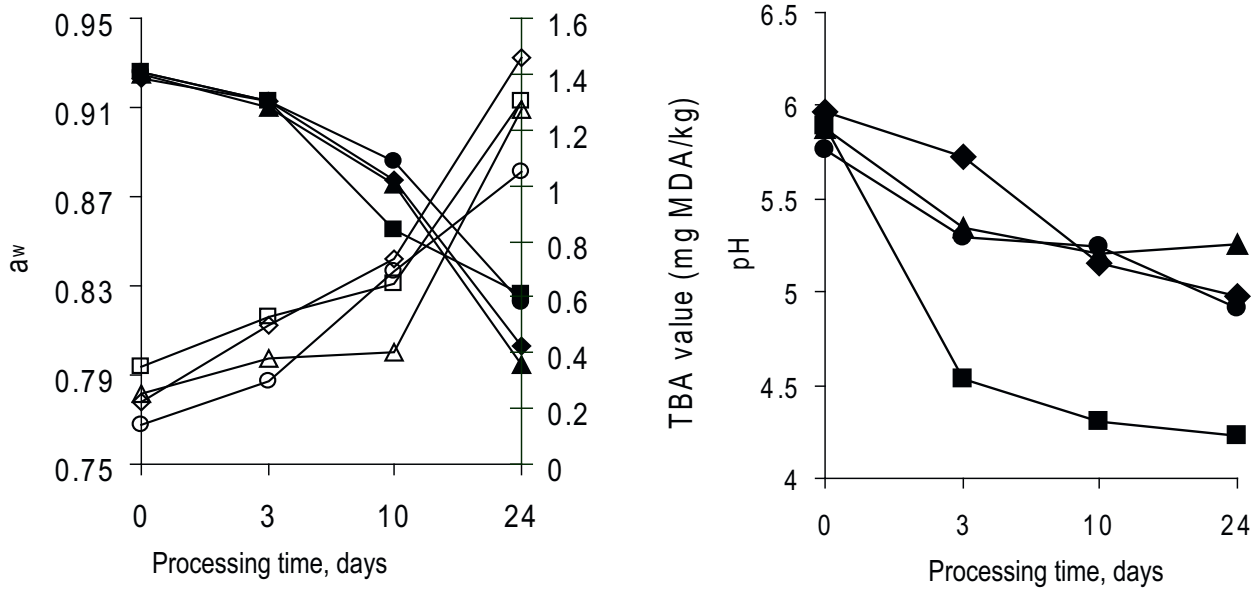

Fig. 1 Changes in water activity (a_w), lipid oxidation (TBA) and pH during the processing of dry fermented Chinese-style sausage inoculated with different starter cultures and control. The solid blocks represent for a_w and pH and hollow for TBA value in samples; *CHS-CONT (-♦-♦-), CHS-LC (-■-■-), CHS-PP (-●-●-) and CHS-SX (-▲-▲-); *As in Table 1

Table 2 Changes in volatile basic nitrogen (VBN) and non-protein nitrogen (NPN) values in dry fermented Chinese-style sausages inoculated with different starter cultures

*Sausages	Ripening time, days				Ripening time, days			
	VBN, mg/100 g dry matter				NPN, mg/100g dry matter			
	0	3	10	24	0	3	10	24
CHS-CONT	11.8 ± 1.22aA	19.2 ± 1.54bB	25.3 ± 0.63cC	25.7 ± 0.53cC	6.5 ± 0.46bB	5.9 ± 0.80abA	4.9 ± 0.67aA	4.8 ± 0.58aA
CHS-PP	12.5 ± 0.61aA	17.5 ± 0.79bAB	21.0 ± 0.67cA	20.8 ± 1.58cAB	5.1 ± 0.33aA	8.3 ± 1.36cB	7.4 ± 0.71bcBC	5.9 ± 1.14abAB
CHS-SX	13.4 ± 1.06aA	17.6 ± 1.92 bAB	20.8 ± 0.26cA	23.1 ± 1.43cB	6.0 ± 0.44aB	8.8 ± 0.94cB	8.0 ± 0.58bcC	6.8 ± 0.57abB
CHS-LC	11.0 ± 1.15aA	14.3 ± 2.29bA	24.4 ± 1.18cB	20.6 ± 1.04cA	5.2 ± 0.28abA	7.4 ± 0.80cAB	6.3 ± 0.83bcB	5.0 ± 0.56aA

Means ± SD with different letters within the same row (a-c) and within same column (A-C) are significantly different ($p<0.05$); n =3
*As in Table 1

process (Table 3). The LC-1.001 (CHS-LC) was the most effective starter in reducing the nitrite level in dry fermented Chinese-style sausage. LAB has been reported to dissipate residual nitrite in cured meat products due to their pH lowering capacity (Marchesini 1992, Yin and Jiang 2001). The results are in agreement with the reported value of similar types of dried and cured sausage (Beriain et al. 1993).

