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On the front cover:

Watercolor of a cucumber, whole and sliced, attributed to Jacques Le Moyne de Morgues, French school, ca. 1575. Used with permission from the Victoria and Albert Museum, London.

The **Cucurbit Genetics Cooperative** (CGC) was organized in 1977 to develop and advance the genetics of economically important cucurbits. Membership to CGC is voluntary and open to all individuals who have an interest in cucurbit genetics and breeding. There are no annual dues. An informal membership list is maintained. If you are interested in becoming a CGC member and receiving email communications concerning CGC, including calls for new contributions to the CGC Report, please contact CGC Chair Amnon Levi at amnon.levi@ars.usda.gov.

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Should the Unpublished Name *Citrullus lanatus* subsp. *vulgaris* var. *megalospermus*, for the ZiGua Seed-Snack Variety from China, be Validated?

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Scientific names must be linked to permanently preserved and publicly accessible type material so that future generations will be able to link research results to unambiguously named organisms. In China, a variety of watermelon with large, red or black seeds is sold as a snack, called 'ZiGua' (Fig. 1). The variety appears to have been first mentioned in 1985 by De Pei Lin (1939 – present) and Rui Tang Chao (1939 – 2004), who had seen ZiGua watermelons being grown by local Uygur farmers in North Xinjiang. Unfortunately, their attempt to name ZiGua watermelons did not fulfil the rules of nomenclature that were in effect in 1985. Those rules required a Latin diagnosis (a few words pointing to some trait differentiating the variety, for example, its large seeds) and citation of a permanently-preserved specimen accessible in an herbarium. Lin and Chao failed to cite a herbarium specimen and provided no Latin diagnosis, and their name therefore is not validly published.

The ZiGua seed-snack watermelon differs from other Asian cultivars in its consistently large and numerous seeds. The seeds are eaten lightly salted, roasted, or sometimes coated in licorice extract. The fruit rind and pulp are discarded, but efforts are underway to use these by-products for making watermelon juice (Zhang et al., 2016; Wang et al., 2018). A video showing the preparation of ZiGua is here: https://www.youtube.com/watch?v=DV6y2pPv76I

Herbarium material does not permit distinguishing ZiGua watermelons from other subspecies of *Citrullus lanatus*, but this would not prevent naming the variety since the Code of Nomenclature for algae, fungi, and plants (https://www.iapt-taxon.org/nomen/main.php) does not require traits recognizable in dead (dried) material. Instead, traits obtainable from living material or from nuclear DNA can also be used. Since 1 January 2012, Latin is no longer required either. Instead, diagnoses can be given in English.

Several hundred Chinese watermelon cultivars as well as material from outside China and even from 6000-year-old seeds have been re-sequenced (Guo et al., 2019; Renner et al. 2021; Pérez-Escobar et al., 2022), including several ZiGua watermelons (WM151, WM196, WM197, WM199, WM201, WM202, WM205, WM206, and WM280 in Guo et al. 2019: Tables S5 & S6). So far, however, it has not been possible to detect mutations (alleles) that would characterize all ZiGua watermelons. This makes it difficult to write a diagnosis based on some genomic feature.

The watermelon seed-processing industry in China is developing rapidly because of an increasing market for this snack. By 2015, the area under cultivation had increased from140,000 ha in 1996 to 320,000 ha (Zhang et al., 1996; Chen et al., 2015). A single plant can bear about 2-3 mature fruits with an average weight of 2.3 kg (Wang et al., 2018) and 100-200 seeds per fruit (Liu et al., 2018). They are harvested using seed-melon harvesters and seed extracting machines (Zhao et al., 2017). Black-seeded ZiGua watermelons are grown mainly in northwest China (Gansu, Xinjiang, Inner Mongolia and Ningxia), while red-seeded ZiGua are more popular in southern China (Guangxi, Anhui, Jiangxi, Hunan). The seeds are rich in protein, crude fat, multiple vitamins, and minerals (Li et al., 2020). The variety is thought to have been cultivated for some 350 years (Chen et al., 2015).

Perhaps once a *de novo* high-quality genome for ZiGua watermelons has been produced, a unique genetic trait will be found that could serve to diagnose the taxon. However, under the current Code of Nomenclature, herbarium specimens are still required, and any *de novo* genome should thus be linked to one or more herbarium specimens deposited in Chinese herbaria as well as herbaria outside China.

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Figure 1. The only known permanent record of ZiGua watermelon material, deposited in the herbarium of Munich, Germany.

North Carolina Performance Trials for Cultivars of Parthenocarpic Pickling Cucumber

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Introduction

Traditionally, cucumber cultivars have been sold as a blend of gynoecious (88%) and monoecious (12%) hybrids to provide sufficient pollen for uniform fruit set (Wehner and Maynard, 2003). This type of production system has the disadvantage of requiring insect pollinators and using valuable field space for lower yield pollenizers (moneocious hybrid).

Parthenocarpy, the ability of plants to form fruits without pollination or fertilization, has been identified in cucumber since the early 1900s (Gustafson, 1942; Pandolfini et al., 2009). Originally, poor fruit quality such as soft fruit and bloating during brining negatively impacted adoption of parthenocarpic pickling cucumbers. Yet the potential advantage of parthenocarpic cucumber to produce uniform seedless fruit in the absence of monoecious pollenizers and insect pollinators, could increase both fruit yield and quality. The development of fruit without pollination permits earlier and more uniform fruit production (Pandolfini et al., 2009). Traditional breeding has significantly improved fruit quality characteristics, making parthenocarpic cucumbers more attractive to producers in the U.S. There is no need for growers to provide hives of honeybees to pollinate the crop in each field. Higher yields along with higher fruit quality make parthenocarpic cultivars an attractive alternative for pickling cucumber growers.

Cultivars are commercially available from seed companies including: Bejo Seeds, Nunhems, Rijk Zwaan, Seminis, HortAg, and US Agriseeds. Seeds of parthenocarpic pickling cultivars from these companies were obtained to evaluate performance in two years and two seasons in North Carolina. The objective of this study was to determine the best performing cultigens in trials run in North Carolina of the parthenocarpic types available.

Methods

The study was conducted at the Cunningham Research Station in Kinston, North Carolina to evaluate yield and quality of parthenocarpic pickling cucumber cultivars for production in North Carolina. Soils were a Norfolk loamy sand (Typic Kandiudults) (Natural Resources Conservation Service, 2017).

2014. Spring plots were sown on 6 May. Harvests were made on 20, 24, 27, 30 June and 3, 8, 11, 15 July. Summer plots were sown on 17 June. Harvests were made on 25, 28, 31 July, and 4, 11, 15 August.

2015. Spring plots were planted 19 May. Harvests were made on 23, 26, 29 June, 3, 7, 10, 14, and 20. Summer plots were planted 25 June. Harvests were made on 31 July, 4, 7, 11, 14, 18, 21, and 25 August.

Cultural Practices. Plots were planted on raised beds covered in black plastic mulch in 2014. In 2015, spring plots were planted on black plastic mulch and summer plots were on white plastic mulch. Plots were 6 m long and on 1.5 m centers. We over-seeded plots by 15% of the desired planting density (49,000 plants/ha) at a depth of 10-15 mm and covered by hand. At 15 days after planting (DAP), plots were thinned to 49,000 plants/ha. Standard production practices were followed (Schultheis et al., 2000). Plots were harvested eight times (six in the summer season of 2014).

Fruit yield and fresh fruit quality. At each harvest, fruit were collected and separated into grades 1 (0 to 27 mm), 2 (28 to 38 mm), 3 (39 to 51 mm), 4 (greater than 51 mm in diameter; oversize), and misshapen culls (nubbins, crookeds) (Wehner, 1986). Weights were summed by grade for each plot. Five grade 2 fruits were measured to determine average length: diameter ratio of each plot. Fruit firmness was measured on three grade 3 fruit using a Magness-Taylor tester with an 8 mm (5/16”) tip.

Brined fruit quality, bloater, and defect evaluation. After data collection at the second, fourth, and sixth harvest, fruit of each cultivar were combined over replications in a burlap sack and transported to Mt. Olive Pickle Company in Mt. Olive, North Carolina to be brined for later evaluation of fruit quality.

In November of both years, cucumber industry personnel were invited to Mt. Olive Pickle Company to judge the brined fruit quality of the cultivars. There were nine judges in 2014 and 11 judges in 2015. Fruit quality was rated 1-9 (1 = poor, 5 = average, 9 = excellent) for categories including fruit shape, exterior color, seed cell size, fruit uniformity, and fruit texture. Those ratings were averaged for an average quality rating. Fruit firmness was measured on ten grade 3 fruits using a Magness-Taylor tester with an 8 mm (5/16") tip.

Longitudinal cross sections of ten to twenty grade 3 fruit were evaluated for bloaters (balloon, lens, honeycomb) and defects (blossom-end, placental hollows, soft centers). Estimates of total volume as a percentage of each fruit that was damaged were recorded.

Disease ratings. In 2015, disease ratings were taken twice for symptoms of downy mildew (causal agent *Pseudoperonospora cubensis*) and once for symptoms of anthracnose (causal agent *Colletotrichum orbiculare*). Disease ratings were from 0 to 9, with 0 meaning no disease, 1-2 meaning trace, 3-4 slight, 5-6 moderate, 7-8 severe, and 9 dead.

Spininess. The level of spininess or number of spines on the fruit surface was rated in the field in two independent ratings with a 0 to 9 scale (0 = no spines, 3 = few spines, 5 = moderate spines, 7 = numerous spines).

Data analysis. Data were subjected to PROC MEANS and GLM (ANOVA) using SAS v 9.4 (SAS Institute, Cary, NC). Years were analyzed separately. Fruit value ($/ha) was calculated based on the weight of the marketable fruit (grades 1, 2, and 3, excluding cull and oversize). Early yield percentage, total yield, total marketable yield, and corresponding dollar values were calculated based on the first two harvests and all harvests, respectively. Fruit value of each grade was determined using industry values (P. Denlinger, 2016, Mt. Olive Pickle Co., NC, personal communication, 2016), and that was used to calculate total and early fruit value. The values used for grades 1, 2 and 3 were $13.50/bu, $8.50/bu, and $6.00/bu, respectively.

Results

Parthenocarpic pickling cucumbers have potential for commercial field production in the United States. Seed companies including Rijk Zwaan, Nunhems, and Seminis Vegetable Seeds have developed cultivars suitable for production in the southeast U.S. Before growers are likely to purchase seed that is four times more expensive than conventional ($12 for seedless vs. $3 for seeded) (Chris Dyk, personal communications; Bayer Crop Science), evaluation of production methods and quality metrics are needed. Parthenocarpic cucumber cultivars evaluated in this study showed large variability in fruit quality traits and yield between years and seasons, but also demonstrated high quality and return value when planted at recommended densities.

Fresh fruit evaluations: Early dollar value was affected by season and cultivar in both 2014 and 2015 (Table A4.1). Values ranged from $316 to $2177 per hectare to $816 to $7280 in 2014 and 2015, respectively (Table 1, 2). Desired planting density was not achieved for eight of the 17 cultivars tested in 2014, which explained, in part, the lower range in early dollar value for that year. Cultivars that consistently performed well for earliness achieving 40 (2014)/ 30 (2015) percent or greater of the total tonnage in the first two harvests included: 12-109, Gershwin, and Puccini. While some other cultivars did have higher yields in 2014 or 2015, they were not consistent. Total dollar value for all cultivars ranged from $1989 to $4423 per hectare in 2014 to $16,008 to $19, 903 per hectare in 2015. Planting density was a contributing factor for the reduced total dollar value in 2014. The percentage of oversize fruit was not consistent with any of the cultivars tested between years, though the highest percentage of culls (15-21%) was seen in cultivars Gershwin and Puccini. Cultivar consistently affected percent culls, but season and year also contributed to variability observed.

