





Older Chinese adults' milk consumption habits: A study across 5 cities

Ao Chen,^{1,2}  Saleh Moradi,^{1,2,3} Joyce Huang,⁴ Sherry Xu,⁴ Mark Sismey,⁴ and Joanne Hort^{1,2*} 

¹Food Experience and Sensory Testing (Feast) Laboratory, Massey University, Palmerston North 4442, New Zealand

²Riddet Institute, Massey University, Palmerston North 4442, New Zealand

³Fonterra Research and Development Centre, Fonterra Co-Operative Group Limited, Palmerston North 4410, New Zealand

⁴MMR Management Consulting (Shanghai) Co. Ltd., Jing'an District, Shanghai 200040, China

ABSTRACT

Milk consumption in China has experienced a rapid growth over the past few decades. This study explored milk consumption habits of older Chinese adult regular milk consumers, by investigating what, where, when, with whom, why, and how milk was consumed. This study (n = 1,000) was conducted in 5 cities in China (first tier: Beijing, Shanghai and Guangzhou; second tier: Chengdu and Shenyang) with participants balanced by sex and age groups (45–55 and 65–75 yr old). Given different economies, general dietary habits, and lifestyles, differences in milk consumption habits between cities were hypothesized. The results showed that almost all participants consumed cow milk, at home and by direct drinking. Most participants consumed milk during breakfast, with their family and for nutrition and health purposes. However, variations by city were found in what type of, what fat level of, what brand of, when and how milk was consumed. Multiple factor analysis showed that “what” variable differentiated cities between tiers and among the first-tier cities, and that “when” and “how” variables also separated the 2 second-tier cities and from the first-tier cities. Although variation in how milk was consumed was also observed between sexes and age groups, hierarchical cluster analysis revealed that the 4 clusters of milk consumption habits derived were mainly differentiated by city: Beijing and Shanghai, Guangzhou, Chengdu, and Shenyang. This study provides comprehensive insights into the milk consumption habits of older Chinese adults and highlights the significant heterogeneity in milk consumption habits in China by city.

Key words: milk consumer, China, consumption scenario, paired foods

INTRODUCTION

Although many countries have a deep cultural connection to dairy products, in China, milk and other dairy products have not traditionally been a part of the diet, except in minority ethnic areas (Wiley, 2011; Zhou et al., 2014). In recent decades, as the Chinese economy has developed and its people have become more exposed to Western foods and culture, there is a growing interest and demand for milk and other dairy products (Xu et al., 2010), leading to a rapid growth of the Chinese dairy industry (DAC, 2019). Domestic production of raw milk increased from 1.2 million tonnes in 1980 to 37.78 million tonnes in 2021 (DAC, 2019). Milk consumption per capita per year increased from 0.4 kg in 1949 to 1.0 kg in 1978 (DAC, 2019), and to 42.3 kg by 2021 (DAC, 2022). Additionally, the Chinese dietary guidelines (Chinese Nutrition Society, 2022) recommend 300 to 500 g of liquid milk equivalent consumption per day, up from 300 g in 2016 (Chinese Nutrition Society, 2016), targeting 109.5 to 182.5 kg per capita per year to further encourage milk consumption.

In China, dairy production has emerged rapidly since the late 1990s, and fluid milk consumption in urban China grew at double-digit rates annually until 2005 (Fuller et al., 2006). Such rapid growth of China's dairy industry in such a short period of time has had an inordinate effect on Chinese milk consumption habits, and hence are unlikely to mirror their evolution in Western societies. A lack of cold-chain distribution has promoted the popularity of shelf-stable products, such as UHT milk, ambient yogurt, and milk powders (DAC, 2019; Chen et al., 2021). Uneven economic growth has resulted in uneven market expansion across different regions (He et al., 2016), and hence, milk consumption patterns are likely to vary across the country. However, despite China being the largest importer in the global dairy trade since 2012 (accounting for 15.0% in terms of quantity in 2021, according to FAO, 2023a), few studies, domestic or overseas, have investigated the detailed consumption habits of this previously nontraditional commodity in the Chinese diet.

Received July 27, 2023.

Accepted December 21, 2023.

*Corresponding author: j.hort@massey.ac.nz

The list of standard abbreviations for JDS is available at adsa.org/jds-abbreviations-24. Nonstandard abbreviations are available in the Notes.

Despite low per capita milk consumption (42.3 kg per capita in 2021) in China compared with the global average (116.4 kg per capita in 2021; FAO, 2023b) and Europe, whose supply of dairy products is over 400 kg of liquid milk equivalent per capita per year (Henchion et al., 2021), there is great variation in milk consumption across regions in China and from rural to urban areas (Fuller et al., 2007). Many studies consistently reveal a positive correlation between income level and dairy consumption (Bai et al., 2008; Mohammed, 2020; Henchion et al., 2021). Consequently, previous studies on dairy consumption in China have mainly focused on first-tier cities, such as Beijing, Shanghai, and Guangzhou (Fuller et al., 2007). However, as milk's popularity has become more widespread, knowledge and understanding are also needed about milk consumption habits in less-developed areas of China. Therefore, this study included 3 out of 4 first-tier cities in China, with per capita regional gross domestic product over 2 times the national average, and 2 second-tier cities, with per capita regional gross domestic product that was about the same level as the national average (National Bureau of Statistics, 2023a). Given different economic developments, general dietary habits, and lifestyles, we hypothesized that differences exist in milk consumption habits between cities.

Unlike other beverages, liquid milk consumption has been shown to be greater among older than younger adults globally (Bai et al., 2008; Singh et al., 2015) due to its contribution to health and well-being during aging (Renner, 1994; Takano, 1998; Davoodi et al., 2013). China also has the largest and fastest growing aged population (WHO, 2019). At the end of 2022, 14.9% of the Chinese population was 65 yr or older (National Bureau of Statistics, 2023b), making it officially an “aged society,” according to the United Nations’ definition (more than 14% aged 65 and older; Kasai, 2010). In the market for foods designed for older adults in China, milk products dominate (Kang et al., 2019; Qiang et al., 2020). Evidently, societal, economic, and cultural transformations experienced by older adults during China’s modern history have fundamentally affected the life course of different generations and may shape their food choice behaviors in later life (Furst et al., 1996). For example, people aged 65 to 75 (born 1947–1957) have childhood and adolescent experiences of the famine (1961) after the Great Leap Forward (1958–1959; Ashton et al., 1984), and experienced Cultural Revolution (1966–1976), also known as the “decade-long catastrophe,” as young adults (Chen et al., 2020). Those aged 45 to 55 (born 1967–1977) experienced the restrictive One-child Policy (1979–2016) during women’s fertile years (Zhang, 2017). Such different life experiences will no doubt have led to the formation of particular relationships with food, and yet understanding older Chinese adults’ (OCA) percep-

tion, consumption, and particular needs regarding milk has been relatively overlooked in the literature.

The aim of this study was to begin to build this knowledge by investigating (1) how OCA engaged with milk, including what, where, when, with whom, why, and how milk was consumed, and (2) whether these habits varied by sex, age, and city. In exploring the milk consumption habits among OCA, this study will shed light on the complex interplay of economic, cultural, and demographic factors and provide valuable insights for the dairy industry about the preferences and needs of this demographic.