A general tendency of decreasing L and b values, while little change in a value were observed during processing (Table 4). Sausage prepared with CHS-SX and CHS-LC cultures showed the highest ($p<0.05$) a value (redness) as compare to others. Increase in red colour of dry sausage was highly preferred by sensory panel.

The texture profile of dry fermented Chinese-style sausage showed no significant difference ($p>0.05$) in springiness and cohesiveness (Table 5). However, the sausage inoculated with P.P-ATCC 333/6 (CHS-PP) showed a significantly lower ($p<0.05$) value for hardness as compared to others. High acidity (pH 4.2) in (CHS-LC) inoculated sausage may adversely affect on physico-chemical property of meat protein, which could lead to hardening of texture in products. However, the Chinese-style sausage has been reported tougher than other types of sausages (Lin and Chao 2001). The use of coarse ground type of lean meat heavily dropped in moisture content and low pH contributed to the harder texture in the product. Sometimes such type of inconsistency has been related to the degree of proteolysis by dominated micro-flora in dry fermented sausages (Herranz et al. 2003).

Effects on sensory quality: Fig. 2 shows that there was no significant difference ($p>0.05$) in sensory parameters like saltiness, rancidity and hardness of sausage. The product

Table 3 Changes in nitrite residue (mg/kg) in dry fermented Chinese-style sausages inoculated with different starter cultures and control

*Sausages	Ripening time, days			
	0	3	10	24
CHS-CONT	93.7 ± 0.40aB	23.0 ± 1.54bB	8.4 ± 0.60cB	7.1 ± 0.58cB
CHS-PP	79.2 ± 1.37aC	25.0 ± 0.78bB	6.0 ± 0.53cC	3.9 ± 0.52dC
CHS-SX	79.4 ± 0.62aC	24.2 ± 1.16bB	4.4 ± 0.47cD	3.5 ± 0.36cC
CHS-LC	84.6 ± 0.36aA	17.8 ± 1.04bA	3.3 ± 0.16cA	2.0 ± 0.37dA

Means ± SD with different letters within the same row (a-d) and within the same column (A–D) are significantly different ($p<0.05$); n =3
*As in Table 1

Table 4 Changes in Hunter colour L, a, b values in dry fermented Chinese-style sausages inoculated with different starter cultures and control

Colour value	Ripening time, days			
	0	3	10	24
*** CHS-CONT**				
L	41.8 ± 1.30cA	37.5 ± 2.61bAB	36.8 ± 0.91bB	31.1 ± 1.65aCD
a	7.0 ± 0.23aA	7.3 ± 2.44aA	6.0 ± 2.00aA	6.8 ± 1.65aA
b	29.2 ± 0.90dB	11.2 ± 0.90cB	6.0 ± 0.43bA	3.2 ± 0.44aA
CHS-SX				
L	34.8 ± 1.55bA	40.4 ± 2.11cBC	35.3 ± 0.78bB	26.6 ± 1.76aA
a	9.6 ± 0.32bB	20.7 ± 0.53cB	9.4 ± 1.73bB	6.3 ± 1.18aA
b	9.1 ± 0.37cA	11.2 ± 0.31dB	4.6 ± 0.59aA	6.1 ± 0.20bC
CHS-LC				
L	36.6 ± 5.84bA	34.6 ± 0.54bA	35.2 ± 2.12bB	27.8 ± 2.17aBC
a	7.0 ± 0.36aA	11.0 ± 2.36bA	7.2 ± 0.82aAB	9.3 ± 0.81abB
b	25.7 ± 4.08bB	5.1 ± 0.67aA	4.1 ± 1.81aA	6.3 ± 0.68aC
CHS-PP				
L	38.7 ± 4.47bcA	42.6 ± 0.74cC	30.4 ± 4.2aA	35.1 ± 2.83abD
a	9.2 ± 0.51abB	9.3 ± 0.33abA	7.6 ± 1.33aAB	10.7 ± 1.28bB
b	12.1 ± 0.88cA	11.1 ± 0.16cB	6.9 ± 1.74bA	4.7 ± 1.08aB