Fruit shape (length:diameter ratios) varied among cultivars and years. Cultivars that consistently produced long fruit (L:D ratios of 3.7 to 4.0) included: Gershwin (Rijk Zwaan) (Table 3, Table 4). Cultivars with fruit with a L:D consistently > 3.2 included: Merengue, Puccini, 12-109, Wagner, Stravinsky. Fresh fruit firmness also varied among years with highest firmness in fresh fruit observed in cultivars 12-109, Surya, Gershwin, NCSU-01, and Wagner (80 to 92 N) in 2014 and RZ-13, Stravinsky, Surya, and Wagner (87-9 4N) in 2015.

For all cultivars, downy mildew ratings were between 4 and 6 (Table 5), indicating moderate disease severity. Cultivars with low (3) one-time ratings for anthracnose symptoms included: 10-170, 20002, Surya, and Wagner. Disease and spininess ratings were only conducted in 2015. Cultivars with numerous spines (7 to 9) included: 10-170, Atik, Karaoke, NUN0001, NUN2001, NUN2002, Liszt, Rubinstein, and RZ-17 (Table 5). Cultivars judged moderately spiny (4 to 6) included: NQ5007, RZ-12, RZ-15, and Merengue. Cultivars with few spines included: 21-340, 20002, 12-109, Bowie, Gershwin, Puccini, RZ-13, Stravinsky, Surya, and Wagner.

Brined fruit evaluations: Most of the brined fruit evaluations were affected, in part, by judge and cultivar, with the exception of bloater ratings (Table 3, 4). Though exact ratings varied, judges were in agreement between high and low quality brined fruit of the cultivars evaluated for shape, exterior, texture, seed cell, and uniformity. Average quality ratings for brined fruit were highest (6.3 to 6.6) for cultivars: 12-109, Gershwin, and Stravinsky (Table 7, Table 8). Brined fruit texture ratings were highest for cultivars 12-109 and Stravinsky. Only cultivar Gershwin consistently was rated high for uniformity across both years.

Brined fruit firmness was highest (90 to 102 N and 98 to 112 N in 2014 and 2015, respectively) for cultivars Puccini, Gershwin, Karaoke, Wagner.

Overall, only cultivar Gershwin consistently had high quality (pre and post brining) and early return across both years evaluated. However, several cultivars that were not tested in both years performed well for yield, quality, and disease resistance. Those cultivars should be tested further for possible use in North Carolina production.

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Table 1. Fruit yield of parthenocarpic pickling cucumbers tested in Kinston, North Carolina for spring and summer seasons of 2014 (cultivars are ranked by dollar value summed over 8 harvests).

		Yield summary					Fruit grade distribution (percentage by weight)						
		Harvests 1 & 2		Harvests 1-8			Harvests 1-8						
Cultivar	Seed source	% of Mg/ha total	$/ha	$/ha	Mg/ha Total	Mg/ha Marketable	Culls	No. 1	No. 2	No. 3	No. 4	Marketable	thp/ha
12-110	Rijk Zwaan	52[z]	1973	4423	13	11	17	17	44	20	2	81	50
12-109	Rijk Zwaan	54	1923	3999	11	9	16	21	45	17	1	82	42
Merengue	Seminis	46	1465	3979	12	11	13	10	43	31	2	85	44
Puccini	Rijk Zwaan	60	2177	3937	13	10	21	12	38	26	2	76	48
Surya	Rijk Zwaan	45	1439	3777	12	9	19	15	43	20	4	78	49
Gershwin	Rijk Zwaan	53	1444	3615	11	9	21	14	47	18	0	79	44
NUN-55007	Nunhems	49	1493	3597	13	10	13	10	35	38	5	82	42
USACR10540	US Agriseeds	34	1102	3519	13	10	16	8	34	30	12	72	41
2943	Bejo Seeds	44	1105	3404	11	9	12	10	48	25	4	84	39
Karaoke	Rijk Zwaan	27	740	3389	11	9	13	14	42	25	6	80	35
Artist F1	Bejo Seeds	41	984	3301	11	9	18	18	43	19	2	80	34
NCSU-01	NC State	24	738	3280	11	9	9	8	30	28	9	79	28
Wagner	Rijk Zwaan	27	922	3114	9	8	11	17	37	17	1	85	42
Stravinsky	Rijk Zwaan	50	1095	2642	8	6	24	15	40	20	1	75	36
HSX-4415-2	Hort Ag	16	316	2124	7	5	9	14	31	19	10	77	24
Ansor F1	Bejo Seeds	40	572	2031	7	5	17	17	48	16	2	81	30
Aviator F1	Bejo Seeds	31	416	1989	6	5	11	15	56	17	1	89	27
Mean		40	1171	3301	11	9	16	14	41	23	4	80	39
LSD (5%)		16	598	1360	4	4	7	8	11	11	6		10

[z]Data are means of three replications from either harvest 1 and harvest 2 or harvests 1 through 8.

Table 2. Fruit yield of parthenocarpic pickling cucumbers tested in Kinston, North Carolina for spring and summer seasons of 2015 (cultivars are ranked by fruit value).

		Yield summary					Fruit grade distribution (percentage by weight)					
		Harvests 1 & 2		Harvests 1-8			Harvests 1-8					
Cultivar	Seed source	$/ha	% of total	$/ha	Total (Mg/ha)	Marketable (Mg/ha)	Culls	No. 1	No. 2	No. 3	No. 4	Marketable
Wagner	Rijk Zwaan	6532[z]	31	19903	59	51	11	13	49	25	3	86
Surya	Rijk Zwaan	4888	25	19786	56	49	9	15	51	21	4	87
Gershwin	Rijk Zwaan	6084	32	19746	63	51	16	11	47	22	4	80
Bowie	Rijk Zwaan	6662	34	19267	56	49	10	13	51	24	2	88
10-170	Bejo Seeds	5021	29	18862	54	49	4	12	54	25	6	90
RZ-17	Rijk Zwaan	4835	26	18221	50	46	7	15	53	23	3	91
Liszt	Rijk Zwaan	4105	20	18075	54	48	5	11	45	31	8	87
Stravinsky	Rijk Zwaan	7280	40	17049	57	46	16	10	37	31	6	79
12-109	Rijk Zwaan	6239	36	16321	51	42	15	13	45	24	3	82
Karaoke	Rijk Zwaan	3436	21	16009	53	44	7	8	41	34	10	83
NUN0001	Nunhems	5693	37	16008	49	43	7	10	45	32	6	87
RZ-15	Rijk Zwaan	6374	41	15614	51	41	15	11	42	28	5	80
Rubinstein	Rijk Zwaan	3104	20	15288	46	40	6	12	48	27	7	87
Puccini	Rijk Zwaan	4889	33	15034	52	40	17	11	41	25	7	77
RZ-12	Rijk Zwaan	4557	33	14682	50	40	9	9	37	35	10	81
RZ-13	Rijk Zwaan	5238	40	13282	41	35	12	11	44	29	4	84
Merengue	Seminis	2523	20	13090	41	35	6	11	42	33	9	86
NQ5007	Nunhems	3416	26	13080	46	36	7	7	37	35	14	79
Atik	Bejo Seeds	1396	12	12605	41	35	5	8	42	34	10	84
21-340	Bejo Seeds	3067	23	12396	43	34	9	8	38	32	12	79
20002	Rijk Zwaan	4333	34	11650	39	29	20	12	41	22	5	75
NUN2001	Nunhems	1631	15	11395	48	33	9	4	27	39	21	69
NUN2002	Nunhems	816	8	10746	35	29	7	9	41	33	10	83
Mean		4440	28	15570	49	41	10	11	43	29	7	83
LSD (5%)		1946	9	4084	13	11	3	3	5	6	4	4

[z]Data are means of three replications.

Table 3. Fruit quality data collected on fresh and brined parthenocarpic pickling cucumber cultivars, 2014.

					Judged brinestock quality					
Cultivar	Seed source	Length:diameter	Fresh firmness (N)	Brined firmness (N)	Average	Shape	Exterior	Texture	Seedcell	Uniformity
2943	Bejo Seeds	3.0[z]	65	66	5.7	5.2	6.1	5.4	5.4	6.5
Ansor F1	Bejo Seeds	3.3	61	65	5.5	4.6	5.6	5.6	6.1	5.6
Artist F1	Bejo Seeds	3.3	59	61	5.5	4.9	5.4	5.4	6.3	5.4
Aviator F1	Bejo Seeds	2.9	53	60	5.7	4.5	5.7	6.0	6.2	6.1
HSX-4415-2	Hort Ag	2.9	67	80	5.0	4.1	4.2	5.7	5.7	5.4
NCSU-01	NC State	3.2	80	91	5.6	5.8	5.5	5.2	5.3	6.2
NUN-55007	Nunhems	3.8	71	83	5.6	5.4	6.2	5.2	5.7	5.7
12-109	Rijk Zwaan	3.8	92	99	6.3	5.2	6.5	6.9	7.0	5.9
12-110	Rijk Zwaan	4.0	77	99	6.3	5.6	6.2	6.8	7.0	6.1
Gershwin	Rijk Zwaan	3.8	86	98	6.3	5.5	6.3	6.7	6.8	6.1
Karaoke	Rijk Zwaan	3.1	73	90	5.5	4.9	5.1	5.8	5.7	5.8
Puccini	Rijk Zwaan	3.5	71	96	5.9	5.3	6.1	6.4	6.3	5.6
Stravinsky	Rijk Zwaan	3.4	73	94	6.5	5.6	6.5	7.3	7.3	6.0
Surya	Rijk Zwaan	3.3	83	102	6.6	6.1	6.5	7.1	7.1	6.2
Wagner	Rijk Zwaan	3.5	85	97	6.4	6.3	6.4	6.4	6.6	6.3
Merengue	Seminis	3.5	64	64	5.6	5.6	5.9	5.1	5.6	5.8
USACR10540	US Agriseeds	3.3	70	87	5.7	5.6	5.7	5.6	5.4	6.0
Mean		3.4	51	84	5.9	5.3	5.9	6.0	6.2	5.9
LSD (5%)		0.3	13	12	0.3	0.6	0.4	0.5	0.5	0.4

[z]Data are means of three replications (taken from harvests 2, 4 and 6).

Table 4. Fruit quality data collected on fresh and brined parthenocarpic pickling cucumber cultivars, 2015.[z]

					Judged brined quality					
Cultivar	Seed source	Length:diameter	Fresh firmness (N)	Brined firmness (N)	Average	Shape	Exterior	Texture	Seed cell	Uniformity
10-170	Bejo Seeds	3.3	78	91	6.0	5.7	5.6	6.2	6.3	6.1
21-340	Bejo Seeds	3.4	82	94	4.7	4.3	4.1	5.1	5.2	4.6
Atik	Bejo Seeds	3.3	71	81	5.4	5.3	5.3	5.4	5.3	5.9
NQ5007	Nunhems	4.0	71	91	5.1	5.1	4.7	5.2	5.5	5.2
NUN0001	Nunhems	3.7	80	96	5.3	5.4	5.8	4.8	5.3	5.5
NUN2001	Nunhems	3.6	77	88	5.6	5.6	5.3	5.5	5.7	5.9
NUN2002	Nunhems	3.7	75	85	5.5	5.1	4.6	5.9	5.9	5.8
20002	Rijk Zwaan	3.5	83	98	5.4	4.9	5.0	5.8	6.0	5.1
12-109	Rijk Zwaan	3.5	92	104	5.6	5.3	5.4	6.2	5.7	5.5
Bowie	Rijk Zwaan	3.8	82	90	5.7	5.3	6.0	5.7	5.8	5.8
Gershwin	Rijk Zwaan	3.7	82	104	6.0	5.6	6.0	6.1	6.3	5.8
Karaoke	Rijk Zwaan	3.3	83	102	5.6	5.7	4.3	5.8	6.0	5.9
Liszt	Rijk Zwaan	3.7	66	74	5.9	6.3	5.1	5.9	6.2	6.2
Puccini	Rijk Zwaan	3.4	81	100	5.8	5.5	5.7	6.1	6.2	5.6
Rubinstein	Rijk Zwaan	3.7	77	80	5.4	5.4	5.3	5.3	5.3	5.6
RZ-12	Rijk Zwaan	3.7	77	88	5.0	4.9	4.6	5.5	5.2	5.1
RZ-13	Rijk Zwaan	3.5	94	99	5.4	5.2	5.9	5.3	5.1	5.6
RZ-15	Rijk Zwaan	3.6	79	88	5.8	5.9	5.7	5.8	6.0	5.8
RZ-17	Rijk Zwaan	3.2	66	70	5.3	5.0	4.8	5.1	5.5	5.9
Stravinsky	Rijk Zwaan	3.6	84	88	5.6	5.0	5.9	6.1	5.7	5.3
Surya	Rijk Zwaan	3.6	91	95	5.4	5.1	5.3	5.7	5.8	5.1
Wagner	Rijk Zwaan	3.8	87	112	5.5	5.5	5.7	5.4	5.5	5.5
Merengue	Seminis	3.5	63	77	5.5	5.7	4.7	5.7	5.9	5.6
Means		3.6	79	91	5.5	5.3	5.3	5.6	5.7	5.6
LSD (5%)		0.1	9	15	0.4	0.7	0.5	0.6	0.6	0.6

LSD = least significant difference

[z]Data are means of three replications (taken from harvests 2, 4 and 6).