MATERIALS AND METHODS

A guided questionnaire approach was adopted to investigate OCA milk consumption habits. This study was assessed and considered as low risk according to the Massey University Human Ethics Committee (ethics notification number: 4000025653, May 11, 2022). All participants indicated informed consent by signing a consent form at commencement of the guided questionnaire, in which they were informed that all data will be de-identified and only reported in aggregate and they were able to withdraw from the survey at any time without giving a reason. Participants were offered ¥70 to ¥100 (¥1 = \$0.15) dependent on residence city to compensate for their time.

Participants

Considering their different life experiences, milk consumers ($n = 1,000$) aged 45 to 55 and 65 to 75 yr old were recruited voluntarily across 3 first-tier cities (Figure 1): Beijing (capital), Shanghai (east), and Guangzhou (south), and 2 second-tier cities: Chengdu (southwest) and Shenyang (northeast), via city-based partners of an international consumer and sensory research agency (MMR Management Consulting [Shanghai] Co. Ltd., Shanghai, China).

A screening survey asked participants about their weekly milk consumption quantity, sex, age, and city residence time, with quotas set for equal numbers of participants ($n = 100$) across the 2 age groups in each of the 5 cities. Within each quota, the minimum proportion of sex (female and male) was set to 40%. No sex diversity was indicated in the screening survey. Eligible participants were those who consumed at least 2 cups or 500 mL of unflavored or flavored mammalian milk from either liquid or powdered form weekly, who had resided in their city for at least 3 yr, and who were living independently and not in a nursing home. The survey also collected participants’ education level, monthly income, employment, and health condition to further characterize the participant sample.



Figure 1. Locations of the 5 Chinese cities (marked in red) where a study was conducted on milk consumption habits.

Older adults do not necessarily take part in conventional online surveys actively because of limited access to, or comfort level with, technology. Therefore, rather than self-report, a guided questionnaire approach was adopted (presented in either Mandarin or Cantonese) in which each participant was accompanied by an agency researcher at a central location in each of 5 cities in May and June 2022. This ensured participants were focused on the task, and any questions they had could be clarified.

Questionnaire Design

The questionnaire regarding milk consumption habits was designed specifically with OCA in mind, utilizing recent milk online market data, related national standards, and existing literature to ensure questions included relevant response options. The questionnaire was divided into 6 parts: (1) what milk was consumed; (2) where milk was consumed; (3) when milk was consumed; (4) with whom milk was consumed; (5) why milk was consumed; and (6) how milk was consumed, as detailed in Table 1.

Part 1 aimed to understand what milk the participant mainly consumed, with regard to milk source (the animal), milk type (the processing method), fat level, and

brand. The options for milk source were set as “cow” or “goat” milk, the primary sources according to national standards (Ministry of Health of the People’s Republic of China, 2010b,c,d), and “other,” to capture minor sources. Milk type included “UHT,” “pasteurized,” “powdered,” and “raw” based on listings in specific national standards (Ministry of Health of the People’s Republic of China, 2010a,b,c,d). Fat levels were set as “whole,” “reduced,” or “skimmed,” according to the levels of fat claims described in the food labeling national standard (Ministry of Health of the People’s Republic of China, 2011). Fat content has previously been shown to be less important to Chinese consumers when purchasing milk (Jin et al., 2019), so an “unknown” option was also provided. Milk brand options included “Yili” and “Mengniu” as the 2 leading nationwide domestic dairy brands (DAC, 2019), as well as “international,” considering its popularity on online markets (Chen et al., 2022), and “local,” defined as brands originated from, and located in, the region where participants resided. Remaining brands were captured via an “other” option.

Part 2 probed where milk was mainly consumed, including at “home” or “other.” Part 3 asked when milk was mainly consumed, with “breakfast,” “before bed-

Table 1. Questions asked regarding milk consumption habits of OCA

Aspect of interest	Question	Option
What	What animal of milk do you mainly consume? (single-choice)	Cow; goat; other
	What type of milk do you mainly consume? (single-choice)	UHT; powder; pasteurized; raw
	What fat level of milk do you mainly consume? (single-choice)	Whole, reduced, skimmed, unknown
Where	What brand of milk do you mainly consume? (single-choice)	Yili; Mengniu; local; international; other
	Where do you mainly consume milk? (single-choice)	Home; other
When	When do you mainly consume milk? (single-choice)	Breakfast; before bedtime; flexible; other
Who	Who do you mainly consume milk with? (single-choice)	Family; alone; other
Why	Why do you consume milk?	Nutrition and health; lifestyle; taste
How	How do you consume milk? (multiple-choice, check-all-that-apply)	Direct drinking; making other beverages; preparing doughs; making cereals; other
	What is the frequency of each way of milk consumption? (single-choice)	<1 per week; 1–5 per week; 6–10 per week; >10 per week
	What is the quantity of each way of milk consumption per serving? (single-choice)	Half a cup (~125 mL); 1 cup (~250 mL); >1 cup (>250 mL)
	Do you mainly add additives to milk when drinking directly? (single-choice)	Yes, (please specify); no
	What are the top 3 most common foods mainly consumed with milk when you drink milk directly? (single-choice and fill-in-the-blank)	Please specify: _____, _____, and _____; none

time,” “flexible time,” or “other” as the choices. Options “lunch” and “dinner” were originally provided because most Chinese individuals (94%) have 3 meals a day (Ma, 2015), but they were merged into the “other” option due to low response frequencies. Part 4 queried with whom milk was mainly consumed, with “family,” “alone,” or “other” as options. However, the “other” option was not reported or analyzed due to low response frequencies. Part 5 investigated their main reason for consuming milk. The options presented were modified from factors considered when purchasing milk in previous studies in China: “nutrition and health” and “taste” (Jin et al., 2019; Cai et al., 2022), plus “lifestyle,” as suggested during pilot testing.

Part 6, the final section, focused on how the participant consumed milk, including method, frequency and quantity of consumption, any additives, and paired foods. After reviewing 58 Chinese top-selling cookbooks, collectively over 15,000 recipes, it was evident that milk was seldomly included as an ingredient in Chinese cooking recipes (<1%), except for making other beverages, preparing doughs, and making cereals. Therefore, they were set as options to the question, “how do you consume milk?,” alongside “direct drinking” and “other” in a multiple-choice, check-all-that-apply, format. The frequency (from <1 to >10 times/wk) and quantity (from half a cup to more than one cup per serving) of milk consumption was requested individually for each method of consumption that participants indicated, respectively. Considering the popularity of sweetened milk in the Chinese market (Liang et al., 2007; Zhu et al., 2022), participants were asked to indicate whether or not they mainly add additives, such as sugar or honey, when they consume milk. Finally, participants were asked to list up to 3 of the most common foods that they pair with milk, if applicable.

Pilot testing of the questionnaire was conducted with 3 local Chinese immigrants aged over 60 yr old to verify the clarity of wording, internal coherence, and language. Time to complete the questionnaire, an average of 10 min, was also measured. Adjustments were made and a final version with 21 questions was created. The questionnaire was presented in Qualtrics software (Qualtrics, Provo, UT), and responses were input directly by the agency researcher.

