Congratulations to 16th International Rapeseed Congress/IRC 2023

Development of multiple function utilization for promoting rapeseed industry in China

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Outline

1. Rapeseed Prodctn and Consptn in China

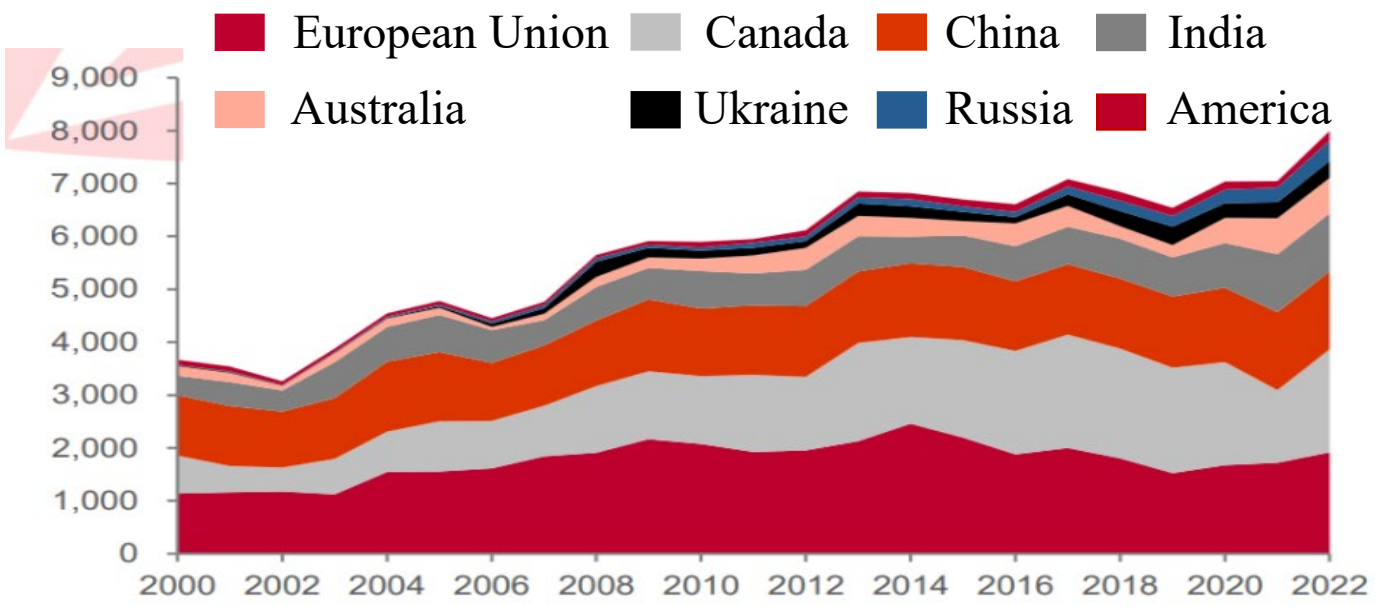
2. Multi-function Utilization of Rapeseed

3. Prospects of Rapeseed Industry in China

1. Rapeseed Production & Consumption in China

EU, Canada and China are major rapeseed producing countries with > 60% world total production

- **The total production increased from 37 million tons (mt) in 2000 to 83.82 mt in 2022**
- **In 2022, China Rapeseed yield was 14.7 mt , 17.5% of world total production (3rd)**



Production in Major Production Countries and Regions in the World (in 10,000 tons)