Means ± SD with different letters within the same row (a-d) and within the same column (A-D) are significantly different ($p<0.05$); n =3; * As in Table 1

Table 5 Texture profile analysis of dry fermented Chinese-style sausage inoculated with different starter cultures and control

Texture profile	*Sausages			
	CHS-CONT	CHS-PP	CHS-SX	CHS-LC
Hardness, g	11122 ± 154b	7419 ± 638a	11196 ± 263b	13391 ± 868c
Springiness, mm	0.88 ± 0.09a	0.88 ± 0.20a	0.90 ± 0.09a	0.83 ± 0.03a
Cohesiveness	0.60 ± 0.20a	0.53 ± 0.01a	0.48 ± 0.04a	0.53 ± 0.05a
Chewiness, g x mm	5018 ± 1045ab	3477 ± 964a	4866 ± 778ab	5910 ± 92b
Gumminess, g	5027 ± 909b	3927 ± 325a	5402 ± 322b	7123 ± 209c
Resilience	0.11 ± 0.01a	0.08 ± 0.01a	0.09 ± 0.01a	0.17 ± 0.03b

Means ± SD with different letters (a-c) within the same row are significantly different ($p<0.05$); n =3, * As in Table 1

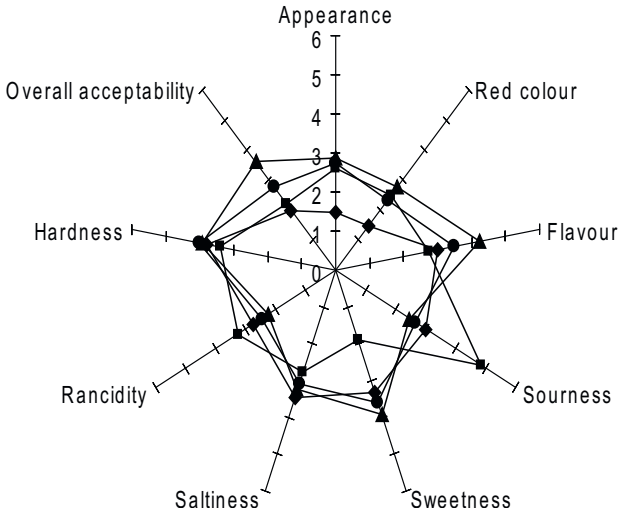

Fig. 2 Sensory characteristics of dry fermented Chinese-style sausage inoculated with different starter cultures. *CHS-CONT (-♦-♦-), CHS-LC (-■-■-), CHS-PP (-●-●-) and CHS-SX (-▲-▲-); *As in Table 1

CHS-LC was significantly ($p<0.05$) higher sour taste than others. A highly significant negative correlation ($p<0.01$) between sourness and overall acceptability reflected that the panelists disliked the product having sour taste. In contrast, a highly significant ($p<0.01$) positive correlation was established between overall acceptability and appearance, red colour and flavour respectively. Hence, sensory evaluation result clearly showed that the sausage CHS-SX was superior in sensory quality as compared to others. *Staphylococcus* species have been reported as meat starter culture to generate volatile components, which would be responsible to generate the flavour compounds in dry fermented sausages (Montel et al. 1996, Søndergaard and Stahnke 2002, Olesen et al. 2004).

Conclusion

This study clearly revealed that addition of different starter cultures could not make much difference in the chemical composition of final products. Starter culture *L. casei* subsp.*casei*-1.001 was found to be the most effective strain in rapid decrease of pH, NPN, VBN and nitrite in final product. Except the culture *P. pentosaceous*-ATCC 33316, no other culture showed a significant antioxidant effect on TBA and texture profile improvement in products. In contrast, the samples inoculated with *S. xylosus*-12 and *L. casei* subsp.*casei*-1.001 as starter cultures significantly improved ($p<0.05$) the red colour of sausages. The sensory analyses results revealed that the product inoculated with *S. xylosus*-12 was found to be superior in quality attributes. Therefore, the pure starter culture of *S. xylosus*-12 could be used to produce a high quality dry fermented Chinese-style sausage.

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