Table 5. Disease and spininess ratings for parthenocarpic pickling cucumber cultivars, 2015.

		Disease Rating		
Cultivar	Seed Source	Downy Mildew	Anthracnose	Spininess
10-170	Bejo Seeds	6[z]	3[y]	7
21-340	Bejo Seeds	6	7	3
Atik	Bejo Seeds	5	7	7
NQ5007	Nunhems	6	7	6
NUN0001	Nunhems	5	7	7
NUN2001	Nunhems	5	6	7
NUN2002	Nunhems	4	5	7
20002	Rijk Zwaan	5	3	3
12-109	Rijk Zwaan	5	7	3
Bowie	Rijk Zwaan	6	7	3
Gershwin	Rijk Zwaan	5	7	3
Karaoke	Rijk Zwaan	5	6	7
Liszt	Rijk Zwaan	4	6	8
Puccini	Rijk Zwaan	4	7	3
Rubinstein	Rijk Zwaan	6	7	7
RZ-12	Rijk Zwaan	6	7	5
RZ-13	Rijk Zwaan	6	7	3
RZ-15	Rijk Zwaan	5	5	4
RZ-17	Rijk Zwaan	6	5	8
Stravinsky	Rijk Zwaan	6	8	3
Surya	Rijk Zwaan	5	3	3
Wagner	Rijk Zwaan	4	3	3
Merengue	Seminis	6	7	6
Mean		5	6	5

[z]Data are means of two ratings of three replications.
[y]Data are means of one rating of three replications.

Table 6. Quality evaluation for brined parthenocarpic pickling cucumber cultivars, 2014.[z]

Cultivar	Seed Source	Total	Total bloaters	% Balloon	Total defects	% Placental hollows	% Blossom end defects	% Soft centers
2943	Bejo Seeds	7.3	2.7	2.7	4.7	0.0	0.0	4.7
Ansor F1	Bejo Seeds	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Artist F1	Bejo Seeds	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Aviator F1	Bejo Seeds	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HSX-4415-2	Hort Ag	3.3	0.0	0.0	3.3	0.7	0.0	2.7
NCSU-01	NC State	2.0	0.0	0.0	2.0	1.3	0.0	0.7
NUN-55007	Nunhems	1.3	0.7	1.0	0.7	0.0	0.0	0.7
12-109	Rijk Zwaan	6.7	0.0	0.0	6.7	6.7	0.0	0.0
12-110	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gershwin	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Karaoke	Rijk Zwaan	1.7	0.0	0.0	1.7	0.3	0.0	1.3
Puccini	Rijk Zwaan	0.7	0.0	0.0	0.7	0.7	0.0	0.0
Stravinsky	Rijk Zwaan	2.3	1.0	1.0	1.3	1.3	0.0	0.0
Surya	Rijk Zwaan	2.7	1.3	1.3	1.3	0.7	0.7	0.0
Wagner	Rijk Zwaan	2.0	0.0		2.0	1.7	0.0	0.3
Merengue	Seminis	4.3	3.7	3.7	0.7	0.7	0.0	0.0
USACR10540	US Agriseeds	4.0	1.3	1.3	2.7	0.7	0.7	1.3
Mean		2.3	0.7	0.7	1.6	0.9	0.1	0.7
LSD (5%)		6.2	2.7	2.7	5.6	4.8	0.6	2.7

[z]Data are means of three replications (taken from harvests 2, 4 and 6).

Table 7. Quality evaluation for brined parthenocarpic pickling cucumber cultivars, 2015.[z]

Cultivar	Seed Source	Total	Total bloaters	% Balloon	% Lens	% Honeycomb	Total defects	% Placental hollows	% Blossom end defects	% Soft centers
10-170	Bejo Seeds	1.3	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0
21-340	Bejo Seeds	4.3	2.7	2.0	0.7	0.0	1.7	1.0	0.0	0.7
Atik	Bejo Seeds	2.3	0.0	0.0	0.0	0.0	2.3	1.0	0.7	0.7
NQ5007	Nunhems	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NUN0001	Nunhems	1.3	0.0	0.0	0.0	0.0	1.3	0.0	0.0	1.3
NUN2001	Nunhems	2.0	0.7	0.3	0.0	0.3	1.3	0.3	0.0	1.0
NUN2002	Nunhems	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20002	Rijk Zwaan	1.3	0.7	0.7	0.0	0.0	0.7	0.0	0.0	0.7
12-109	Rijk Zwaan	2.3	0.0	0.0	0.0	0.0	2.3	0.7	0.0	1.7
Bowie	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gershwin	Rijk Zwaan	0.7	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Karaoke	Rijk Zwaan	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3
Liszt	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Puccini	Rijk Zwaan	0.7	0.0	0.0	0.0	0.0	0.7	0.7	0.0	0.0
Rubinstein	Rijk Zwaan	0.7	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0
RZ-12	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RZ-13	Rijk Zwaan	4.7	3.7	3.7	0.0	0.0	1.0	0.0	0.0	1.0
RZ-15	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RZ-17	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stravinsky	Rijk Zwaan	4.3	0.0	0.0	0.0	0.0	4.3	2.0	0.0	2.3
Surya	Rijk Zwaan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wagner	Rijk Zwaan	3.7	0.7	0.7	0.0	0.0	3.0	1.3	0.0	1.7
Merengue	Seminis	3.3	2.3	2.3	0.0	0.0	1.0	1.0	0.0	0.0
Mean		1.4	0.6	0.5	0.0	0.0	0.9	0.3	0.0	0.5
LSD (5%)		3.8	2.7	2.7	0.4	0.2	2.3	1.8	0.4	1.6

[z]Data are means of three replications (taken from harvests 2, 4 and 6).

Diversity of *Cucurbita moschata* Duchesne (loche and cushé) and *Cucurbita ficifolia* Bouché (chiclayo) in Southern Amazonas, Perú

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Introduction

The National Institute for Agrarian Innovation (INIA) in Perú, among countless projects, maintains the Peruvian National *Cucurbita* spp. germplasm bank representing the remarkable *Cucurbita* spp. diversity in Perú. Prior to this project, the INIA *Cucurbita* collection covered much of the southern Perú *Cucurbita* spp. diversity but was lacking *Cucurbita* spp. samples from northern Perú. Therefore, the Fulbright Program funded this project to investigate and inventory the disappearing diversity of *Cucurbita moschata* and *Cucurbita ficifolia* in the Department of Amazonas, Perú. The collection focused on three landraces that belong to two different species (Table 1). The two *C. moschata* landraces are known in the Amazonas region as loche and cushé, whilst the *C. ficifolia* landrace is commonly known as chiclayo. Loche has a higher economic value and culinary influence, whilst cushé has a greater phenotypic diversity but is farmed on a smaller scale. All three, loche, cushé and chiclayo, show different physical, culinary, cultural, and geographic adaptations. The objectives of this project included: (a) collecting *C. moschata* and *C. ficifolia* samples from different districts in the Department of Amazonas, Perú for seed saving, (b) taking morphological data and photos of each collected sample for analysis, and (c) collecting cultural, historical, and culinary information.

The focused look into the use of the two species over a relatively small amount of terrain allowed for observations worthy of conveying in writing though by no means all-inclusive of the profound *Cucurbita* information that the landscape of Amazonas holds.

Materials and Methods

Collection trips: The project started with collection of *Cucurbita* fruit samples. Collection trips took place in six of the seven Amazonas provinces: Bongará, Bagua, Chachapoyas, Luya, Rodriguez de Mendoza and Utcubamaba (Figure 1). Most of the collection trips were performed with the guidance of extension employees, of the Research Institute for the Sustainable Development of the Ceja de Selva (INDES-CES) of the Toribio Rodriguez de Mendoza National University (UNTRM), based in each specific collection location, allowing for local knowledge of each province. Collection trips took 2-4 days and were based in a central town, with sample collection conducted within 0–150 km of the base town. Samples were collected based on local knowledge, connections of extension agents, and word of mouth. Most samples were collected via motorcycle directly from producers, excluding the samples collected in Chachapoyas, which were all purchased from the main market.

During the search for samples, locals were asked for any insight on "loche", "cushé", or "chiclayo" fruits. These common names are the terms used for *C. moschata* and *C. ficifolia* fruits in Amazonas. Over 50 samples were collected, of which 40 had viable seeds and were mature enough to take meaningful physical data (Table 2). Throughout the collection trips, informal interviews were conducted to investigate cultural and culinary uses, as producers were asked how the fruit and plant are used in the area. After each collection trip, the samples were brought back to the UNTRM Laboratory of Plant Physiology and Biotechnology for seed saving, fruit photography and collection of morphological data. Culinary and cultural uses of the fruits, along with physical data and seeds of each sample, were consolidated and submitted to the INIA Donoso Agricultural Experiment Station. Collaborators at INDES-CES of the UNTRM were excellent hosts and crucial to successful collection trips and data collection.

Morphological Data Collection: Physical data were collected based, with slight variations, on descriptors published by ECPGR (2008). The data collected included over 30 characteristics ranging from fruit weight and size to soluble solids content and dry matter. Prior to data collection, photos were taken of the whole fruit and a section of it. The fruit was cut, and the seeds were collected, cleaned, and dried at room temperature for two weeks before storage in manila envelopes. All data were collected in the Laboratory of Plant Physiology and Biotechnology at UNTRM, using simple balances, measuring tapes, verniers and some specialized equipment of the laboratory.

Brix measurement was used to measure soluble solids content using an Atago 3810 (PAL-1) Digital Pocket Refractometer. Flesh juice was extracted with a lemon press and three readings per fruit sample were averaged. Dry matter was calculated by drying the fresh fruit flesh. Three pieces of fresh flesh ranging from 3–5 grams were weighed, placed on petri dishes, and dried in an oven for 12 hours at 70 degrees Celsius. The dried flesh was weighed and using the equation, (Average (dry weight/wet weight)) * 100, the dry matter was calculated. pH was taken by averaging five Apera pH60S monitor readings from each sample. Flesh and rind strength was recorded using the average of three digital force gauge readings.

Results and Discussion

Based on conversations with producers, chefs and locals, the use of each researched landrace was shown to hold unique cultural values. Of the three landraces, the loche (Figure 2) was by far the highest in economic value (~$2-5 USD per kg) and has the most well-known culinary use based on Peruvian *Norteña* (northern) Cuisine, such as *espesado* (thick corn and meat stew), *crema de loche* (creamed loche soup), and *arroz con pato* (rice and duck) (see Figure 3).