Data Analysis

Initially response frequencies were determined for each question. Frequency to single-choice questions were calculated across options. Frequency of response for multichoice questions were calculated for each option individually.

Effects of Sex, Age, and City on Milk Consumption Habits. To determine whether participant demographics (sex, age, and city) affected milk consumption habits, chi-squared tests (SPSS Statistics version 28, IBM) were employed to compare observed frequencies of a response with expected frequencies obtained if the null hypothesis was true. When the null hypothesis was rejected on the city factor ($P < 0.05$), post hoc tests were conducted based on adjusted residuals with a Bonferroni adjustment to identify which cities were different from their expected frequencies.

Relationships Between Sex, Age, and City and Milk Consumption Habits. To examine the relationships among participant demographics and milk consumption habits, participant responses were pooled across sex, age, and city, creating 20 new observation variables in a format of sex-age-city (e.g., females 45–55 yr old and living in Beijing; males 65–75 yr old and living in Chengdu, and

Table 2. Numbers and demographic characteristics of the participants

Item	Sex		Age		City				
	Female	Male	45–55	65–75	Beijing	Shanghai	Guangzhou	Chengdu	Shenyang
Number of participants (n)	547	453	500	500	200	200	200	200	200
Average age (yr)	59.4	57.7	49.5	67.7	58.5	58.4	58.6	59.4	58.1
Education (%)									
Primary school and below	4	3	1	6	1	1	9	7	1
Middle school	20	16	2	34	10	8	26	23	22
High school	29	28	14	43	30	28	23	27	36
University and above	47	53	83	17	59	63	42	43	41
Employment (%)									
Working	31	54	82	1	39	42	40	40	48
Retired	69	46	18	99	61	58	60	60	52
Monthly income ¹ (%)									
<¥2,500	2	0	0	2	0	0	1	2	3
≥¥2,500 and <¥5,000	50	28	24	56	31	31	33	46	60
≥¥5,000 and <¥8,000	28	31	29	29	28	29	33	30	25
≥¥8,000	20	41	47	13	41	40	33	22	12
Health issue (%)									
Cardiovascular	8	9	1	16	7	7	11	12	5
Bone or joint	10	6	3	13	1	1	16	12	12
Diabetes	3	3	0	5	4	1	5	3	3
Digestive	3	2	1	4	1	1	3	4	5
Memory deterioration	3	2	0	4	1	0	1	2	7
Appetite loss	2	2	1	3	0	0	3	2	5

¹¥1 = \$0.15 in May to June 2022.

so on). Multiple factor analysis (MFA) was performed on XLSTAT (version 2022.5.1, Lumivero, Denver, CO) to reduce the complexity of the data and provide a concise visual summary of the relationships between variables. The active variables consisted of the average response frequencies, grouped into “what,” “when,” “who,” “why,” and “how” data tables. Sex, age and city were also included as supplementary variables. Because the milk source, the place, and the method of milk consumption was dominated by “cow,” “at home,” and “direct drinking,” respectively (≥97%), they were not included in the MFA. Because the frequency and quantity of milk consumption were only recorded when applicable to a specific method of consumption, they were not included in the MFA either.

OCA Segmentation. Agglomerative hierarchical cluster analysis using squared Euclidean distances and Ward’s agglomeration was applied to the active variables used in the MFA to determine if segmentation was evident according to sex-age-city observation groups, using XLSTAT (version 2022.5.1, Lumivero, Denver, CO). The number of clusters selected was determined by inspecting the clusters at various similarity levels on the dendrogram for a meaningful solution (MacFie, 2007).

RESULTS

Detailed demographic information is listed in Table 2. Notably, female and male participants tended to have similar education levels, but male participants had a lower retirement rate with a higher income level. Age

had a fundamental effect on participant education level, employment rate, monthly income, and health condition. For cities, participants in Beijing and Shanghai had higher education levels, greater income, and fewer health issues in general.

What Milk Was Consumed

Table 3 and Appendix Table A1 summarizes the source, type, fat level, and brand categories of milk mainly consumed by OCA. Cow milk dominated the milk source, being consumed by 97% of participants. Over half (52%) consumed UHT milk, followed by powdered (31%), pasteurized (15%), and raw milk (2%). The proportion of participants consuming whole-fat milk (44%) was similar to those consuming reduced (30%) and skim milk (13%) combined. The remainder were unaware of their milk’s fat level (13%). Yili and Mengniu brands accumulatively accounted for 49% of the milk consumed, followed by brands local to the city (28%), international brands (14%), and other (9%). Chi-squared analysis indicated no difference between different sexes and age groups for milk source ($P = 0.09$ and $P = 0.55$, respectively), type ($P = 0.59$ and $P = 0.17$, respectively), fat level ($P = 0.15$ and $P = 0.05$, respectively), or brand ($P = 0.33$ and $P = 0.42$, respectively). However, there were substantial significant differences among cities for all aspects ($P < 0.01$) except milk source ($P = 0.08$).

Specifically, in second-tier cities, higher proportions of Chengdu and Shenyang participants consumed UHT

Table 3. Characteristics of milk consumed by participants of different sexes, ages, and cities¹

Item	Overall (%)	Sex (%)		Age (%)		City (%)				
		Female	Male	45–55	65–75	Beijing	Shanghai	Guangzhou	Chengdu	Shenyang
Milk source										
Cow	97	97	96	98	96	94	99	96	96	98
Goat	2	2	3	1	3	4	0	3	2	1
Other	1	1	1	1	1	3	1	1	2	1
Milk type										
UHT	52	51	52	52	51	52	37↓	18↓	73↑	78↑
Powder	31	30	32	29	34	18↓	37	70↑	21↓	11↓
Pasteurized	15	16	14	16	13	23↑	24↑	9	6↓	11
Raw	2	3	2	3	2	7↑	2	3	0	0
Fat level										
Whole	44	47	41	49	40	48	63↑	28↓	41	39
Reduced	30	29	31	28	31	31	27	40↑	27	24
Skimmed	13	13	13	12	14	17	8	29↑	6↓	7↓
Unknown	13	11	15	11	15	4↓	2↓	3↓	26↑	30↑
Brand										
Yili	27	25	28	26	26	23	15↓	25	42↑	26
Mengniu	22	21	23	24	20	25	26	14↓	23	22
Local	28	29	27	26	30	36	36	14↓	16↓	37↑
International	14	15	14	15	14	7↓	17	38↑	7↓	4↓
Other	9	10	8	9	10	9	6	9	12	11

¹Up arrow indicates proportion higher than expected; Down arrow indicated proportion lower than expected (Bonferroni adjusted $P < 0.05$).

milk than average (73% and 78%, respectively), whereas in Shanghai and Guangzhou, UHT milk was less popular, and higher proportions consumed pasteurized (24%) and powdered milk (70%), respectively. Comparatively, higher proportions of Beijing participants consumed pasteurized (23%) and raw (7%) milk, but lower proportions consumed powdered milk (18%) than average. Regarding milk fat level, whole-fat was more popular in Shanghai (63%), while low-fat was more common in Guangzhou (40% consumed reduced fat and 29% consumed skim milk). More participants from second-tier cities (26% in Chengdu and 30% in Shenyang) and fewer participants in first-tier cities (<5%) were unaware of the fat level

of the milk consumed. In terms of brand, Guangzhou, Chengdu, and Shenyang participants consumed a higher proportion of international brands (38%), Yili (42%), and local brands (37%), respectively.