rapeseed production in 2022

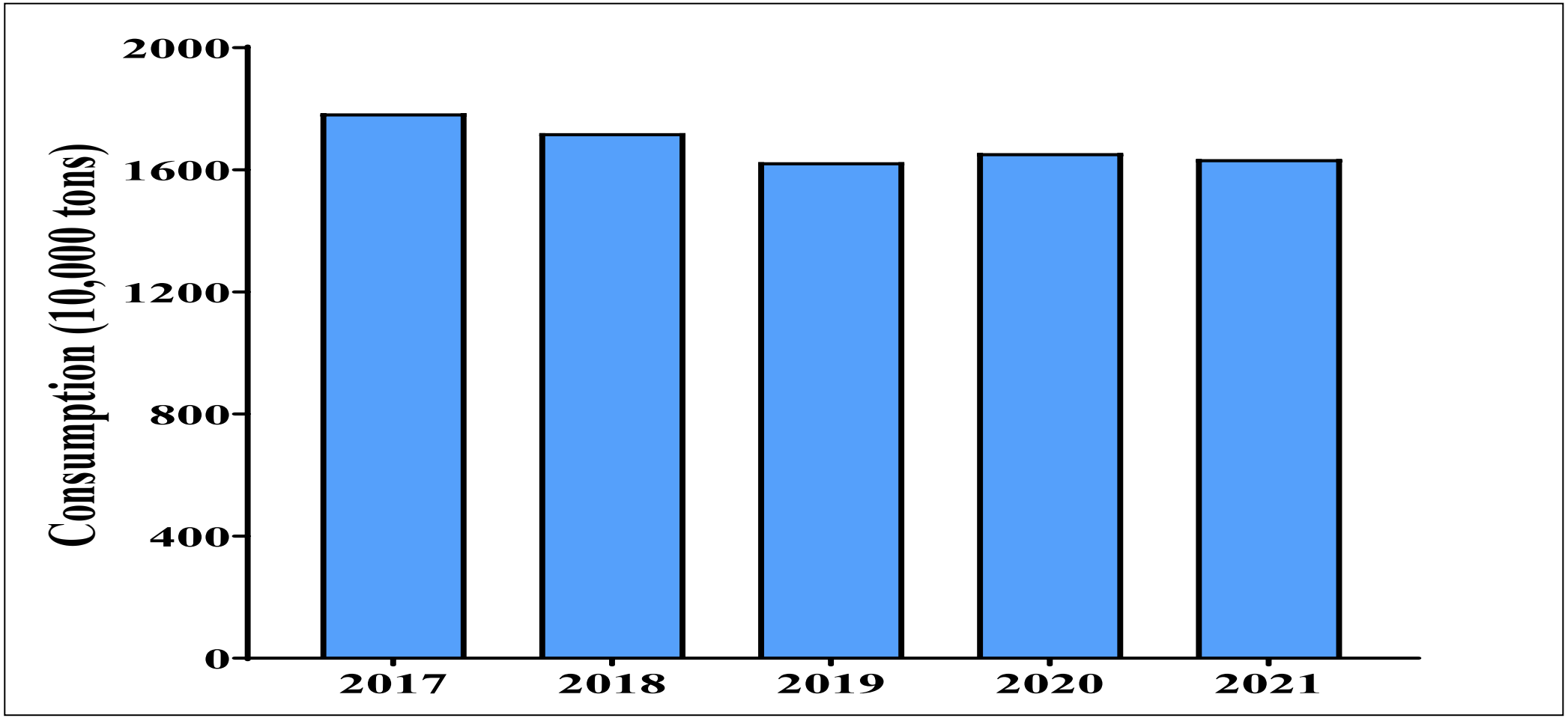
China：17.5% （14.7 mt）

Canada：23% （19.5 mt）

European Union：23% （19.5 mt）

Data Source: United States Department of Agriculture (USDA)

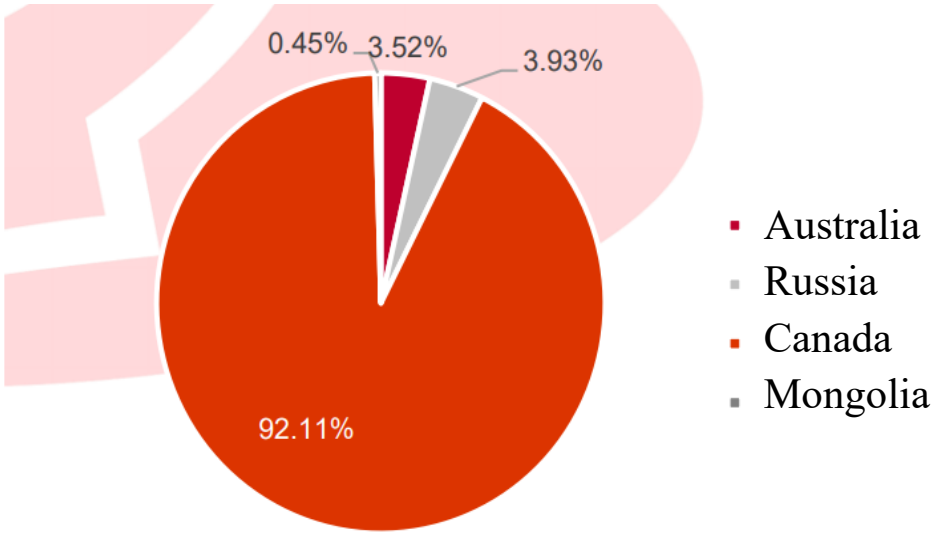
Rapeseed consumption from 2017 to 2021 in China



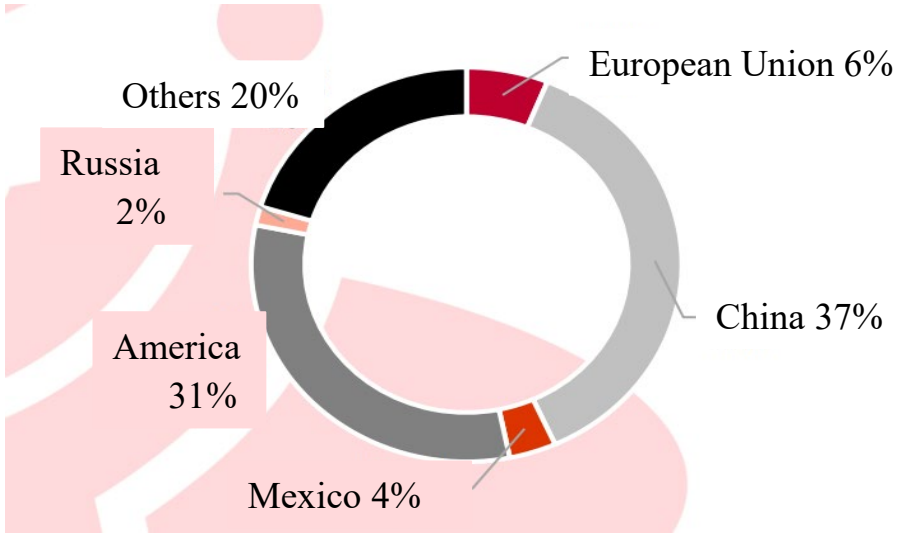
Data Source: National Bureau of Statistics of China and USDA

China is the 3rd-largest producer & the biggest consumer

- **Production is not enough for domestic consumption in China**
- **In 2021, 1.8 million tons imported , 90% from Canada**



2021 China Rapeseed Import Source Countries' Proportion



Global Distribution of Rapeseed Oil Imports (2022)

Data Source: General Administration of China Customs, USDA

Many strategies adopted to promote rapeseed industry

- **Cultivars breeding with high-resistance, yield and quality**
- **Winter fallow farmland use for rape in Yangzi valley**
- **Agricultural mechanization**
- **Rapeseed multi-function utilization**