Loche is commercially grown and increased through vegetative propagation in the hotter coastal regions of Perú. It is often grown with irrigation and shipped across Perú, making it easy to find in most markets. Although, loche is grown in hotter regions of Amazonas, such as Jaen, most loche found in Amazonas markets is imported from commercial production in coastal zones as loche produces best in hot climates. The clonal varieties of loche grown in Amazonas are thought to be cold hardy. In general, the loche stands alone with specific, well-documented, traditional uses in books, websites, and other resources (Andres et al., 2006). It is usually seedless and propagated vegetatively for production and maintains high sugar levels (6.5 degrees in this study). For this reason, this project put more resources into studying the less documented, but equally as important, landraces of cushé and chiclayo.

Cushé and chiclayo have many traditional uses, yet are not as well documented, nor as consistently used in current Peruvian cuisine. Many interviews revealed younger generations in Amazonas having to refer to memories with grandparents or older generations to recall the use of cushé and chiclayo. These landraces currently hold a low economic value compared to the loche, but a strong historical and cultural value.

Cushé, also known as cushebamaba (Amazonas) and chuyan (Amazonas sierra), is mostly grown in the lower altitudes, with their warmer climate, in Amazonas. It is seeded early in the rainy season (October – December) and in general produces mature fruit from April – September. Traditionally, cushé was grown alongside corn as a ground protector, allowing for corn and cushé harvest at a similar time. Currently, cushé fruits are still grown in more rural areas, but are rarely grown for market production. The majority of cushé fruits stay on farm for family consumption.

Cushé is the most diverse of the three landraces in all morphological aspects. The fruit varies in size, shape, texture, and color (Figure 4). In this study, cushé showed the highest range of sugar content, from 2.8-9.2 degrees brix as well as the highest brix average of 6.6 degrees. As expressed by Doña Marinita, a Chachapoyan woman who shares traditional Peruvian cuisine on YouTube and Facebook, getting a super-sweet cushé is mostly luck as some cushé will be extremely sweet while others are bland and bitter. Still, the cushé holds unique characteristics, has high nutritional value, and a thick shell that was traditionally used to create serving vessels. The shape of the cushé and loche was often recreated in pottery as seen in museums across Perú, showing its historical value as well (Whitaker and Cutler, 1967).

During this study, bi-colored cushé were found (Figure 5). This finding is consistent with the previous scant reports of the rare bi-colored *C. moschata* occurring in Perú, Ecuador, Colombia, and Brazil (Lietzow et al., 2005–2006). This trait suggests the presence of the *B* gene, which has been used widely to increase carotenoid content in *Cucurbita pepo* (Andres and Paris, 2020). The diversity within the cushé landrace in Amazonas reveals a pool of genetic diversity that may be useful to plant breeders.

Traditionally, cushé is prepared by chopping into 3–5-inch pieces that are boiled with the skin and served on a plate in the middle of the table to accompany the main dish. One interviewee of the town of Levanto expressed that the plate of cooked cushé should be as full after eating as it was when the meal started, constantly being refilled throughout the meal. Other preparations include *tortillas* (fried cushé patties), *dulces de cushé* (sweetened cushé pudding), *picarones* (cushé donuts), *harina de cushé* (flour) and *locros* or *caldos* with immature fruits (soups with green fruit) (see Figure 6). In an interview, David Ocampo, a local Chachapoyan, expressed the opinion that the cushé holds a relatively high protein content, making it a good option as fodder for the fattening phase of livestock. However, the protein content of cushé has not been documented. Ocampo spent pre pandemic years breeding cushé to grow with a thinner skin to ease the feeding process.

Overall, the cushé is a historically important crop with its high sweetness and hard shell. The shell of the cushé has been an important vessel for serving for many generations, as it maintains its shape when dried. Unfortunately, cushé is currently in decline. As other materials become easily accessible for serving food and limited time does not allow for the time-consuming removal of the shell, the cushé has lost some appeal. Low market value (~$0.25 – 2.00 USD per fruit), as well as a lack of personnel to harvest the crop, has made it much less popular among farmers and households in Amazonas. Many towns, such as Magdalena or Pedro Ruiz in Amazonas, produced cushé on a regular basis. Currently, few community members are known to still plant and harvest the crop. For this reason, it is important that these cushé landraces are collected, to be conserved in the INIA seed bank, especially with the presence of bi-colored fruits.

Chiclayo, also known as chiuche (Cajamarca), calabaza blanca (Lima), lacayote (Arequipa), and sambumba (Piura), mostly flourishes in the higher altitudes and cooler climates of Amazonas. The plant is extremely vigorous and can be found growing like a weed on the side of the road, climbing over fences, or covering house yards. Most commonly, the plant self-propagates from seeds within old, fallen fruits. There are areas like Pomacochas, Perú where chiclayo is planted and harvested to be sold in city markets. Chiclayo holds a unique cultural history as it is included in many legends and histories of the Chachapoyan culture.

Chiclayo fruits are relatively unvarying in morphological aspects (Figure 7). Externally, the fruit generally resembles a watermelon. Internally, it has white, stringy flesh and white or black seeds; the nutritional value is low and has a low sugar content. In this study, the average sugar content of the chiclayos sampled was a low 4.3 degrees Brix. One unusual chiclayo morphological feature was some of the fruits having extended necks, revealing potential morphological diversity in the *C. ficifoli*a of Amazonas.

The fruit is most known for the classic *dulce de chiclayo* (see Figure 8) consisting of boiled chiclayo pulp, seeds and *chancaca* (solid product of boiling sugar cane). This is often served at traditional events or as street food. The seeds are an important nutritional aspect of the fruit and are toasted and sold with *canchitas* (cooked corn kernels) or milled into a flour used in soups (*Sopa de Pepitas*) or baked goods. The immature fruits are often added to *locros* (corn veggie soups) Since the fruit grows freely, fruits will often be used as filler for animal fodder. Overall, even though the chiclayo has a low economic value (~$0.50 – 2.00 USD per fruit), it holds an important place in current day Amazonas culture due to its vigor and productivity, and popularity when prepared as *dulce de chiclayo*.

Conclusion

This project allowed for the study of the diversity of *Cucurbita* in the Department of Amazonas, Perú from a social, morphological, historical, and culinary perspective. The finding of bi-colored cushé (*C. moschata)* adds information to the cucurbit community as bi-color has rarely been documented in *C. moschata*. Worth noting as well, chiclayo and cushé landrace use is diminishing, emphasizing the importance of conserving these landraces. All 40 samples were registered in the *Cucurbita* germplasm bank at the Donoso Experiment Station of INIA in Huaral, Perú, to be included in the up-and-coming INIA investigation into Peruvian Cucurbit biodiversity.

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Table 1. Common and scientific names of landraces studied.

Common name in Amazonas	Scientific name
Chiclayo	*Cucurbita ficifolia*
Cushé	*Cucurbita moschata*
Loche	*Cucurbita moschata*

Table 2. Number of samples collected by species, and by province in the Department of Amazonas, Peru.

Species	
Cucurbita ficifolia	11
Cucurbita moschata	29
Total	40
Province of Amazonas	
Utcumbamba	3
Luya	2
Chachapoyas	19
Bongará	6
Rodriguez de Mendoza	8
Bagua	2
Condorcanqui	0
Total	40

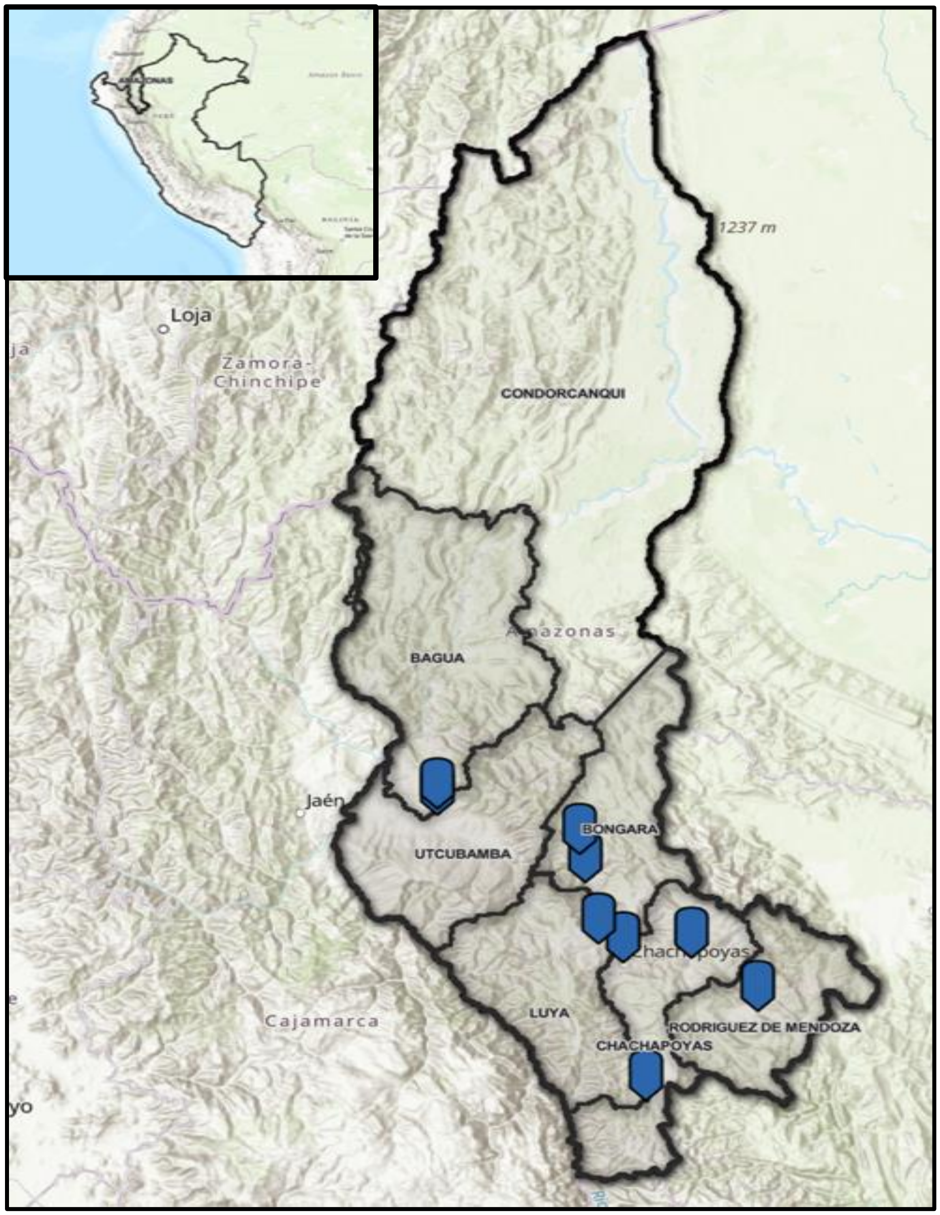

Figure 1. Map of locations in the Department of Amazonas, Perú where collection trips were conducted.

Figure 2: Examples of various fruit forms of loche

Figure 3. (a) harvested loche fruits in the field in Patapo (fruit to scale in red ring), (b) young, vegetatively propagated loche plant, (c) longitudinal section of loche fruit, (d) espesado (thick corn meat stew) made with loche (green) and ceviche, a classic Norteña dish made with fish cooked by lime juice, (e) crema de loche--creamy loche noodle sauce served with grilled meat.

Figure 4. Examples of various fruit forms of cushé.

Figure 5. Bicolor cushé, *Cucurbita moschata*: (a) side photo of exterior coloration, (b) top view of exterior coloration, (c) interior pulp color variation viewed in cross-section, (d) interior surface of rind.

Figure 6. (a) serving vessels made from the hard shell of cushé, (b) harvested cushé fruit (in foreground, not to scale) in Mayno with a producer, (c) huaco (sacred vessel) in the form of a duck/cushé dating back to the Incan empire, (d) picarones (cushé donuts) made with the puree of cushé, (e) cushé for sale in the Luya Tuesday market, (f) dulce de cushé boiled with the skin in a sugar syrup, (g) three forms of cushé: bowls made from the thick skin, puree made from boiled flesh, and roasted seeds with salt, (h) longitudinal section of a cushé, (i) snack made from the roasted seeds of cushé or chiclayo mixed with canchitas (cooked corn kernels).