Where, When, with Whom, and Why Milk Was Consumed

As revealed in Table 4 and Appendix Table A2, almost all participants mainly consumed milk at home (99%) and the majority consumed milk during breakfast (76%), with family (65%), and for nutrition and health benefits (87%). Notably, there were only 2% and 11% of the par-

Table 4. Where, when, with whom, and why milk was consumed by participants of different sexes, ages, and cities¹

Item	Overall (%)	Sex (%)		Age (%)		City (%)				
		Female	Male	45–55	65–75	Beijing	Shanghai	Guangzhou	Chengdu	Shenyang
Where										
Home	99	99	98	98↓	100↑	98	98	99	100	99
Other	1	1	2	2↑	0↓	2	2	1	0	1
When										
Breakfast	76	74	77	75	76	84↑	81	78	86↑	48↓
Bedtime	11	12	10	10	12	7	9	10	10	21↑
Flexible	11	12	11	14	9	6	8	12	3↓	28↑
Other	2	2	2	1	3	3	2	0	1	3
Who										
Family	65	66	64	67	63	69	59	59	65	73
Alone	35	34	36	33	36	31	40	41	35	27
Why										
Nutrition and health	87	88	87	85	89	86	88	89	84	87
Lifestyle	11	11	11	13	9	12	10	11	13	10
Taste	2	1	2	2	2	2	2	0	3	3

¹Up arrow indicates proportion higher than expected; down arrow indicates proportion lower than expected (Bonferroni adjusted $P < 0.05$).

Table 5. How milk was consumed by participants of different sexes, ages, and cities¹

Item	Overall (%)	Sex (%)		Age (%)		City (%)				
		Female	Male	45–55	65–75	Beijing	Shanghai	Guangzhou	Chengdu	Shenyang
Method										
Direct drinking	100	100	100	100	100	100	100	100	100	100
Other beverages	48	52↑	43↓	58	37↓	60↑	74↑	50	28↓	27↓
Doughs	38	47↑	27↓	43↑	33↓	43	33	36	28↓	53↑
Cereals	9	13↑	5↓	8	11	8	10	18↑	8	4↓
Other	1	1	1	1	1	1	1	3↑	0	2
Additive										
Sugar or honey	11	9↓	14↑	8↓	14↑	14	10	16	4↓	13
Paired food										
Bread	59	62↑	56↓	64↑	55↓	66	70↑	68↑	44↓	50↓
Egg	26	29	23	24	29	27	23	11↓	52↑	19
Biscuit	20	22	18	21	19	21	28	24	5↓	25
Steamed bread	18	18	17	14↓	21↑	20	19	3↓	39↑	10↓
Cake	17	19	15	20↑	14↓	11	26↑	26↑	12	11
Steamed bun	10	10	10	11	9	3↓	11	9	26↑	2↓
None	24	22	26	22	25	19	22	21	21	37↑

¹Up arrow indicates proportion higher than expected; down arrow indicates proportion lower than expected (Bonferroni adjusted $P < 0.05$).

Participants consumed milk mainly for the taste and lifestyle purposes, respectively. We found significant differences between cities regarding when milk was consumed ($P < 0.01$). There were rising proportions of Shenyang participants consumed milk before bedtime (21%) or at a flexible time (28%), instead of during breakfast (48%). Additionally, proportions of participants in Beijing (84%) and Chengdu (86%) who consumed milk during breakfast were higher than average.

How Milk Was Consumed

Milk was predominantly consumed by direct drinking (~100%, Table 5 and Appendix Table A3), followed by making other beverages (48%), preparing doughs (38%), making cereals (9%), and other cooking activities (1%). As Figure 2 indicates, drinking directly was not only the most popular, but also generally the most frequent method of milk consumption, and how the largest quantities were consumed. Overall, 11% of participants consumed milk with additives such as sugar or honey, and 76% consumed milk with paired foods. The most popular foods that at least 10% of participants mainly consumed milk with were bread (59%), eggs (26%), biscuits (20%), steamed bread (18%), cake (17%), and steamed buns (10%).

Sex and age significantly affected how milk was consumed (Table 5 and Appendix Table A3). Alternative methods of milk consumption were more common among female and younger age participants, including making other beverages (both $P < 0.01$) and preparing doughs (both $P < 0.01$). However, a higher proportions of male (14% vs. 9%, $P = 0.01$) and older participants (14% vs. 8%, $P = 0.01$) preferred to use sweet additives, compared

with their counterparts. Although sex and age did not affect the proportions of participants consumed milk paired with other foods, bread was more popular among female (62% vs. 56%, $P = 0.03$) and younger participants (64% vs. 55%, $P < 0.01$) than their counterparts. Additionally,

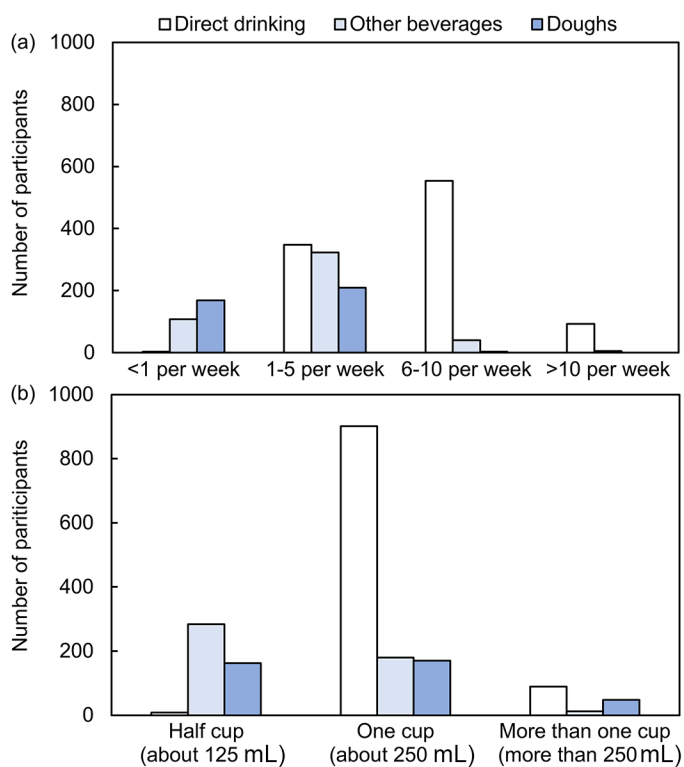


Figure 2. Older Chinese adult milk consumers' frequency (a) and quantity per serving (b) of milk consumption by different methods (direct drinking, making other beverages, preparing doughs).