2. Multi-function Utilization of Rapeseed

Rapeseed Multi-function Excavation and utilization in China

2.1 Utilization for edible oil

2.2 Utilization for edible vegetable

2.3 Utilization for flower tourism

2.4 Utilization for green animal feeds

2.5 Utilization for honey industry

2.6 Utilization for green manure

2.7 Utilization for sand-storm reduction

2.8 Utilization for saline-alkali land improvement

2.1 Utilization for edible oil

Rapeseed used for oil with a very long history

- **Han Dynasty：rapeseed used as oil for lamp**

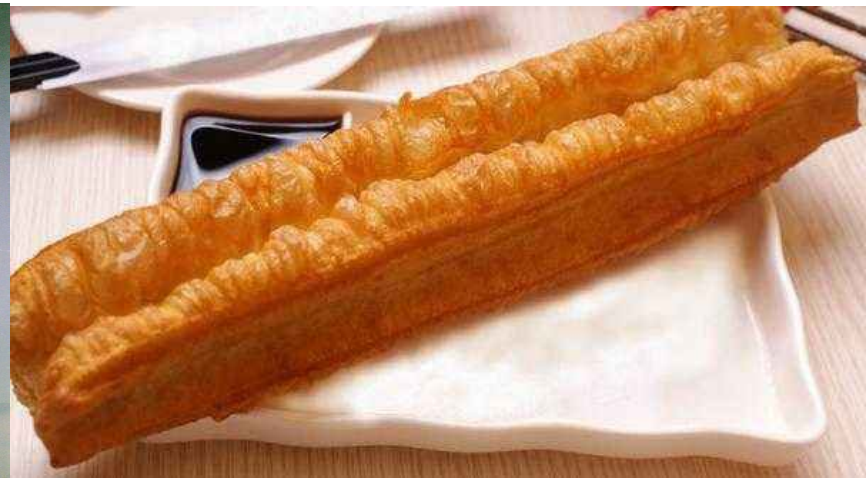
  距今1857-1865年，东汉崔崔寔撰写农书《四民月令》AC 158-166, 二世纪中即已记有六月中伏后可种芜菁，七月可种芜菁，十月可收芜菁，四月收芜菁子

- **Tang Dynasty：rapeseed used as medicine for detumescence**

  贞观七年三月，曾因多饮，至夜觉身体骨肉疼痛，至晓头痛，额角有丹如弹丸，肿痛，目不能开，痛苦几毙。此时，忽然想想本草有芸薹治风游丹肿的记载，遂取叶捣敷，随手即消，其验如神。（唐名医孙思邈）

- **Since Song Dynasty：rapeseed oil became an important edible oil and part of Chinese food culture**

  《天工开物》1637年, 距今386年：菜籽入釜，文火慢炒，透出香气，然后碾碎受蒸，记录了当时榨油经验和方法



Today double low rapeseed oil

most nutritious & popular edible plant oil

① Not only for Fatty acid balance and high oleic acid

	Saturated Fatty Acids	Oleic acid（18:1,ω-9）	Linoleic acid（18:2，ω-6）	α-linolenic acid（18:3，ω-3）	ω-6/ω-3
Double low rapeseed oil	**3.5-7**	**61-70**	**15-30**	**8-14**	**2-3**
Olive oil	8.0-26.35	**55-83**	3.5-21	1.0	12
Soybean oil	10.6-21.0	**17.7-28.0**	49.8-59.0	5.0-11.0	6.8
Peanut oil	12-27.7	**35-67**	13-43	0-0.3	-
Sunflower seed oi	8.1-17	**14-39.4**	48.3-74	0-0.3	-
Sesame oil	12.7-21.1	**34.4-45.5**	36.9-47.9	0.2-1.0	71
Camellia oil	7.5-18.8	**74-87**	7-14	0	-
Rice bran oil	13.4-23.0	**40.0-50.0**	29.0-42.0	0-1.0	71
Corn oil	8.9-23.1	**20-42.2**	34-65.6	1.0	50
Grapeseed oil	8.5-19.9	**12.0-28.0**	58.0-78.0	0-1.0	-
Walnut oil	8.0-16.0	**11.6-25.5**	50.0-69.0	6.5-18.0	4.9
Cottonseed oil	24.3-32.0	**14.7-21.7**	46.7-58.2	0-0.4	-
Palm oil	43.3-57.4	**36.0-44.0**	9.0-12.0	0-0.5	42
Flaxseed oil	5.7-14.4	**13.0-39.0**	12.0-30.0	39.0-62.0	0.42

Recommended by WHO and Chinese Nutrition Society "Reference Intake of Nutrients for Chinese Residents":

ω-6/ω-3 between 1 to 6

② Rich in phytosterol, lipid-soluble vitamin and phenolics

	Rapeseed phytosterol	Campesterol	Stigmasterol	β-sitosterol	Avenasterol	Total phytosterol
Rice bran oil	6.33	226.43	132.90	735.2	157.4	1891.82
Corn oil	4.13	197.3	45.5	539.9	97.9	990.94
Rapeseed oil	136.64	267.5	25.67	394.11	40.92	864.84
Sesame oil	0	90.3	86.89	349.4	98.79	625.38
Flaxseed oil	6.8	128.41	34.37	85.63	164.95	420.16