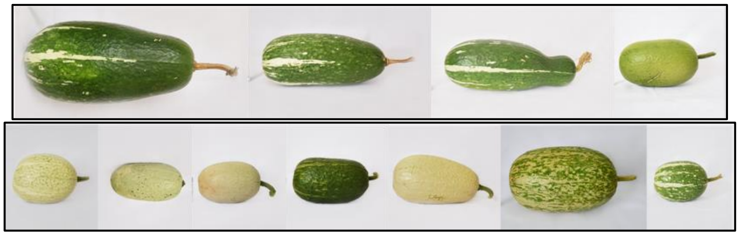

Figure 7. Examples of various fruit forms of chiclayo.

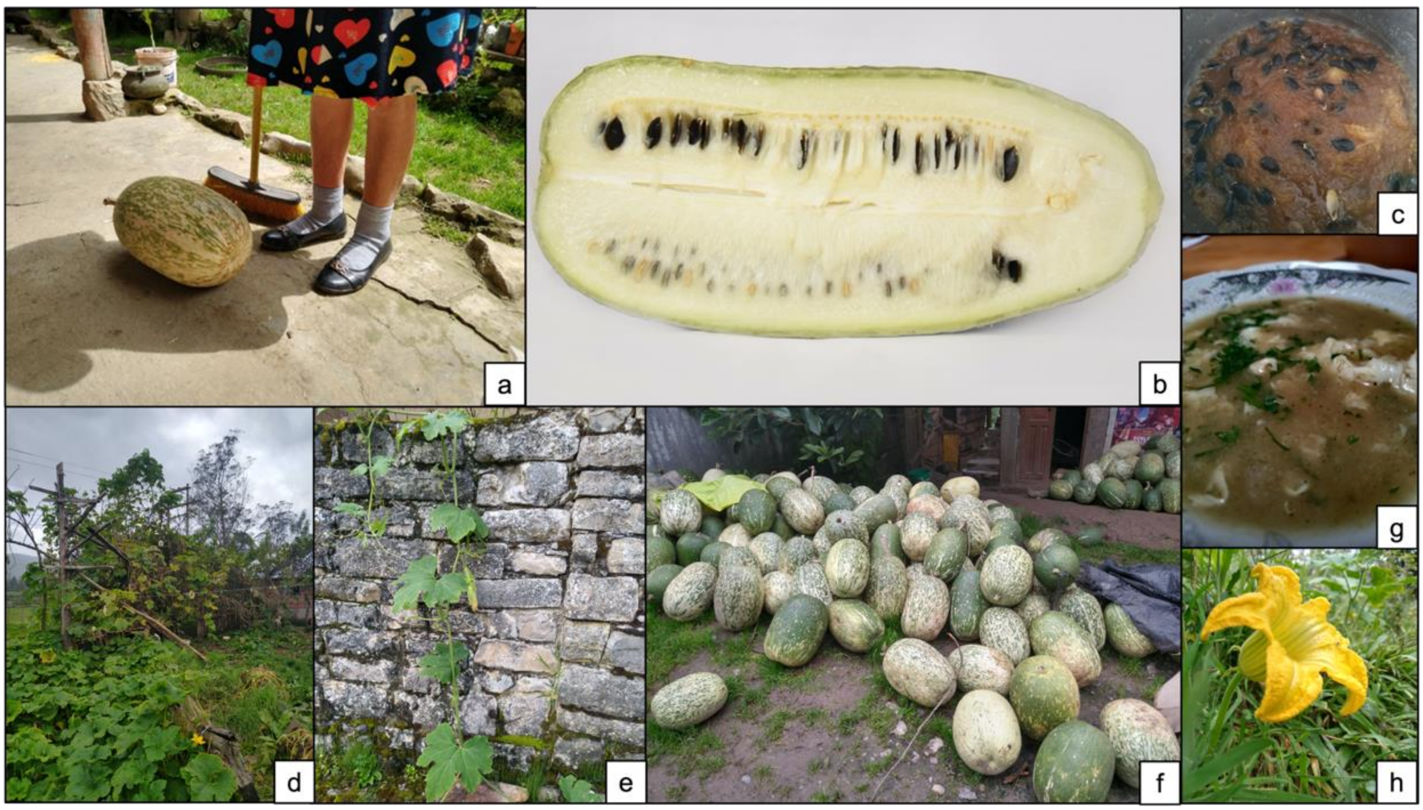

Figure 8. (a) chiclayo fruit with producer in Leimebamba, (b) longitudinal section of fruit with black seeds, (c) dulce de chiclayo (sweeten chiclayo pudding), (d) example of chiclayo plant overtaking a yard in Molinopampa, (e) example of a chiclayo plant growing as a weed on the side of a building, (f) mound of chiclayos in Pomacochas ready for trucking to Lima and larger cities, (g) pepian-soup made from the flour of roasted and milled chiclayo seeds, (h) the chiclayo flower, eaten raw in salads.

A Late 16th-Century Look-Alike of the 'Romanesco' Cocozelle Squash

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Pumpkins and squash, *Cucurbita* species, are native to the Americas. The first known images of *Cucurbita* outside of the Americas appear in the *Grandes Heures d'Anne de Bretagne* (Paris et al., 2006) of France and the *Villa Farnesina* (Janick and Paris, 2006; Formiga and Myers, 2020) in Italy. The *Grandes Heures*, a book finished in early 1508, contains an illustration of a pyriform gourd. The festoons decorating the *Villa Farnesina*, which were completed by 1518, contain images of oviform and pyriform gourds and pumpkins.

From 1540, images of *Cucurbita* proliferate, mostly in botanical herbals but also in artistic paintings of the 16th and 17th centuries (Zeven and Brandenburg, 1986; Paris, 2000; Teppner, 2000). Most of the images in the herbals and paintings are quite realistic, allowing easy diagnosis to the species level and even to the subspecies, cultivar-group (morphotype), market type, or even specific cultivar. Most of the early depictions are fruits of the Pumpkin Group of *Cucurbita pepo* L. subsp. *pepo* and include both the grooved market types of eastern North America resembling 'Connecticut Field' and 'Small Sugar' and the ribbed pumpkins of southern North America from the landraces of Mexico and Guatemala. Almost all of the other early depictions are of *C. pepo* subsp. *ovifera* (L.) D.S. Decker, including of the Acorn Group resembling 'Table Queen', 'Mammoth Table Queen', and 'Sweet Dumpling', the Scallop Group, and various small ornamental gourds.

One of the most unusual of these images occurs in a painting dated to approximately 1580, *Fruittivendola* (Fruit Vendor), by the Italian artist Vincenzo Campi. This painting contains several cucurbits, including a large, oblate, ribbed yellow pumpkin of *Cucurbita pepo* subsp. *pepo*. Most interesting, though, are small images of what appear to be female and male flower buds and foliage of this taxon. The largest female flower bud has what appears to be a ribbed ovary three-and-a-half times longer than wide, with the widest part being just under the calyx, and hence was identified as of a Cocozelle Group squash closely resembling 'Romanesco' (syn. 'Costata Romanesca') (Paris and Janick, 2005). These images do lack some detail, though, casting some doubt as to their identification. The large male flower bud, while most resembling that of *C. pepo*, also has some resemblance to a young fruit of okra, *Abelmoschus esculentus* (L.) Moench (Malvaceae). A high-resolution representation of the painting can be viewed here: https://postiepasti.com/2020/07/08/finestre-sullarte-1-la-fruttivendola-vincenzo-campi.

Quite recently, I came across a curious image in a publication describing a recent inquiry into the origin of the vegetable motifs appearing in 16th-century tapestries entitled *Fidelidad de Penélope* in the Badajoz Cathedral (Vázquez Pardo et al., 2018). In this publication, several highly detailed and accurate images of plants are reproduced. These images were designed by the Flemish artist Joris Hoefnagel (1542–1601) and appeared in his *Archetypa studiaque patris Georgii Hoefnagelii* (Hoefnagel, 1592), engraved and published in Frankfurt in 1592 by his son Jacob. This is a collection of 52 engravings containing images of plant parts, insects, and animals drawn *ad vivum* by Joris Hoefnagel and is divided into four parts of 12 plates each, each part also having a separate frontispiece. It is noteworthy that the artist had spent considerable amounts of time in lands that are today in Belgium, France, England, Spain, Italy (including Rome), Germany, Austria, and others.

The Frontispiece of Part 2 of the *Archetypa studiaque patris Georgii Hoefnagelii* shows various animal, insect, fruit, flower, and foliage subjects (Figure 1). Among them is a large cucurbit fruit (Figure 2). As compared with the adjacent grape cluster and pears, this cucurbit fruit could be estimated at 40 or so cm in length. It is nearly cylindrical except that it is swollen at its stylar end. It is also longitudinally ribbed, with five ribs drawn along most of the length of the fruit. The size of the fruit and the ribbing indicate that the fruit is of *Cucurbita pepo* subsp. *pepo* (Paris et al., 2012). Ordinarily, subsp. *pepo* fruits have 10 longitudinal ribs, in accordance with the five main vascular tracts connecting the peduncle to the sepals and five more connecting to the petals. Hence, five of the ribs would be seen if the fruit is observed from its side, as occurs in the illustration. However, nine ribs appear at the stylar end, indicating that the fruit is either tilted or curved toward the viewer at this end. This fruit is quite elongate and, accounting for the tilting or curvature, has a length-to-width ratio approximating 3.5. This high length-to-width ratio coupled with the obviously swollen stylar end indicates that this fruit is a cocozelle squash (Paris, 1986) and, with its prominent ribs, it strongly resembles 'Romanesco' (https://specialtyproduce.com/produce/Romanesco_Costata_Squash_10948.php; also: https://www.mygardenlife.com/plant-library/3925/cucurbita/pepo/costata-romanesco). 'Romanesco' cocozelles are prized in the kitchen on the day of anthesis and a day or two prior or after, often eaten with the flower still attached as the flowers of this cultivar are particularly firm and fleshy (Umiel et al., 2007). The illustrated mature fruit, therefore, was well beyond its peak of culinary quality but would certainly have remained a fit subject for illustration, for a much longer period of time before deteriorating, than would a flower or young fruit. Its stylar scar is smaller than ordinarily encountered in 'Romanesco' fruits. 'Romanesco' cocozelles have a fairly large stylar scar when the fruit is young and of culinary use but, as the fruit grows and broadens, the size of the scar relative to the diameter of the fruit becomes smaller. Interestingly, in the *Archetypa*, the fruit is adorned at the peduncle end with a cluster of grapes, similar to the pumpkins of the *Villa Farnesina*. Moreover, the fruit is adorned with two leaf laminae that are similar in their appearance to those produced by 'Romanesco'. Foliage similar to that of *C. pepo* is also depicted adjacent to the flower buds in the *Fruittivendola*. There are Italian cookbooks from 1614 and 1644 describing the culinary preparation of tender shoots of *Cucurbita* together with their flower buds and young fruits (Lust and Paris, 2016).

So the flower buds in Campi's *Fruittivendola* (1580) and the mature fruit in the *Archetypa studiaque patris Georgii Hoefnagelii* (1592) seem to represent the same cultivar of cocozelle squash, 'Romanesco'. Yet another image of a cocozelle squash, perhaps of 'Romanesco', appears in another drawing by Hoefnagel dated, at the latest, to 1580 (Paris, 2023). This situation brings sharply to the forefront a quandary, the answer to which has been pondered again and again. Were long-fruited squash, such as 'Romanesco', already present in North America and brought to Italy subsequent to 1492? Or were long-fruited squash selected directly, from newly imported North American pumpkins, within 100 years, in Italy and perhaps other Old World countries?