Table 6. Explained variability and association of grouped active variables and supplementary variables to first 4 factors of MFA

Item	F1	F2	F3	F4
Active				
What	0.907	0.035	0.034	0.072
When	0.185	0.767	0.022	0.000
Who	0.101	0.043	0.673	0.133
How	0.492	0.672	0.066	0.069
Why	0.280	0.036	0.307	0.754
Global	1.966	1.553	1.101	1.029
Supplementary				
City	0.889	0.942	0.031	0.087
Age	0.000	0.015	0.014	0.142
Sex	0.002	0.010	0.013	0.024
Variability (%)	25.620	20.238	14.352	13.406

a higher proportion of younger participants consumed milk with cake (20% vs. 14%, $P = 0.03$), whereas a higher proportion of older participants consumed milk with steamed bread (21% vs. 14%, $P = 0.01$).

In addition, we found significant differences across cities for all aspects analyzed ($P < 0.01$, Table 5 and Appendix Table A3). A lower proportion of Chengdu participants than average consumed milk in ways other than direct drinking and only a small percentage added sweet additives (4%). Higher-than-average proportions of participants in Beijing (60%) and Shanghai (74%) made other beverages using milk, whereas a higher-than-average proportion of Shenyang participants used milk in dough preparation (53%). Consuming milk with traditional Chinese breakfast foods (i.e., egg, steamed

bread, and steamed bun) were more popular in Chengdu (52%, 39%, and 26%, respectively), whereas Western-style breakfast foods (i.e., bread and cake) were more popular in Shanghai (70% and 26%, respectively) and Guangzhou (68% and 26%, respectively). The proportion of Shenyang participants pairing milk consumption with other foods was lower than average (63%).

Overall Relationship Between Sex, Age, and City and Milk Consumption Habits

The first 4 factors (F; F1–F4) of the MFA explained 73.62% of total data variability (Figure 3). According to Table 6, individual coordinates for each grouped variable showed that “what” was strongly associated with F1 (0.907), “when” and “how” to F2 (0.767 and 0.672, respectively), “who” to F3 (0.673), and “why” to F4 (0.754). Furthermore, for supplement variables, city was highly associated with F1 (0.889) and F2 (0.942), whereas sex and age were not highly associated with any of the 4 factors (Table 6).

The variable correlation biplot (Figure 3a) visualizes that F1 separated cities by “what” variable, and F2 separated cities by “when” and “how” variables. Specifically, the projections in the upper left quadrant indicate that participants in Guangzhou tended to consume skimmed and powdered milk from international brands, most likely with bread, cake, and for making other beverages. Participants in both Shenyang and Chengdu (right quadrants), however, tended to consume UHT milk and not be

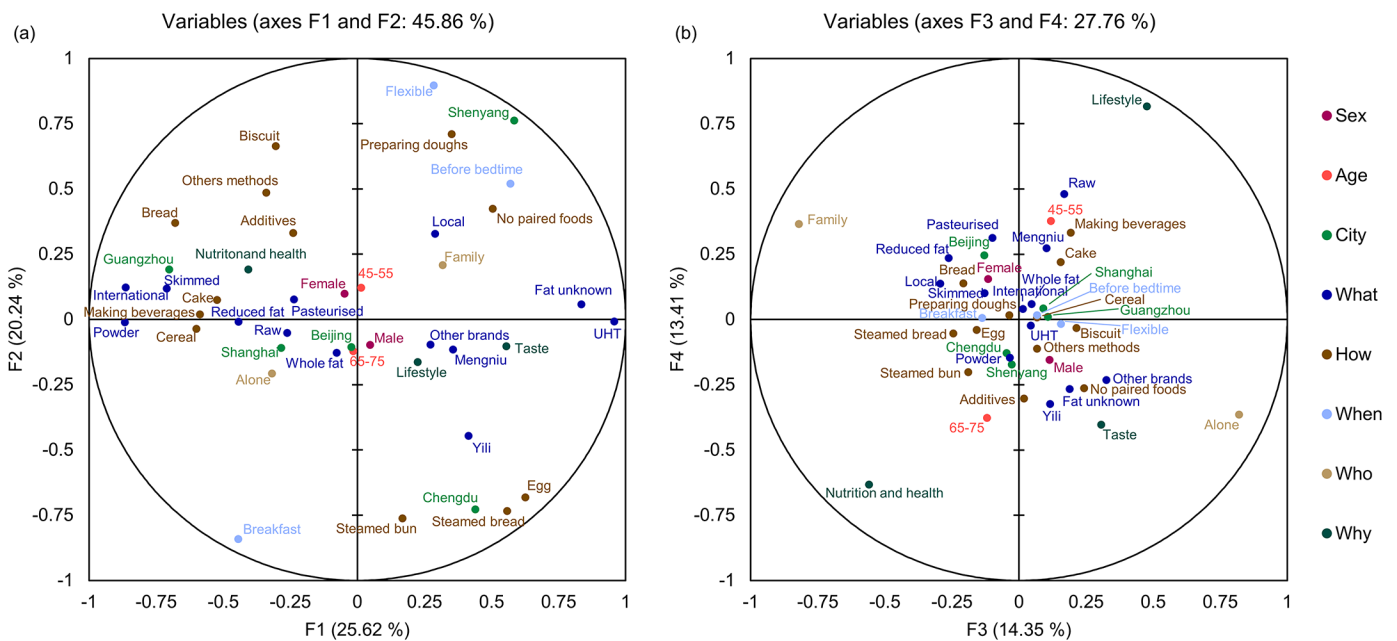


Figure 3. Projection of active and supplementary variables of milk consumption habits on factors F1 and F2 (a) and F3 and F4 (b) in MFA.