TABLE 2.
PHENOLIC ACID CONTENT IN PLANT OIL EXTRACTS

Oil	Phenolic acid content (μg/100 g oil)*							
	Protocatechuic	*p*-hydroxybenzoic	Vanillic	Caffeic	*p*-coumaric	Ferulic	Sinapic	Sum
Soybean	nd	0.8 ± 0.03^{a}	1.1 ± 0.06^{b}	0.8 ± 0.07^{b}	1.5 ± 0.06^{a}	$1.2 \pm 0.08^{c,d}$	0.9 ± 0.03^{b}	6.3 ± 0.33^{d}
Sunflower	nd	1.5 ± 0.05^{b}	6.9 ± 0.15^{e}	4.9 ± 0.10^{e}	1.8 ± 0.06^{b}	1.3 ± 0.08^{d}	1.4 ± 0.03^{c}	17.8 ± 0.47^{g}
Rapeseed	nd	$1.6 \pm 0.05^{b,c}$	nd	0.3 ± 0.05^{a}	13.1 ± 0.12^{f}	5.6 ± 0.10^{f}	236.0 ± 0.50^{e}	256.6 ± 0.73^{i}
Corn	nd	1.7 ± 0.02^{c}	nd	nd	$1.9 \pm 0.08^{b,c}$	5.8 ± 0.10^{f}	$0.6 \pm 0.03^{a,b}$	10.0 ± 0.23^{c}
Grapeseed	nd	nd	0.8 ± 0.05^{a}	nd	nd	nd	0.2 ± 0.08^{a}	1.0 ± 0.13^{b}
Hemp	nd	6.0 ± 0.06^{e}	2.0 ± 0.10^{d}	nd	2.0 ± 0.15^{c}	$1.0 \pm 0.08^{b,c}$	3.0 ± 0.05^{d}	14.0 ± 0.44^{f}
Flax	nd	3.1 ± 0.07^{d}	1.0 ± 0.15^{b}	nd	nd	1.0 ± 0.05^{b}	nd	5.1 ± 0.27^{c}
Rice bran	nd	nd	nd	nd	nd	0.4 ± 0.03^{a}	nd	0.4 ± 0.03^{a}
Pumpkin	3.1 ± 0.15	nd	11.4 ± 0.10^{f}	nd	3.8 ± 0.06^{c}	3.8 ± 0.06^{c}	nd	22.1 ± 0.37^{h}

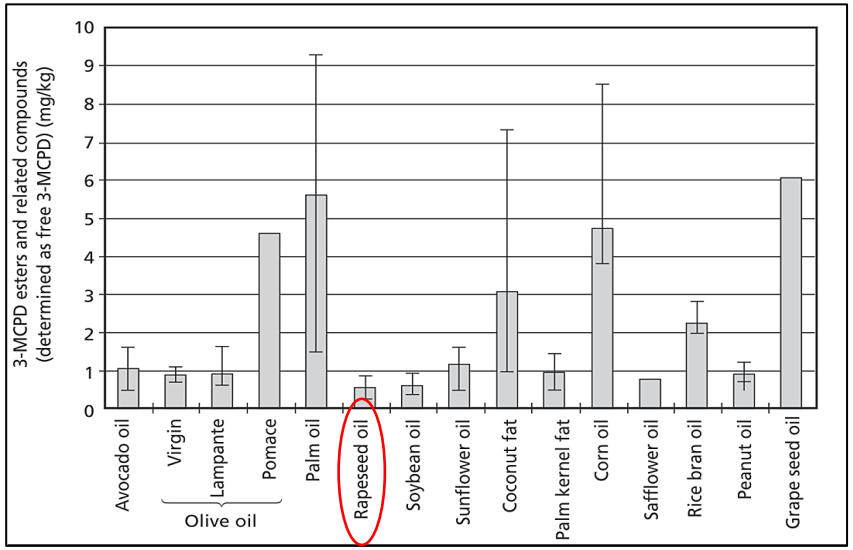
(β+γ)-VE	**38.21**	-	13.41	10.30	35.13	57.55	19.31	64.65	67.14	-	2.62
δ-VE	**11.87**	-	2.84	16.15	1.39	35.53	5.30	2.11	0.00	-	0.00

③ Low palmitic acid and contaminants in rapeseed oil

- **Rapeseed oil, almond oil, flaxseed oil, peony seed oil have low palmitic acid**
- **Low in external contaminants including e.g. aflatoxins and internal contaminants such as trans-fats, chloropropylene glycol ester and glycidyl ester**

Types of samples	n	number of non-compliant samples	non-compliance rate/%	AFB_1 contamination level	
				average	concentration range
Blended oil	123	1	0.8	6.4	1.6~22.5
Camellia oil	110	0	0	2.2	1.0~4.1
Soybean oil	132	0	0	1.3	0.7~1.6
Peanut oil	248	21	8.5	78.9	17.5~282.7
Rapeseed oil	195	0	0	0.8	0.5~1.5
Corn oil	170	2	1.2	7.3	3.6~27.8
Sesame oil	125	0	0	1.9	0.9~3.4

AFB_1 Contaminants Levels in Edible Oils



FAO/WHO 83JECFA, 2016, ROME

2.2 Utilization for edible vegetable

① Utilization of stalk for a nutritious vegetable

- **Sensory Flavor： Delicious and flavorful**
- **Nutritional value： Rich in Se, Ca, and V_C**
- **Specialized function： Benificial for male reproductivity**

② Rapeseed new varieties for both seed and stalk use rich in Ca, Zn and Se released

Analysis of 3500 rapeseed stalks from Sichuan, Yunnan, Hubei and Jiangxi showed nutritional value Variety: CiXiyuan No1, No 2, Dadi 199, Dadi 95 and Huayouza 62…

Nutritional quality (50 parameters)	● Rich in Vc、Ve、V_K ● Rich in Se、Ca、Zn ● Rich in amino acid（16 kinds）and Soluble sugars (4 kinds) ● Rich in betaine, polyphenols (5 kinds)