Some oblong-fruited but no truly long-fruited Mexican or Guatemalan landraces of *Cucurbita pepo* subsp. *pepo* have been illustrated, described or listed in scientific literature and USDA PI collections (Zhiteneva 1930; Whitaker and Knight, 1980; Teppner, 2004; Castellanos-Morales et al., 2019), but a few long-fruited variants can sometimes be found within otherwise round-fruited Mexican landraces. Most of the cocozelles and all of the tested zucchinis are more closely related to accessions of Old World pumpkins than to those of the New World (Gong et al., 2012). The Old World pumpkins are genetically intermediate between the pumpkins of northern and those of southern North America (Paris et al., 2015), likely having resulted from chance crossing when the pumpkins of north and south were first grown in near proximity, in European gardens. So most if not all of the long-fruited cultivars of *C. pepo* subsp. *pepo* appear to possess a European ancestry, having resulted from chance crossing followed by selection for longfruitedness on that continent within a century or two of the voyages of Columbus. However, the ribbed cocozelles 'Romanesco' and its likely derivative 'Lungo Fiorentino', as well as the viney Spanish cocozelle PI 261610, fall within the central core of *Cucurbita pepo* subsp. *pepo* accessions which includes old and primitive North American cultivars and landraces (Gong et al., 2012). These cocozelles would seem to have a direct North American origin, having been derived by selection within Mexican landrace pumpkins for long-fruited variants. In cucurbits, longfruitedness results in improved culinary adaptation of the young fruits (Lust and Paris, 2016). Prior to the arrival of *Cucurbita*, people of the Italian peninsula and some other parts of Europe had centuries of experience in selecting for and maintaining longfruitedness in two other cucurbit taxa, *Lagenaria siceraria* (Molina) Standl. (bottle gourd) and *Cucumis melo* L. subsp. *melo* Flexuosus Group (snake melon). From the images in the *Fruittivendola* and the *Archetypa studiaque*, it appears that selection for longfruitedness in *Cucurbita pepo* subsp. *pepo* succeeded within 100 years of the first voyage of Columbus, with the development of the cocozelle 'Romanesco'.

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Figure 1. Frontispiece of Part 2 of *Archetypa studiaque patris Georgii Hoefnagelii* (Hoefnagel, 1592).

Figure 2. Frontispiece of Part 2 of *Archetypa studiaque patris Georgii Hoefnagelii* (Hoefnagel, 1592), partial view, magnified.

Diversity and Valorization of Local Genetic Resources of *Cucurbita* in Tunisia

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The genus *Cucurbita* (2n = 40, Whitaker and Robinson, 1986), incorporating pumpkin and squashes or vegetable marrows, is a valuable genus of the Cucurbitaceae family with 21 species, five of which (*C. moschata* Duchesne, *C. pepo* L., *C. maxima* Duchesne, *C. argyrosperma* Huber and *C. ficifolia* Bouché) are cultivated (Khoury et al., 2019). Pumpkins and squash are easily grown in tropical, sub-tropical, warm-temperate and temperate climates, and in cool-temperate climates can be successfully grown if provided early-season protection from low temperatures (Paris, 2018). Pumpkin now occupies a prominent place among vegetables owing to its high productivity, nutritive value, good storability, long period of availability, and better transport potentialities (Hazra et al. 2007). They are generally cultivated for their fruits and sometimes for their oil seeds, flowers, and leaves (Caili et al. 2006).

Cucurbita spp. have versatile fruits with fleshy shell, seeds, and even edible flowers. The immature fruits of various *Cucurbita* have been used for culinary purposes in different parts of the world. Ripe pumpkin fruits can be boiled, baked, or steamed (Roberts, 2006). The benefits of *Cucurbita* fruits are very important in terms of human health and are good for digestion and supplying energy (Bisognin, 2002). Raw or roasted pumpkin and squash seeds are used as a snack food for human consumption in many countries all over the world. A seed extract has been reported to have antidiabetic, antitumor, antibacterial, anticancer, and antioxidant activities. It has also been found to have strong hypotriglyceridemic and serum cholesterol-lowering effects (Tlili et al. 2020; Caili et al. 2006). Pumpkin has high nutritional value essential for food security (Gbemenou et al. 2022). Despite many benefits, it is still considered an orphan crop in Africa and very little information is available on the potential and production of pumpkin in Africa due to neglect by researchers and improvement programs (Gbemenou et al. 2022).

In Tunisia, pumpkin (*Cucurbita* spp.) has significant economic importance especially in subsistence agriculture because of its vigor, nutritional values, and long shelf life. There are no improved cultivars of squash and pumpkin in Tunisia. The production of *Cucurbita* is based on local accessions and landraces with the exception of zucchini where imported F_1 hybrids are cultivated in greenhouses for immature fruit production.

Pumpkin collections at the Regional Research Centre on Horticulture and Organic Agriculture (CRRHAB, Tunisia) were initiated in 2016 and some accessions were collected from different regions of Tunisia (Figure 1). Several studies were initiated to characterize those landraces. Chikh-Rouhou et al. (2019) showed that these landraces correspond to three species: *C. maxima*, *C. pepo*, and *C. moschata* with a predominance of *C. maxima*. Significant differences were found for all the phenotypic traits evaluated revealing a great diversity among the landraces and among the 3 species of *Cucurbita* especially in fruit shape, size (Figure 1, Table 1), peduncle (angled or cylindrical) (Figure 2), leaves (rounded shallow lobes or lobes acute or obtuse; with or without whitish blotches) (Figure 3A), and growth habit (bushy, intermediate or prostrate) (Figure 3B).

The cultivation of *C. maxima* (winter squash) is based on local open-pollinated varieties which are maintained by farmers, produced for self-consumption and sold at local markets. Similarly, the production of *C. moschata* is based on local varieties for home consumption or sale at local markets. *C. pepo* (summer squash) is produced in greenhouses and open fields, and F1 hybrids are cultivated in greenhouses for zucchini production. Squash seeds have been used as a snack in Tunisia like in other Mediterranean countries.

Winter squash, summer squash, and pumpkin populations of Centre-East Tunisia showed high variability for seed size, color, and weight (Chikh-Rouhou et al. 2019). However, very few studies have been initiated regarding the characterization and utilization of Tunisian local germplasm. Hamdi et al. (2017) characterized 15 landraces of *C. maxima* using either morphological or biochemical traits and Hamdi et al. (2020) evaluated the population structure of a Tunisian and Italian *C. maxima* germplasm collection by combining morphological and molecular markers, observing a large qualitative variability according to fruit-related traits and effective discrimination of all the accessions. Also, Enneb et al. (2020) investigated the biochemical and nutritional properties of *C. moschata* extracts from pulp, fibers, and seeds, showing the great diversity of these landraces collected from arid lands of Medenine south Tunisia in regards to the biochemical traits evaluated.

In order to develop new varieties of pumpkin for seed production, selection studies are being conducted in the CRRHAB since 2018. In these studies, different seed sources were collected and are under evaluation. Varieties of naked-seed pumpkin (characterized by having a thin membranous seed coat, which makes the entire seed edible and easily pressed to extract the prized culinary oil) will be introduced and research will be conducted with this type of variety. Naked pumpkin seeds are a popular ingredient in many snacks, breads, breakfast cereals, soups, and other edible goods (Meru and Fu, 2021, Baxter et al. 2012). Pumpkin seeds are rich in oil (50% w/w), protein (35%), unsaturated fatty acids (86%) (Meru et al. 2018), and antioxidants that have many health benefits. Oil-seed pumpkins can be purchased by the bottle for culinary/condiment use or as capsules in health food stores (Stevenson et al. 2007).

Biochemical analysis of pumpkin landraces (flesh and seeds) is ongoing in collaboration with INRAT (Tunisia). On the other hand, screening for resistance to cucurbit powdery mildew (CPM) and downy mildew (*Pseudoperonospora cubensis*) is ongoing at CRRHAB to select the best accessions for further breeding programs. The first results are promising and some potential landraces resistant to CPM and with high yield are being identified (Chikh-Rouhou et al. in preparation). Pumpkin diversity and associated microbiota are being also determined (Aydi-Ben-Abdallah et al. in press). Indeed, comparative studies of plant microbiomes with resistant and tolerant phenotypes to different diseases in pumpkin accessions are ongoing at CRRHAB. Assessments for resistance to various soilborne pathogenic fungi using these accessions are also ongoing in collaboration with the Department of Plant Science of CITA (Spain).

In Tunisia, the most frequent use of pumpkins is the inter-specific F1 hybrids of *C. moschata* x *C. maxima* as rootstocks to melon and watermelon grafting, all of which are imported. Here we emphasize the utilization of our local landraces which might open the potential to create local rootstocks and save hard currency paid for importing seeds.

We emphasize here the need to evaluate local pumpkin diversity for more efficient management and utilization of landraces for sustainable conservation and valorization of the collected accessions. Indeed, phenotypic and molecular studies are necessary for more accessions of regional or national collections to determine the genetic diversity and structure of the local varieties, populations, landraces, hybrids, introduced accessions, and wild species.

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Figure 1. Diversity of pumpkin (*Cucurbita* spp.) landraces collected from local farmers and evaluated at the Research Centre on Horticulture and Organic Agriculture (CRRHAB), Tunisia.

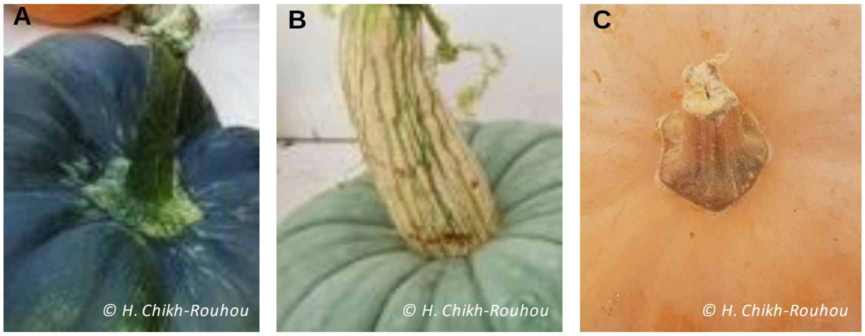

Figure 2. Variation in peduncles of *Cucurbita* landraces in Tunisia. (A) smoothly angled and expanded or flared at fruit attachment (*C. moschata*). (B) spongy, cylindrical, corky (*C. maxima*). (C) angled with little or no expansion at fruit attachment (*C. pepo*).

Figure 3. Leaf type and plant growth habit among *Cucurbita* species in the CRRHAB collection. A: Leaves (rounded shallow lobes or lobes acute or obtuse; with or without whitish blotches), B: Plant growth habit (a) bushy, (b) intermediate, (c) prostrate. (Photo H. Chikh-Rouhou)

Table 1. Range of values of phenotypic traits of landraces of three species of *Cucurbita* in the collection at the Research Centre on Horticulture and Organic Agriculture (CRRHAB), Tunisia.

Number of accessions	Species	Fruit weight range (kg)	Flesh thickness range (cm)	Seeds number range
10	*C. moschata*	1.4 – 17.1	1.5 – 7.3	81 – 774
15	*C. maxima*	4.8 – 25.3	3.0 – 13.1	90 – 524
5	*C. pepo*	0.5 – 4.2	1.5 – 6.5	31 – 435

Cucurbitlocal – A Collaborative Initiative to Strengthen Valorization of *Cucurbita* Local Germplasm for Sustainable Agriculture

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Genetic resources contain a vast reservoir of genes to foster the breeding of new cultivars suitable for low input conditions. Conservation of local germplasm is crucial to maintain the extant natural genetic diversity of *Cucurbita* spp. and to provide novel traits for the cultivation of crops in sustainable agri-food systems. In the framework of the Cucurbitlocal project, we aimed to valorize and to rationalize conservation efforts of *Cucurbita* local landraces stored in major European genebanks (IPK, UPV, SvG), and/or in regional communities in Spain, Italy, and Tunisia to make them available for growers in their respective countries through EURISCO/AEGIS network or other European or national initiatives.