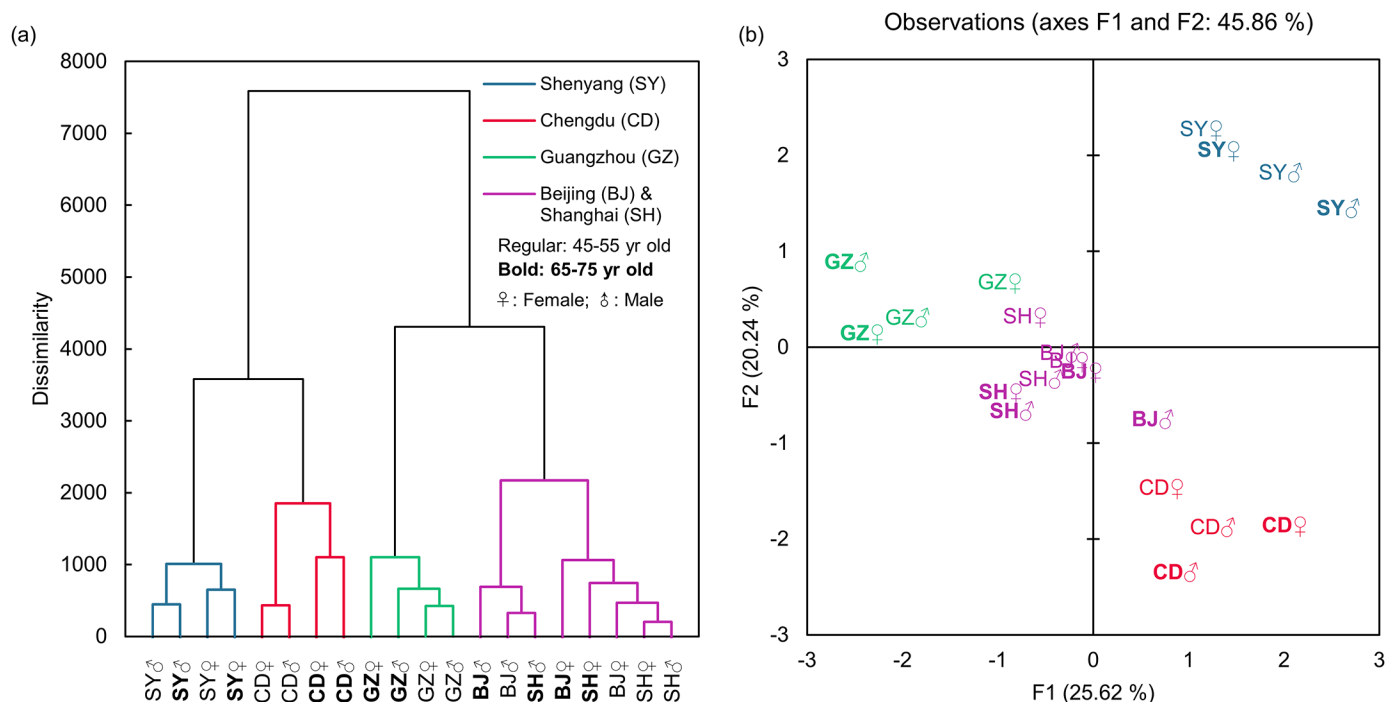


Figure 4. Hierarchical cluster analysis dendrogram revealing participant clusters according to milk consumption habits (a) and projection of observations on the plane defined by MFA factors F1 and F2 with clusters indicated (b).

aware of the milk fat level. The upper right quadrant indicates participants in Shenyang tended to consume milk before bedtime or at flexible times and were less likely to consume milk paired with foods but used it in dough preparations. They were also more likely to consume milk with local brands. Consuming milk produced by Yili for breakfast, with egg, steamed bread, and steam buns was associated with participants in Chengdu (bottom right quadrant). Shanghai and Beijing were positioned in the bottom left quadrant, near the center but closer to Guangzhou than the second-tier cities. Sex and age projected very close to the center of the biplot indicating less association with any particular variables. Factor 3 indicates a slight separation by age and sex with the male and younger participants more associated with milk consumption alone than with family, and F4 separated the younger from the older participants on “why” variable (i.e., consuming milk for lifestyle reasons), whereas the older participants are more associated with milk consumption with health and taste.

Hierarchical cluster analysis revealed 4 clusters of participants’ milk habits mainly differentiated by city: Beijing and Shanghai, Guangzhou, Chengdu, and Shenyang, confirming that most variation in milk consumption habits were attributed to city of residence (Figure 4a). Figure 4b shows the positioning of these clusters on planes of F1 and F2 of the MFA.

DISCUSSION

The study aimed to compare the hitherto unknown milk consumption habits of OCA of different sexes and generations across different cities in China; OCA shared some milk consumption habits, but others were shown to vary considerably by city.

Consistency in Milk Consumption Habits of OCA Consumers

Milk Consumption Habits in Common. All OCA regular milk consumers in this study had 3 specific habits in common: cow milk (97%) was the main milk source consumed, direct drinking was the main method of consumption (100%), and consumption mainly happened at home (99%).

As cow milk is the most predominant milk source in China (DAC, 2019), it was unsurprising that cow milk was the most common source consumed by OCA. In fact, Chinese domestic cow milk production was 36.83 million tonnes in 2021, accounting for 97.5% of the overall raw milk production (China Animal Husbandry and Veterinary Yearbook Editorial Committee, 2021). In the Chinese liquid milk market, milk source is required be specified in the name of the product (Ministry of Health of the People’s Republic of China, 2010b,d), mak-

ing “cow milk” a frequently used term in China. Some Chinese-English dictionaries (Cowie and Evison, 1986; Li, 2010), Google translate (<https://translate.google.com/>), and ChatGPT (<https://chat.openai.com/>) translate “milk” as “*niúnǎi*,” which literally means “cow’s milk” in Chinese, further reflecting the prevalence of cow milk in China. Although in this study, the proportion of participants mainly consuming goat or other milk sources was too low to be significant, the proportion of the older participants was about twice that of younger ones, suggesting their popularity was potentially higher among older generations.

Direct drinking was the most popular method of consumption, in terms of the prevalence, frequency, and quantity among OCA. This preference for direct drinking of milk can be traced back to the historical popularity of drinking soymilk in China (Fu, 2018). The introduction of milk as a new and similar food likely led people to naturally adopt similar consumption habits, incorporating milk into their diet in ways reminiscent of how they consumed soymilk.

Given that 91.8% of Chinese have breakfast at home (Ma et al., 2006), this can account for the finding that milk was mainly consumed at home because milk was mainly consumed at breakfast or before bedtime. Similarly, a previous study found that 90.6% of Chinese adults’ energy intake from dairy products occurs at home, with much lower proportions from dairy consumed in restaurants and workplaces (Tian et al., 2016). Consequently, as milk consumption habits tend to be private at home, this study provides valuable insights, minimizing the influence of egocentric bias, which refers to the tendency for individuals to interpret information in a way that aligns with their own viewpoint, often overlooking alternative perspectives or experiences of others.

Milk Consumption Habits in General. Most OCA milk consumers consumed milk with their families (65%) and for the purpose of nutrition and health (87%). These findings were consistent across sexes, ages, and cities.

The OCA did not often consume milk in public or while socializing with friends, colleagues, or others, but mainly with family, facilitating the intimate family relationships. This is supported by the presence of family-related sociological well-being messages on the pack of milk products targeting OCA (Chen et al., 2022). In Europe, where milk constitutes a regular and unexotic part of the diet, milk is associated with goodness, health, family, childhood, and the bonds between parents and children (Wilken and Knudsen, 2008). Similarly, in Chinese families, milk may also serve as a means of demonstrating care and affection, fostering emotional bonds among family members of OCA. This may stem from OCA’s primary reason for milk consumption being nutrition and health, and hence providing milk can be

widely viewed as providing care (Wilken and Knudsen, 2008).

It is a well-documented phenomenon that Chinese consumers’ purchase and consumption of milk is always associated with nutrition (Cheng et al., 2015; Cai et al., 2022). In this study, the proportion of participants citing nutrition and health as the main reason to consume milk among participants was particularly high, probably due to the increasing health concerns among OCA (Tian, 2020). In this study, only 2% of OCA consumed milk for the taste. This may be why sensory attributes were the least frequently mentioned aspect well-being messaging on the pack of milk products targeting OCA (Chen et al., 2022). However, for European consumers in general, taste was commonly one of the most important motives stimulating the purchase and consumption of milk (Kurajdova and Táborecka-Petrovicova, 2015). Possible reasons for the low proportion of participants consuming milk for its taste could be that they are not accustomed to the taste of plain milk in general. A previous study conducted in Qingdao, China, reported that the primary reason for individuals not consuming milk regularly was the “unpleasant taste” of fluid milk, accounting for 75% of the responses (Bai et al., 2008). Previous studies with Chinese participants showed hedonic scores ranged from 4.1 to 6.3 (Su et al., 2022) and 4.7 to 6.1 (Yan et al., 2020) for UHT and pasteurized milks on a 9-point hedonic scale, further suggesting low levels of liking for milk per se. Age-related decline in taste perception could be a further reason contributing to the fewer participants consuming milk because of its taste (Methven et al., 2012).