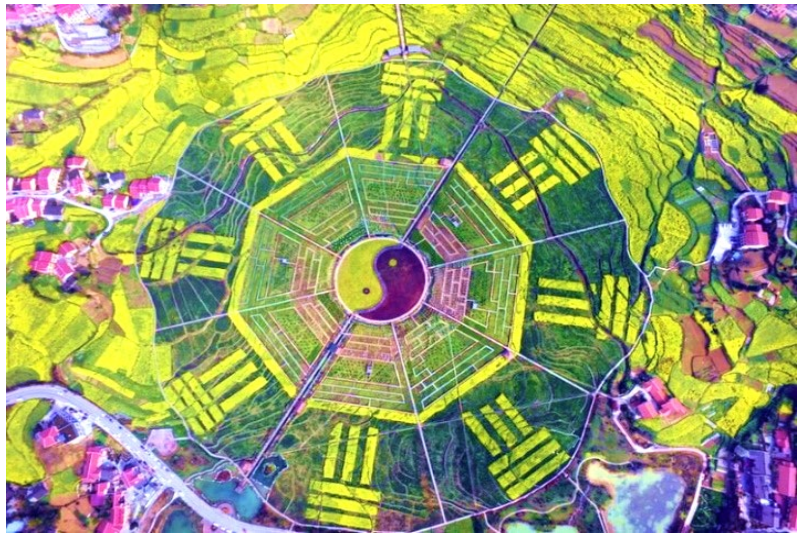
Chinese dishes from Rapeseed stalk

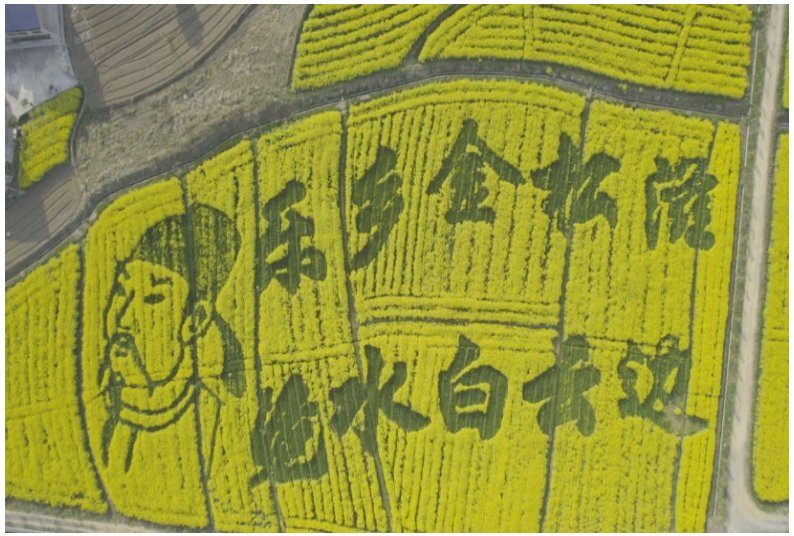
Delicacies from stalk

2.3 Utilization for flower tourism

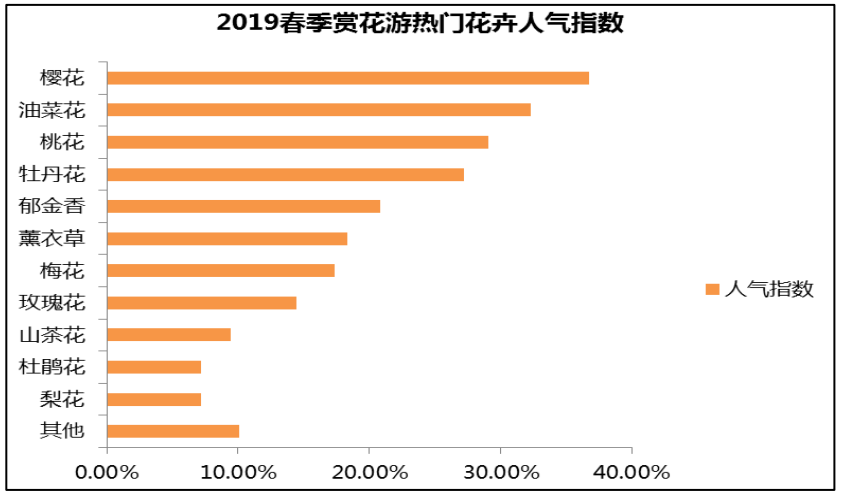
① Tourism flower varieties with 30 colors bred and planted

② Four Seasons Blooming Tech and design for tourism in resort

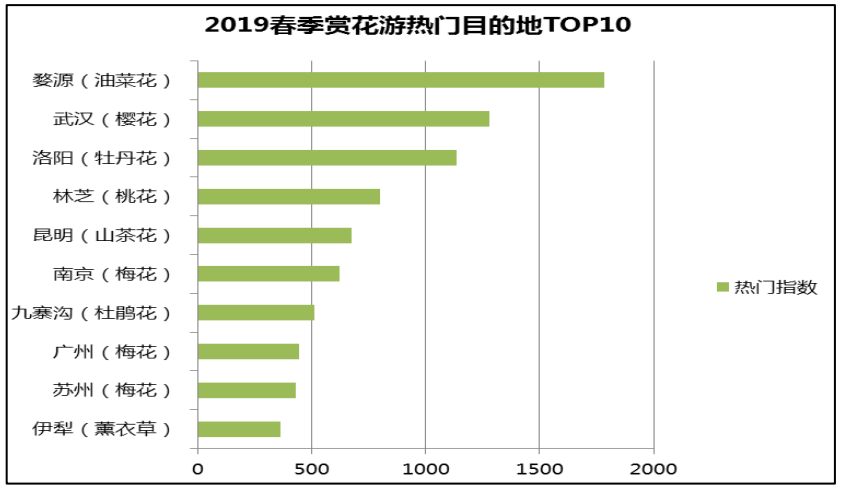




③ Tongcheng Network: rapeseed flowers are the most popular tourism flowers in China



Top Spring Flower Viewing Destinations in 2018 and 2019: Rapeseed Flowers Ranked Second in Popularity Index



Top Spring Flower Viewing Destinations in 2018 and 2019: Wuyuan (Rapeseed Flowers) Ranked First

Data source：Tongcheng Network

2.4 Utilization for green animal feeds

① Rich in nutrients compared with ryegrass and vetch

- **High crude protein in seedling and flowering stages: vetch > rape > ryegrass**
- **Low crude fiber before podding stage: rape < vetch < ryegrass**
- **High Fructose and glucose in growth stage: rape > ryegrass > vetch**