In 2021 and 2022, researchers in five countries (Germany, Italy, Romania, Spain, and Tunisia) evaluated the diversity of 132 *Cucurbita* landraces (Figure 1) based on standardized descriptors related to growth habit, fruit and seed type. Taxonomic determination of cultivar groups was assigned according to the criteria described in Mansfeld's Encyclopaedia of Agricultural and Horticultural Crops (Jeffrey, 2001).

Leibniz Institute of Plant Genetics and Crop Plant Research (IPK, Germany) characterized 39 (2021) and 36 (2022) *Cucurbita* accessions including *C. maxima*, *C. pepo*, *C. argyrosperma*, *C. moschata*, and *C. ficifolia* for agro-morphological characters, especially fruit and seed traits. All data are publicly available in the Genebank Information System (GBIS).

University of Naples Federico II (Italy) evaluated 12 *C. pepo* landraces for morphological plant and fruit traits. In addition, an open field trial under water deficit was conducted using the same genotypes. A potential genotype tolerant to drought was identified.

Suceava Gene Bank (Romania) assessed the diversity of 10 local landraces of *C. pepo* and 10 of *C. maxima.*

In CRRHAB (Tunisia), 12 landraces belonging to *C. maxima*, *C. pepo*, and *C. moschata* were characterized for their agro-morphological traits under open field conditions; these landraces were previously collected from local farmers a few years ago. A preliminary evaluation for low watering regime as well as powdery mildew tolerance was done. Such information can be valuable to select accessions adapted to diverse agroclimatic and stressful conditions.

UPV (Universitat Politècnica de València, Spain), evaluated 13 traditional landraces (1 *C. pepo*, 7 *C. moschata*, and 5 *C. maxima*) using descriptors under greenhouse conditions in Valencia and in an open, saline-stressed field in Alicante (saline soil and water). Organic farming conditions were used in both trials. The greenhouse trial in Valencia was strongly affected by Watermelon Mosaic Virus (WMV) as these traditional landraces lack resistance to this virus. Two accessions with lower susceptibility were identified: *C. maxima* 'De Torrar' and *C. moschata* 'Cacahuet'. The Alicante field trial was less affected by viruses (although some plants infected by WMV and Cucumber Mosaic Virus (CMV) were detected). A stronger incidence of powdery mildew was found under saline conditions.

The Cucurbitlocal project (https://www.ecpgr.cgiar.org/working-groups/cucurbits) strengthened collaboration among researchers with unique scientific expertise to increase crop genetic conservation and the valorization of *Cucurbita* local germplasm diversity and richness. Moreover, this pilot project will contribute to the sustainable use of *Cucurbita* resources and could be extended in Europe and other regions.

Acknowledgements

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Figure 1. *Cucurbita* accessions evaluated in the Cucurbitlocal project.

Status and Prospects of *Lagenaria siceraria* (Bottle Gourd) Landraces in Tunisia: A Neglected and Underutilized Resource

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The genus *Lagenaria*, a member of the *Cucurbitaceae* family, contains five wild dioecious species including *L. brevifilora* (Benth) Roberty, *L. abyssinica* (Hook F.) Jeffrey, *L. rufa* (Gilg) Jeffrey, *L. sphaerica* (Sonder) Naudin and *L. guineensis* (G. Don) Jeffrey. The genus also contains a single cultivated monoecious species *L. siceraria* (Molina) Standl. (Morimoto et al., 2005). No previous research has been done regarding this species in Tunisia. The lack of information about the diversity of *L. siceraria* in Tunisia, and the absence of an adequate conservation strategy, can easily result in genetic erosion and the loss of local ecotypes. In this report, we emphasize the need to characterize and valorize Tunisian landraces of *L. siceraria*.

Lagenaria siceraria (2n = 22), commonly known as the white-flowered gourd, bottle gourd, or calabash, is a vigorous annual climber that has been exploited for its nutritional and medicinal properties by local peoples in many tropical and temperate countries (Mashilo et al., 2022; Yetisir and Aydin, 2019). Great diversity of bottle gourd varieties exists in India (Sunil et al., 2014) and West Africa (Stephens and Suresh, 2015). Tropical Africa is considered the primary gene pool for *L. siceraria* (Singh, 1996).

The immature fruits of bottle gourd are generally consumed as a vegetable in Africa and Asia. They are typically boiled, fried or stuffed like the fruit of *Cucurbita pepo*. Cultivars of bottle gourd differ markedly in their sweetness and bitterness (Mashilo et al., 2017). Selected varieties are comparable in consumer favor to the popular summer squash varieties of temperate regions. Young shoots, tendrils and flower buds of less bitter types are sometimes eaten as a green vegetable. Leaves can also be eaten as a vegetable (Stephens and Suresh, 2015).

The flesh of the mature fruits of bottle gourd is often removed by scraping and the shells are then used as containers, bowls, musical instruments, for various decorative purposes or, in some cases, fishing floats. The seeds are harvested for oil extraction and also used in cooking. Use of cooking oil extracted from harvested seeds is common in Africa. The seeds of *L. siceraria* contain an oil that is comparable in content to sunflower and grape seed oil (Axtell and Fairman, 1992). Loukou et al. (2011) reported that seeds of bottle gourd are rich in protein, oil, and energy.

Seeds, tendrils, and young leaves of bottle gourd are also used for medicinal purposes (Manandhar, 2002; Moerman, 1998) in various countries. Uses include as a pectoral medicine, an anthelmintic, a purgative and even as a headache remedy (PROSEA, 2018; PROTA, 2018). Syrup made from the green fruit is used to treat bronchial disorders including cough and asthma (Shah et al., 2010; Sivarajan and Balchandran, 1996).

In addition to its nutritional and medicinal uses, bottle gourd has been used for decades in Asia as a rootstock for watermelon. Its use promotes root system development under conditions of water, salinity and heat stress. It also minimizes the deleterious effects of soil-borne pathogens (Yetisir et al., 2007, 2003; Colla et al., 2006; Oda, 2002; Lee, 1994) and increases plant growth by increasing water and nutrient mineral uptake (Yetişir et al., 2007). These characteristics make bottle gourd a crop to be utilized in climate change adaptation strategies. Yetişir et al. (2007) reported that bottle gourd was a preferred rootstock for watermelon because it confers resistance to Fusarium wilt in addition to enhancing female flower formation. Bottle gourd also improves the yield and vigor of the watermelon scion when compaed to other rootstocks because of its high graft compatibility and stability (Davis and Perkins-Veazie, 2007; Yetişir et al., 2003). Positive effects of bottle gourd rootstocks on watermelon fruit quality have also been reported (Davis and Perkins-Veazie, 2007).

In Tunisia, bottle gourd is a neglected and underutilized crop. Bottle gourd is a minor crop, locally cultivated only in small regions of the country. Various landraces are favored for cultivation in regions of south Tunisia and used for food, a musical instrument (known as Darbouka), decorative purposes and containers. Bottle gourd does not require complex or sophisticated field management practices. It grows well with only small amounts of nitrogen fertilizer and in low-input farming systems. There is a need for well-established pre-breeding and breeding programs in Tunisia aimed to utilize bottle gourd genetic resources and identify and design consumer-preferred varieties to serve the diverse value chain.

Collection of Tunisian bottle gourd landraces was intitated in 2017 at the Regional Research Centre on Horticulture and Organic Agriculture (CRRHAB, Tunisia). Examples of the fruit of these landraces are depicted in Figure 1. There is wide diversity in seed yield and size, fruit trait qualities, including size and shape (Chikh-Rouhou et al., 2021). In addition, characterization of these landraces for root system morphology and resistance to the soil-borne fungal pathogens *Fusarium oxysporum f.sp melonis* race 1.2 (Fom), *Fusarium oxysporum f.sp niveum* (Fon), *Neocosmospora falciformis*, and *Monosporascus cannonballus* has been initiated. Preliminary results indicate that some accessions could have an apparent high-level of resistance to *Fom* race 1.2 and *Fon* race 0 (unpublished data). In case we confirm the resistance, these landraces could be useful as rootstocks for melon or watermelon production in soils infested with Fusarium wilt.

Research to evaluate these landraces as rootstocks for melon and watermelon production is ongoing. Use of local landraces as rootstocks provides an opportunity to limit the need to import rootstock seeds. Promoting the use of Tunisian bottle gourd landraces as rootstocks also serves to support crop diversification efforts and contributes to improving the income of smallholders and rural women in our country.

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Figure 1. Diversity in size and shapes of dried mature fruits of some bottle gourd (*Lagenaria siceraria*) landraces collected from local farmers in Tunisia.

Cucurbits Illustrated in the Late 16th-Century by Joris Hoefnagel (1542–1601)

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The Flemish-born artist Joris Hoefnagel (1542–1601) was a prolific illustrator of insects, animals, and plant parts, including fruits, flowers, and foliage, drawn *ad vivum*. Collections of his drawings are available for viewing on-line at the National Gallery of Art, Washington DC (https://www.nga.gov/collection/artist-info.2569.html), the Getty Museum Collection (https://www.getty.edu/art/collection/person/103K9F), and the Internet Archive (Archetypa stvdiaqve patris GeorgiI Hoefnagelii : Hoefnagel, Joris, 1542-1601 : Free Download, Borrow, and Streaming : Internet Archive). It is noteworthy that this artist spent considerable amounts of time in lands that are today in Belgium, France, England, Spain, Italy, Germany, Austria, and others.

One of his most informative illustrations is the Part 2 Frontispiece of the *Archetypa studiaque patris Georgii Hoefnagelii* (Hoefnagel, 1592). This black-and-white plate contains highly detailed images of various animals and plants. Among them is a mature fruit look-alike of *Cucurbita pepo* subsp. *pepo* Cocozelle Group 'Romanesco' (Paris, 2023). This is but one of many cucurbit images by Hoefnagel. Cucurbits seem to have been one of his favorite subjects. Herein I present, identify to taxon and interpret a few of his more striking cucurbit images.

Cucurbita pepo L. subsp. *pepo*

In the *Animalia volatilia et amphibia* (*aier*), a compilation of color illustrations completed by 1580, there are several images of *Cucurbita pepo* subsp. *pepo* (Figure 1). One of them, from Plate 38, shows an elongate, curved, ribbed, greenish-brownish-yellow squash illuminated from its left side and casting a deep shadow at its right side, the same as the adjacent large melon, which is also closer to the viewer. This fruit is approximately 3.5 times longer than its broadest diameter and is swollen at its stylar end, indicating that it is a cocozelle squash (Paris, 1986), and its color suggests that it is fully mature. Although the brightness of the left side of the image makes interpretation difficult, this squash does seem to have five prominent ribs all along its length. This appears to be yet another early image of *Cucurbita pepo* subsp. *pepo* Cocozelle Group 'Romanesco'. The leaf lamina immediately adjacent to the fruit fits 'Romanesco' as well. All told, there are perhaps as many as three late 16th-century images of the 'Romanesco' cocozelle (Paris, 2023).

Another image, from Plate 12, shows a mature, oval, ribbed pumpkin having broad dark green stripes on a light yellow-orange background (Figure 1). Two more, from Plate 44, show a mature, oblate, strongly ribbed, orangish-green pumpkin, much reminiscent of the guicoys of Guatemala, and a mature, oval-oblong, ribbed, light orange pumpkin.

Cucumis melo L.

Melons were illustrated repeatedly by Hoefnagel. The fruit shown in Figure 1, though appearing to be very large, is disproportionately close to the viewer. Like the squash, it is illuminated from the left, in shadow toward the right. Nearly spherical and 10-lobed, it is pale yellow, and greenish in the depressions. A large slice or split at the top right reveals orange flesh and seed cavity. Brown areas on the rind and flesh suggest the fruit was beginning to rot. The rind is smooth, not netted, and therefore this melon appears to be of the Cantalupensis Group. A similar round, lobed, smooth, orange-fleshed melon, but having greenish-orange external color, is shown in Figure 2, as is another round, lobed, smooth melon, split, yellowish-brown externally with salmon-orange flesh. Both of these also appear to be of the Cantalupensis Group.