Variations in Milk Consumption Habits of OCA Consumers

Variations in Milk Consumption Habits by City. Substantial variations occurred in the remaining aspects of milk consumption habits studied, including what, when, and how milk was consumed, and these often related to the city of residence.

In terms of type of milk consumed, UHT was generally the most popular one (especially in the second-tier cities, Chengdu and Shenyang), followed by powdered milk (especially in Guangzhou). Pasteurized milk was more popular in Beijing and Shanghai, but its share was still less than one-quarter. Until the availability of refrigeration and pasteurized milk in China, UHT and powdered milk were the most common types of milk available to many Chinese households, and habits persist in consumers, especially among the elderly (Fuller et al., 2007). In this study, the proportion of older adults consuming powdered milk was particularly high in Guangzhou. Similarly, Fuller et al., (2007) reported a lower consumption

of liquid milk and a higher consumption of powdered milk in Guangzhou than Beijing and Shanghai (27.4 vs. 56.8 and 51.5 kg/capita per year, and 1.1 vs. 0.8 and 0.7 kg/capita per year, respectively). Wu et al., (2021) found that expenditures on powdered milk was higher than on liquid milk and yogurt in all 3 income levels in Guangzhou based household as well. The popularity of milk powder found in this study might be due to Guangzhou participants consuming more milks with international brands (38% vs. 14% in average), which were more likely to be powdered milk (71% of the international milks consumed in this study were powdered milk). The popularity of pasteurized milk depends on the development of cold-chain transportation as well as the dairy industry local to that region (Hatt and Wilbey, 1994; Barraquio, 2014), for example Sanyuan Foods Co. Ltd. in Beijing and Bright Dairy & Food Co. Ltd. in Shanghai. The higher proportions of participants in Beijing and Shanghai consuming pasteurized milk may partly be due to the higher levels of development of the local dairy companies (China Animal Husbandry and Veterinary Yearbook Editorial Committee, 2021). Additionally, as household income increases, liquid milk consumption was seen to shift gradually from UHT to pasteurized in urban China (Yang et al., 2021), which may account for why Beijing and Shanghai had higher proportions of participants consuming pasteurized milk than the other cities.

Regarding milk fat level, in second-tier cities Chengdu and Shenyang, not only were lower proportions of OCA consuming skim milk, but higher proportions of OCA were not aware of their milk's fat level. This result supports a previous finding that the relative importance of milk fat level to consumers was lower in less-developed cities across China (Jin et al., 2019). In contrast, Shanghai and Guangzhou had more participants consuming whole-fat and skimmed milk, respectively. In Europe and North America, the consumption of low-fat milk increased as the dairy industry developed (Trichopoulou et al., 2002; McCarthy et al., 2017; Jones et al., 2019). However, low-fat milk was not always more popular in Chinese first-tier cities, indicating that milk fat level opted for in China was influenced by other factors such as regional dietary habits. For example, low-fat milk, which was particularly popular in Guangzhou, could be associated with the general lower fat content of the regional Cantonese cuisine (Zhao et al., 2021).

Concerning brand, with a combined market share of ~44% in 2018 (DAC, 2019), it is not surprising Yili and Mengniu were the top 2 nationwide popular brands consumed by 49% of participants overall. The consumption of brands local to the city were higher in Beijing, Shanghai and Shenyang, suggesting higher development and acceptance of their local dairy companies (China Animal Husbandry and Veterinary Yearbook Editorial Commit-

tee, 2021). After the milk contamination scandal in 2008, the demand for imported dairy products has continued to grow until the COVID-19 pandemic, especially for infant formula milk powders (Tian et al., 2022). However, this was not the case for milk consumed by OCA in this study. Only 2 port cities, Shanghai and Guangzhou, had proportionally more participants consuming milk with international brands.

It was not surprising that milk was generally consumed at breakfast (76%), where it has been generally incorporated in place of more traditional soymilk for breakfast in China (Fu, 2018). Variations were found among cities that Shenyang, located in the northeast, had a relatively lower proportion of participants consuming milk at breakfast, probably due to a lifestyle of skipping one meal out of 3 (Ma, 2015), especially during the harsh winter, resulting in no formal "breakfast" (Foodie Today, 2018). Consequently, Shenyang OCA tended to consume their milk before bedtime or more flexibly in the day, compared with the other cities. Additionally, according to the data collected by smart bracelets, northeastern China is the region suffering most badly from sleep problems (ZEPP, 2017) and the consumption of milk before bedtime is generally believed to promote sleep quality due to its high level of L-tryptophan in the α -LA protein (Komada et al., 2020).

Concerning methods of milk consumption other than direct drinking, OCA from first-tier cities had a higher tendency to consume milk in other beverages, such as coffee and milk tea, than those from second-tier cities, a likely consequence of the popularity of such exotic beverages in China initially starting in first-tier cities (Shi et al., 2021). Divided by the Qin Mountain-Huai River Line, south and north China have distinct dietary habits; for example, the use of rice in the south versus flour in the north and sweet flavors in the south versus savory in the north (Melnick and Marazita, 1998; Ma, 2010). This explains the general dietary difference that participants in the north (Beijing and Shenyang) were more likely to use milk in preparing doughs than those in the south (Shanghai, Guangzhou, and Chengdu). Milk was seldomly used in other cooking activities by OCA, which is in line with the finding that milk is presented in only 0.5% of recipes in top 58 Chinese cookbooks related to local cooking (unpublished data, A. Chen, S. Moradi, and J. Hort).

Sugar-sweetened milk products are commonly available in China to improve the taste when drinking milk directly (Liang et al., 2007; Zhu et al., 2022). The accumulating evidence of health risks caused by sugar overconsumption (Lustig et al., 2012) has, however, resulted in the prevalence of "no added sugar" claims on the pack of milk products targeting OCA (Chen et al., 2022). Nevertheless, this study found that 11% of participants

added sugar or honey as additives when consuming milk, suggesting a need for milk taste improvement for OCA. This percentage is higher than the sugar-sweetened soft beverage consumption rate (5.0%) among the Chinese urban population aged 45 and over (Pan et al., 2022). Notably, a lower proportion of participants from Chengdu were sweetening their milk, but the reason is not clear and further investigation is needed.

As OCA mainly consumed milk during breakfast, foods consumed with milk were normally foods for breakfast, including bread and cake as Western-style breakfast options, as well as steamed bread and bun as Chinese traditional breakfast options (Bai et al., 2014; Ma, 2015). The consumption of bread, the most popular paired food consumed with milk, was found to be positively correlated with the consumption of milk for breakfast, suggesting the commercial promotion of milk and bread in China benefited each other (Bai et al., 2014). A higher proportion of participants in Shenyang consumed milk with no paired food, likely due to fewer OCA there consuming milk for breakfast. In first-tier cities, particularly Shanghai and Guangzhou, Western-style breakfast foods (i.e., bread and cake) were more prevalent, but in Chengdu, steamed bread, steamed bun, and egg were also popular.