	Crude protein (%)			
	Seedling	Sedge	Flowering	Podding
Rape	27.8	23.9	15.4	8.9
Ryegrass	20.2	15.6	11.6	10.3
Vetch	31.5	31.9	31.4	25.1

	Crude fiber (%)			
	Seedling	Sedge	Flowering	Podding
Rape	9.3	11.9	16.4	28.3
Ryegrass	16.5	15.1	17.5	28.6
Vetch	14.6	14.5	16.6	22.6

	Total sugar (g/100g)			
	Seedling	Sedge	Flowering	Podding
Rape	**34.2**	**25.3**	**14.8**	**13.7**
Ryegrass	**14.3**	**15.2**	**9.5**	**7.7**
Vetch	**12.7**	**6.5**	**6.0**	**5.7**

Fructose and glucose enhance palatability and provide more energy

② Higher glutamic acid, lysine and histidine than ryegrass

氨基酸 Amino acids	苗期seedling stage			薹期sedge period			花期flowering stage			结荚期podding stage		
	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch
天门冬氨酸Asp	2.05	1.84	3.18	1.24	0.78	2.39	0.66	0.45	1.71	0.88	1.06	1.45
苏氨酸Thr	0.97	0.84	1.27	0.60	0.38	0.81	0.35	0.25	0.76	0.34	0.41	0.56
丝氨酸Ser	0.95	0.79	1.30	0.59	0.37	0.85	0.35	0.24	0.80	0.36	0.43	0.59
谷氨酸Glu	3.68	2.25	3.62	2.19	1.01	1.87	0.89	0.62	1.72	1.84	2.23	3.03
甘氨酸Gly	0.99	0.91	1.32	0.64	0.43	0.90	0.37	0.27	0.88	0.40	0.47	0.64
丙氨酸Ala	1.22	1.19	1.61	0.84	0.56	0.99	0.44	0.36	0.94	0.40	0.49	0.67
缬氨酸Val	0.01	0.02	0.05	0.76	0.50	0.96	0.45	0.32	0.92	0.42	0.51	0.69
蛋氨酸Met	1.30	1.05	1.60	0.10	0.17	0.22	0.06	0.08	0.18	0.07	0.08	0.11
异亮氨酸Ile	0.12	0.18	0.19	0.53	0.40	0.77	0.28	0.21	0.71	0.29	0.36	0.48
亮氨酸Leu	0.72	0.61	0.98	1.17	0.80	1.50	0.59	0.46	1.38	0.59	0.72	0.97
酪氨酸Tyr	0.41	0.34	0.57	0.76	0.58	1.05	0.44	0.41	0.90	0.10	0.13	0.16
苯丙氨酸Phe	0.99	0.93	1.42	0.40	0.23	0.27	0.22	0.15	0.36	0.36	0.44	0.59
赖氨酸Lys	1.69	1.31	2.26	1.04	0.57	1.33	0.56	0.39	1.21	0.52	0.63	0.86
组氨酸His	0.50	0.43	0.66	0.24	0.15	0.35	0.14	0.09	0.33	0.13	0.16	0.22
精氨酸Arg	1.17	1.24	1.71	0.67	0.40	0.90	0.34	0.23	0.81	0.52	0.62	0.85
脯氨酸Pro	0.78	0.64	0.87	0.65	0.17	0.51	0.25	0.15	0.89	0.18	0.55	0.78
必需氨基酸 Essential amino acids	5.80	4.94	7.77	4.60	3.06	5.84	2.53	1.86	5.52	2.58	3.14	4.27
总氨基酸 total amino acids	17.55	14.55	22.62	12.44	7.51	15.67	6.41	4.70	14.49	7.40	9.29	12.67

③ Rich in Ca, Mg, Se and with lowest Cu

- **Benifiting for animal bone development and growth**

元素 Elements	苗期seedling stage			薹期sedge period			花期flowering stage			结荚期podding stage		
	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch	油菜 rape	黑麦草 ryegrass	光叶苕子 vetch
钙Ca，mg/kg	18755	5472	14346	13816	4256	12600	7684	3707	8737	11577	4154	8971
铁Fe，mg/kg	676	912	2444	206	733	1524	119	572	570	105	137	277
钾K，mg/100g	2442	2562	2454	2266	2858	2714	2678	3139	3527	2709	3373	3075
镁Mg，mg/kg	5312	1890	6328	2319	1487	2758	1873	1263	2346	2233	1504	2855
锰Mn，mg/kg	144	162	420	123	190	352	49	140	244	39	109	141
钠Na，mg/100g	555	802	63	340	602	16.5	139	323	8.7	63.7	250	14.3
锌Zn，mg/kg	40.5	36.1	130.0	36.8	37.4	101.5	23.6	19.2	59.3	26.3	27.3	75.3
硒Se，mg/Kg	0.156	0.172	0.288	0.0968	0.225	0.181	0.104	0.138	0.125	0.0893	0.0989	0.0979
铜Cu，mg/kg	4.84	10.50	15.10	4.55	9.94	66.7 0	9.96	17.90	19.10	7.87	8.99	12.40

Gain weight, protein and bull reproduction improved

- **Beef cattle：** 3kg and 5kg rapeforage increased daily weight 28.2% and 31.5%, respectively
- **Dairy cow：** Increase milk production and protein content, while reduce milk fat content
- **Bull：** Feeding rape to bulls resulted in a 40% increase in semen production
- **Pigs：** an increase weight of 51.34g/day (1540g/month) with 14.82% growth rate
- **Laying hen：** Egg increased by 22.1% with thicker eggshell and more yellow yolk