Cucumis sativus L.

Cucumbers, too, are a frequently appearing cucurbit in illustrations by Hoefnagel. Most of his illustrations are of pickling cucumbers, which have a length-to-broadest width ratio of 3:1 or less (Figure 3). They have large but sparse warts and spines, quite similar to those that had been illustrated in late-medieval manuscripts of Italian provenance but not those of northern French provenance, which had very many small warts and spines (Paris et al., 2011). Hoefnagel illustrated cucumbers in realistic detail and did not shy from illustrating distorted "cull" fruits.

Lagenaria siceraria (Molina) Standl.

Bottle gourds, too, were frequently drawn by Hoefnagel (Figure 4). Most of them are very long; these are edible when young but desiccate as they mature and most of those illustrated are well beyond their prime for kitchen use. Large bell-shaped bottle gourds, which are utilitarian when mature and dry, appear less frequently. In Plate 64 of the *Animalia volatilia et amphibia* (*aier*), foliage and a flower of *Cucurbita pepo* are shown attached to the green, bell-shaped gourd.

Citrullus lanatus (Thunb.) Matsum. & Nakai
Citrullus amarus Schrad.
Cucurbita maxima Duchesne
Cucurbita moschata Duchesne
Cucurbita. pepo subsp. *ovifera* (L.) D.S. Decker

These five taxa are absent from the illustrations of Hoefnagel. They have long-keeping fruits, more so certainly than those of *Cucumis*. As both dessert watermelons and citron watermelons had been present in Europe since Roman times (Paris, 2015), it is surprising that Hoefnagel either did not encounter them or did not select any for illustration. *Cucurbita pepo* and *Cucumis sativus* would certainly be better adapted climactically, in most of the lands that Hoefnagel resided in, than *Citrullus* species (Wehner et al., 2020). Yet melons, which are quite cool-temperature sensitive too, appear frequently in his illustrations. As for *Cucurbita maxima* and *Cucurbita moschata*, there are few illustrations and descriptions of these taxa in Europe that antedate the works of Hoefnagel (Formiga and Myers, 2020), so it is possible that he simply did not encounter them. European illustrations of *Cucurbita pepo* subsp. *ovifera* antedate and were contemporary to the works of Hoefnagel, as were illustrations of the grooved pumpkins of eastern North America (Paris, 2000; Teppner, 2000), so it seems odd that these are absent.

Conclusions

Among the four cucurbit species that Hoefnagel illustrated, quite a bit of variation is evident in three of them. Of the *Cucurbita pepo*, all were distinctly ribbed and from the same subspecies, but there were two distinct shape profiles, most of the fruits being nearly round (oblate to oval-oblong) but two were about three-and-a-half times long as they were wide and swollen at the stylar end (Figure 1; Paris, 2023). Hence, both pumpkins and cocozelles were illustrated. The pumpkins differed in rind color and, regardless of shape, all of the fruits were shown at full maturity. Likewise, the *Lagenaria siceraria* fruits were of two distinct shapes, most very long but two were bell-shaped (Figure 4). They were depicted at various stages of maturity, many of them too mature to be of culinary use. Though most of the cucumbers illustrated were of the short, pickling type (Figure 3), others were of intermediate length or very long (not presented). Again, some appeared to be mature, well past their prime for culinary use. Only the melons had little variation, and were fairly large, round, and lobed, differing only in rind color (Figure 2).

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Figure 1. Images of *Cucurbita pepo* subsp. *pepo* in the *Animalia volatilia et amphibia* (*aier*), ca. 1575/1580 (National Gallery of Art). Top left: Plate 38, mature ribbed cocozelle squash (adjacent and behind one large melon and to the side of a stunted one). Top right: Plate 12, mature, ribbed, striped pumpkin (adjacent to pears). Bottom: Plate 44, mature ribbed, oblate Guatemalan pumpkin or "guicoy" (left) and mature, ribbed, oval pumpkin (right).

Figure 2. Images of *Cucumis melo*. Left: *Animalia quadrupedia et reptilia (terra)* Plate 29, ca. 1575/1580 (National Gallery of Art). Right: *Mira calligraphiae monumenta*, Ms. 20 (86.MV.527) folio 144v, 1591–1596 (Getty Museum Collection).

Figure 3. Images of *Cucumis sativus*. Top left: two pickling cucumbers, *Archetypa studiaque patris Georgii Hoefnagelii*, Part 2 Frontispiece, 1592 (National Gallery of Art). Top center: cull pickling cucumber and part of adjacent foliage including peduncle, stem, tendrils, and leaf, *Archetypa* Part 1 Plate 11 (National Gallery of Art). Top right: one mature distorted (adnated) pickling cucumber, *Mira calligraphiae monumenta*, Ms. 20 (86.MV.527) folio 38, 1591–1596 (Getty Museum Collection). Bottom: pickling cucumbers, one large and one very young with attached corolla, and with adjacent foliage of stem, tendrils, and leaves, *Archetypa* Part 2 Plate 11 (National Gallery of Art).

Figure 4. Images of *Lagenaria siceraria*. Left to right: One long and one bell-shaped gourd, *Archetypa studiaque patris Georgii Hoefnagelii*, Part 4 Frontispiece, 1592 (National Gallery of Art); mature pale-colored long and immature green bell-shaped gourds, and oval-oblong, ribbed, mature orange-yellow pumpkin of *Cucurbita pepo*, with foliage and flower of *C. pepo* attached to the bell gourd, *Animalia volatilia et amphibia* (*aier*) Plate 64, ca. 1575/1580 (National Gallery of Art); long, immature, pale-green gourd, *Animalia quadrupedia et reptilia* (*terra*) Plate 29, ca. 1575/1580 (National Gallery of Art); two long, light green and yellow-green immature gourds, *Mira calligraphiae monumenta* Ms. 20 (86.MV.527) folio 144v, 1591–1596 (Getty Museum Collection); yellow-green immature gourd, *Mira calligraphiae monumenta* Ms. 20 (86.MV.527) folio 132v (Getty Museum Collection).

In memoriam
David Warren Groff, Plant Breeder (1938 – 2022)

David Warren Groff, PhD, Age 84 of Lake Wisteria, Tifton, Georgia, passed away at home on Dec. 8, 2022.

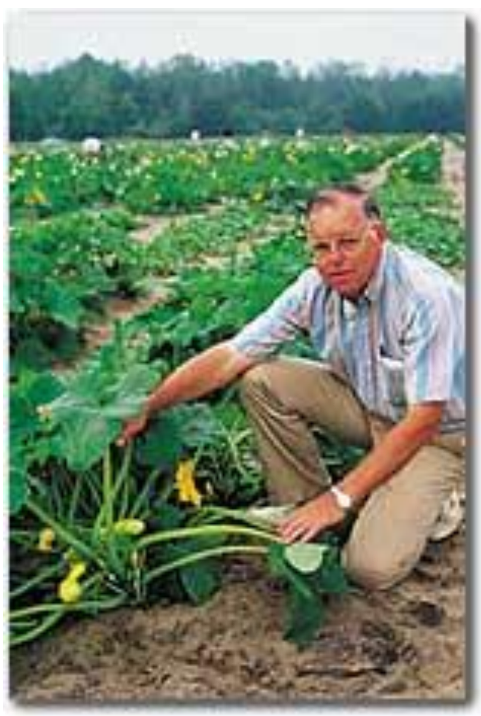
Dave was a plant breeder, station manager and seedsman for The Asgrow Seed Company in Bridgeton, New Jersey (1966-1988) and Tifton, Georgia (1988-2000). From his work, over 100 hybrids of cucumber (92), squash (10) and spinach (9) varieties have been sold commercially worldwide. During 1994-2000, the company released the first commercial transgenic squash cultivars (Freedom II; Destiny III, and Liberator III) with multi-virus resistance (to ZYMV-WMV in 'Freedom II'; to ZYMV-WMV-CMV in 'Destiny III' and 'Liberator III'). After his retirement from Asgrow-SEMINIS Vegetable Seeds, he independently bred cucumber, squash, and bush-habit winged gourds.

Dave was born in Bethlehem, Pennsylvania, the son of the late Warren C. and Eleanor Rapp Groff. He married the former Susan Pierson of State College, Pennsylvania on June 17, 1961, who survives him in Tifton, Georgia. Together they had three children and were blessed with five grandchildren and two great-grandchildren. He achieved B.S. (1960) and M.S. (1962) degrees in horticulture and plant breeding, respectively, from Pennsylvania State University in State College and a Ph.D. in horticulture from the University of Arizona (1966).

Dave was passionately committed to hobbies, church and civic affiliations including hunting, breeding, and showing Brittany spaniels, and board positions and volunteering at the Georgia Museum of Agriculture.

He had served on the USDA Cucurbit Advisory Committee and, in 2001, received the American Society of Horticultural Science "Vegetable Breeding Working Group Award of Excellence."

Contributor: Jean M. Poulos, PhD



In memoriam

Robert Warren Barham, Plant Breeder (1953 – 2023)

Dr. Robert Warren Barham passed away on March 2, 2023, at the age of 69, leaving behind a legacy of extraordinary achievements and fond memories. With heavy hearts, we mourn the loss of a beloved father, brother, and friend, whose life touched everyone he encountered. Robert is survived by his children, Andy, Laura, Kelly, and Emily, as well as his seven grandchildren: Val, Atticus, Owen, Eleanor, Everett, Ramona, and June. He is also survived by his sisters and brothers in law, Barbara and Mari and Juanita and Max, as well as many nieces and nephews whom he loved greatly, and was predeceased by his sister Margaret Ann.

Robert was born the fourth child to Margaret and Dr. Warren Barham in Raleigh, North Carolina. Later in childhood he moved to Vacaville, California, where he spoke fondly of spending afternoons exploring nature on his own, teaching tennis, and playing trombone in the band. He earned his Bachelor of Science from UC Davis, and later his PhD in Genetics and Plant Breeding from the University of Minnesota. In his early years, he was introduced to the science and art of plant breeding at home with his father, who had both a personal and professional passion for plant breeding. Robert later went on to build his career as a second-generation plant breeder; he worked on many crops including radish, broccoli, onions, and watermelon.

Robert was a visionary plant breeder and a gifted entrepreneur. Robert and his father were partners in the plant breeding company, Barham Seeds Inc. They worked together breeding watermelons and saw success releasing some of the early triploid watermelon (seedless) varieties into the US marketplace, including 5244, Fandango, and UltraCool. They also developed seeded watermelon varieties including Summer Flavor 800.

Later in his career, Robert would go on to work with his daughter, Laura Brown, and together they developed triploid watermelon varieties with their team at Enza Zaden Research, USA. He was instrumental in breeding and releasing the triploid hybrids Cracker Jack, Red Garnet, Red Amber, Red Opal, Rio Grande, and Minibee. The pipeline of germplasm he developed will continue his legacy into the future (Figure 1).

In his career he also worked on broccoli breeding. He developed heat tolerant broccoli and secured a utility patent on the heat tolerant trait. Robert was always very interested in seed production and developed seed production research projects in both broccoli and watermelon throughout his career.

His passion and dedication inspired his colleagues and collaborators alike. Through his unique plant breeding insights, he made the world a better place, leaving a distinctive legacy. Robert's brilliance, creativity, and unyielding spirit were evident not only in his work but also in his life. He cherished every moment, living with urgency and passion, and considered his family to be his brightest legacy.

A natural performer, Robert was always quick with a joke, a song, a lesson, or advice. We remember him as a wholly unique individual who loved spending time with family, swimming (not to mention waterslides!), music, and nature. His favorite place was among the redwoods of California, where he found peace and serenity. His spirit will always be at home in those majestic trees.

Submitted by Laura Brown, Enza Zaden Research

Figure 1. Robert Barham harvesting watermelon in field plots in Gilroy, California and Myakkla, Forida, U.S.A. (Photos contributed by Laura Brown)