In general, the MFA highlighted that most variation in milk consumption habits was attributed to city of residence, compared with sex and age. Previous studies in China have shown that a city's economic development, population and population structure can have fundamental influences on milk consumption amount (Takahashi, 1984; Fuller et al., 2007; Cheng et al., 2015). In this study, 4 clusters were observed based on milk consumption habits by cities: Beijing and Shanghai, Guangzhou, Chengdu, and Shenyang. Specifically, 3 first-tier cities were similar in when and how milk was consumed but Guangzhou was different from Beijing and Shanghai in what milk was consumed. Second-tier cities were different from the first-tier cities in terms of what, when, and how milk was consumed. Although 2 second-tier cities were similar in what milk was consumed, they were distinct in when and how milk was consumed.

Variations in Milk Consumption Habits by Sex and Age. Effects of sex and age on food preference, food choice and dietary habits were well established (Ma et al., 2005; Westenhoefer, 2005). However, in this study, sex and age effects were limited within OCA, and were mainly significant in how milk was consumed. The female and younger participants, engaged with milk in more diverse ways than their counterparts, beyond direct drinking. Similar results have been observed for milk tea with higher proportions of younger and female regular consumers than their counterparts (Shi et al., 2021). Additionally, female and younger participants were more open to pairing milk with Western-style foods. The re-

sults may be explained by the food neophobia associated with male and older participants, stemming from limited exposure to foods when their food habits were formed (Siegrist et al., 2013). Male and older participants, however, were more likely to add sugar or honey to milk when consuming it. Similarly, Liu et al. (2018) reported that elderly male Chinese adults had more added sugar in their diets than their female counterparts (3.6% vs. 3.0% of total energy intake). Additionally, a decline in taste perception associated with aging (Methven et al., 2012) could also be responsible for the proportion of the participants adding sugar or honey to their milk.

CONCLUSIONS

This study focused on OCA milk regular consumers. Almost all participants mainly consumed cow milk, at home, and by direct drinking. Most of them chose to consume milk during breakfast, with their family, and for nutrition and health reasons. There were variations by city in what (i.e., milk types, fat levels, and brands), when, and how milk was consumed (i.e., methods of consumption, additives, and paired foods). Cities between tiers and within the first-tier were mainly distinguished by the “what” variable, whereas the “when” and “how” variables further separated 2 second-tier cities. Variations by sex and age of participants in their milk consumption habits were also found regarding how milk was consumed. However, hierarchical cluster analysis revealed 4 clusters in milk consumption habits mainly differentiated by city: Beijing and Shanghai, Guangzhou, Chengdu, and Shenyang, indicating most variations in milk consumption habits were attributed to city of residence. This study provides insights into the milk consumption habits of OCA and highlights the significant heterogeneity in milk consumption habits in China by city.

NOTES

This research was funded by the New Zealand Ministry of Business, Innovation and Employment (Wellington, New Zealand) through the New Zealand Milks Mean More Endeavour Programme (Contract MAUX1803). We thank Caroline Giezenaar (Palmerston North, New Zealand) and Amanda Dupas de Matos (Palmerston North, New Zealand) for providing advice on data processing. This study was assessed and considered as low risk according to the Massey University Human Ethics Committee (ethics notification number: 4000025653, May 11, 2022). The authors have not stated any conflicts of interest.

Abbreviations used: F = factor; MFA = multiple factor analysis; OCA = older Chinese adults.

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ORCID

Ao Chen  <https://orcid.org/0000-0003-4360-4413>
 Joanne Hort  <https://orcid.org/0000-0001-8609-4543>

APPENDIX

Table A1. What milk was consumed by the number of participants of different sexes, ages, and residing cities

Item	Overall	Sex		Age		City				
		Female	Male	45–55	65–75	Beijing	Shanghai	Guangzhou	Chengdu	Shenyang
Milk source										
Cow	968	532	436	490	478	187	199	193	192	197
Goat	21	9	12	6	15	8	0	6	5	2
Other	11	6	5	4	7	5	1	1	3	1
Milk type										
UHT	517	280	237	262	255	104	75	36	146	156
Powder	314	167	147	144	170	35	74	141	43	21
Pasteurized	147	86	61	80	67	47	48	18	11	23
Raw	22	14	8	14	8	14	3	5	0	0
Fat level										
Whole	442	257	185	242	200	97	127	57	83	78
Reduced	298	159	139	142	156	62	54	80	53	49
Skimmed	131	70	61	60	71	33	15	58	12	13
Unknown	129	61	68	56	73	8	4	5	52	60
Brand										
Yili	264	135	129	132	132	45	30	51	85	53
Mengniu	221	116	105	122	99	51	53	27	46	44
Local	280	158	122	129	151	73	73	27	32	75
International	144	81	63	74	70	14	33	77	13	7
Other	91	57	34	43	48	17	11	18	24	21

Table A2. Where, when, with whom, and why milk was consumed by the number of participants of different sexes, ages, and residing cities

Item	Overall	Sex		Age		City				
		Female	Male	45–55	65–75	Beijing	Shanghai	Guangzhou	Chengdu	Shenyang
Where										
Home	988	543	445	490	498	196	196	198	200	198
Other	12	4	8	10	2	4	4	2	0	2
When										
Breakfast	756	406	350	376	380	168	163	156	172	97
Bedtime	113	68	45	51	62	14	18	19	21	41
Flexible	114	65	49	69	45	13	15	25	5	56
Other	17	8	9	4	13	5	4	0	2	6
Who										
Family	650	362	288	333	317	138	118	118	130	146
Alone	347	184	163	165	182	61	80	82	70	54
Why										
Nutrition and health	871	479	392	426	445	172	176	179	169	175
Lifestyle	110	60	50	64	46	24	21	21	25	19
Taste	19	8	11	10	9	4	3	0	6	6

Table A3. How milk was consumed by the number of participants of different sexes, ages, and residing cities

Item	Sex		Age		City					
	Overall	Female	Male	45–55	65–75	Beijing	Shanghai	Guangzhou	Chengdu	Shenyang
Method										
Direct drinking	998	546	452	499	499	199	200	200	200	199
Other beverages	476	283	193	291	185	119	148	100	56	53
Doughs	381	259	122	215	166	85	65	71	55	105
Cereals	94	72	22	39	55	16	20	36	15	7
Other	11	7	4	6	5	1	1	6	0	3
Additive										
Sugar or honey	112	48	64	42	70	27	20	32	8	25
Paired food										
Bread	593	341	252	320	273	132	139	135	88	99
Egg	261	156	105	118	143	53	45	22	104	37
Biscuit	203	121	82	106	97	42	55	47	10	49
Steamed bread	178	101	77	72	106	40	37	5	77	19
Cake	170	104	66	98	72	22	52	52	23	21
Steamed bun	98	53	45	53	45	6	21	17	51	3
None	236	118	118	110	126	37	43	42	41	73