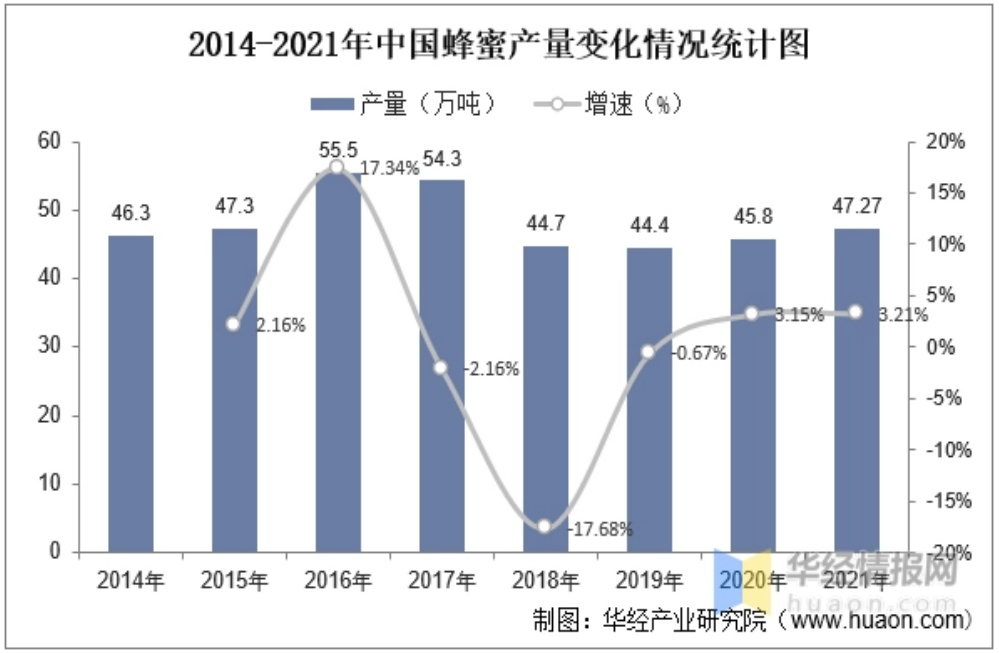


Date Source: Professor Zhou Guangsheng from Huazhong Agricultural University

2.5 Utilization for honey industry

① Rape honey contributes 40% of total honey production in China

- China total honey 450,000 tons/y, rape flower is the largest nectar source
- Bee helping pollination also enhances the yield of rapeseed



② Rape pollen utilized for prostate medicine

- **Annual rape pollen production ranges from 2000 to 2500 tons**
- **Rich in nutritional functional components**

(1) Enhance human immunity
(2) Anti-aging and cosmetic effects
(3) Prevent cerebrovascular and cardiovascular diseases
(4) Prevent prostate diseases
(5) Weight loss
(6) Regulate gastrointestinal function
(7) Liver protection
(8) Regulate nervous system, promote sleep
(9) Assist in the treatment of other diseases

2.6 Utilization for green manure

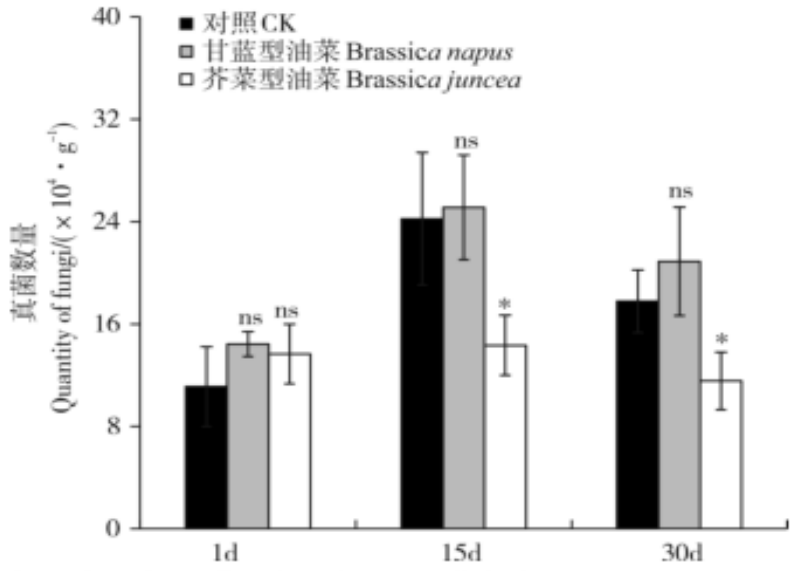
Rapeseed green manure with great potential for soil improvement

- High plant yield and improve soil fertility and quality
- Beneficial to reduction of chemical fertilizer and soil-borne diseases

Region	Cropping system	Years of cultivation	Increase in soil organic matter (g/kg)	Crop yield increase (%)	Source
Hunan	rape-rice-rice	27	1.81	10.6	Yang Zengping et al., 2011
Jiangxi	rape- rice - rice and rapeseed - rice- rice rotation	8	3.70	7.2	Xu Minggang et al., 2015
Zhejiang	rape-rice	4	4.52	11.0	Danying Wang et al., 2011
Hunan	rape-rice	2	/	16.4	Huang Pingna et al., 2010

Beneficial to mitigate pests and soil-related diseases

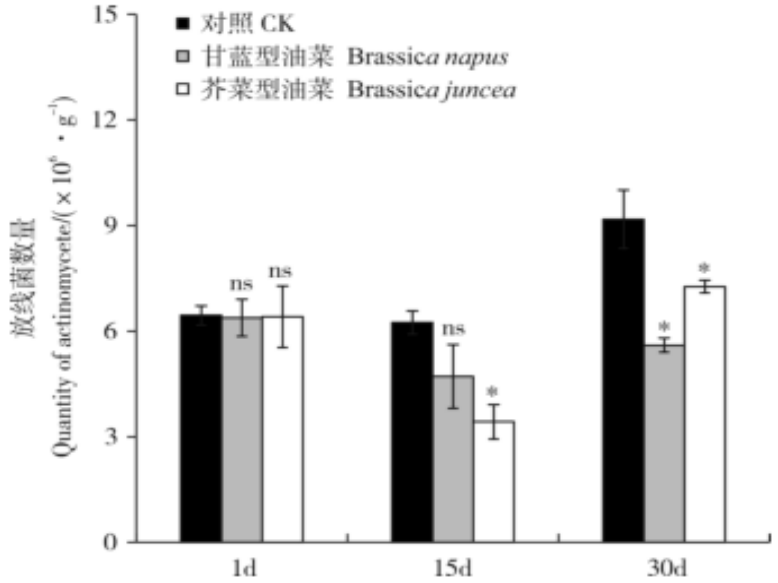
- **Isothiocyanates (ITCs) from raperoot beneficial to control fungal pathogens, restrain soil-borne pathogens, and suppress soil-related diseases**



注：ns为差异不显著；*为差异达5%显著水平

Note: ns: not significant; *: significant differences at 0.05

图4　盆栽模拟还田后土壤微生物中真菌的变化



注：ns为差异不显著；*为差异达5%显著水平

Note: ns: not significant; *: significant differences at 0.05

图5　盆栽模拟还田后土壤微生物中放线菌的变化

Planting green manure rapeseed before chrysanthemums

2.7 Utilization for sand-storm reduction

① In North-China rape used for sand fixation and sand-storm reduction

Fruit-rapeseed intercropping model for pest control

2.8 Utilization for saline-alkali land improvement

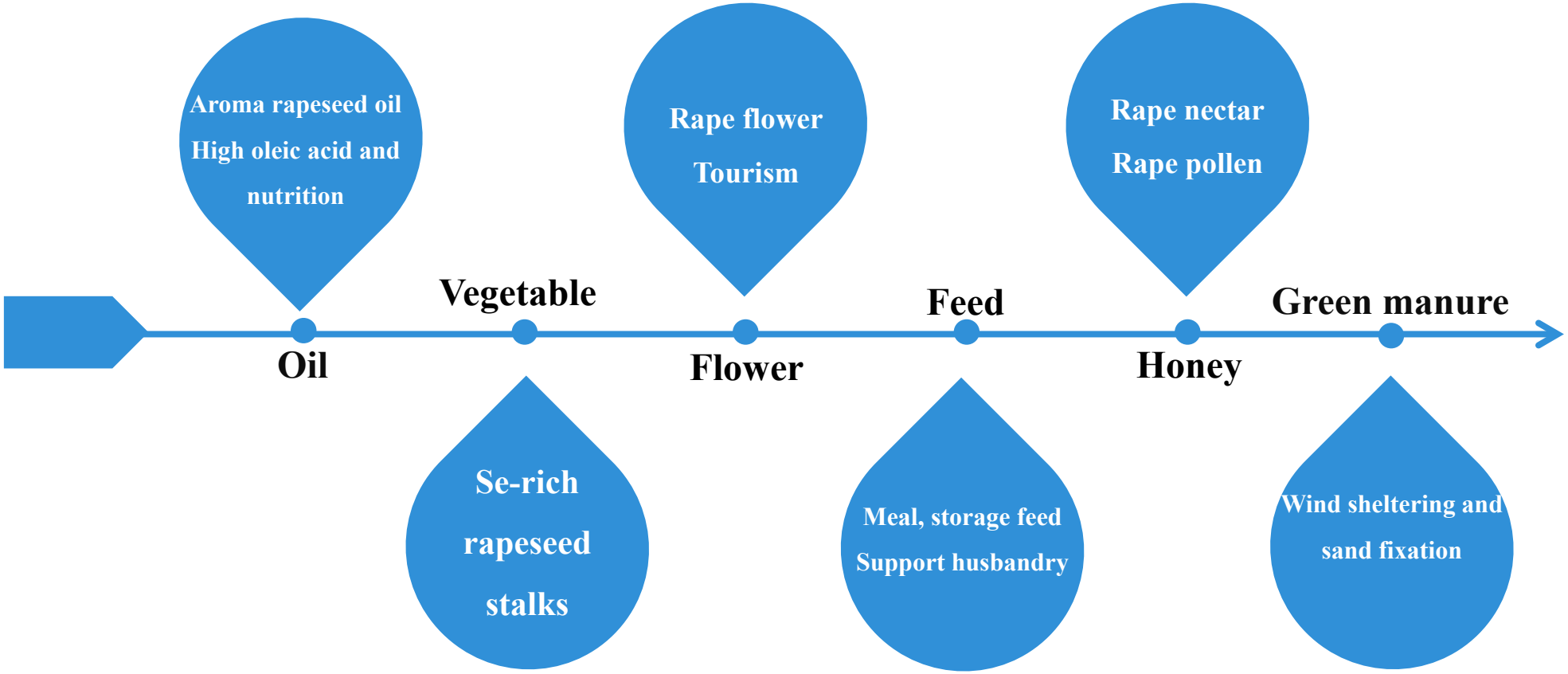
Saline-alkali land improvement by rapeseed plantation

- **Huayouza 62, Siyou 2, and Huayouza158 could grow normally in saline-alkali lands with a pH of 10 - 11.2 and a salt concentration upto 0.5% - 0.7%**

Beitun, Xinjiang Province,China

3. Prospects of Rapeseed Industry in China

Rapeseed Multi-uses Chain facilitated the diversified efficient rape industry



The Future of rapeseed industry in China

- **Rapeseed Multi-utilization for edible oil, vegetable, flower-tourism, feed, honey, green manure, sand fixation and saline-alkali land improvement…**
- **Set up the whole rapeseed industry chain for not only for edible oil, also for soil fertility, agri-tourism, culture-tourism and beautiful countryside environment**

Which can promote the high-quality and sustainable development of rapeseed industry in future

Thank you for your attention!