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Investigation on phenological stages, blooming behaviour and pollen functional ability of different pear genotypes under Kashmir conditions

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Abstract
The present investigation was conducted in the Experimental Farm of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir during the year 2017. Nine pear genotypes viz., William Bartlett, Fertility, Chinese Sandy Pear, Clapp's Favourite, Max Red Bartlett, Kings Pear, Beurre de Amanalis, Carmen and Abate Fetel were evaluated. The study showed significant differences among all the genotypes in all the phenological stages, blooming behaviour and pollen functional ability. The blooming pattern of genotypes revealed that "Chinese Sandy Pear" and "Kings Pear" were first to come into flowering followed by "Clapp's Favourite" and "Beurre de Amanalis" whereas, "William Bartlett", "Max Red Bartlett", "Fertility", "Carmen" and "Abate Fetel" were observed to be late bloomers. The flowering duration (15 days) was longest in "Fertility" followed by 14.67 and 14.22 days in "William Bartlett" and "Max Red Bartlett", respectively and shortest (11.45 days) in "Chinese Sandy Pear". The highest pollen viability (84.07%) and germination (73.25%) was observed in "William Bartlett".

Keywords: Pear, Genotype, Phenological stages, Pollen viability

Introduction
Pear (*Pyrus communis* L.) belongs to family Rosaceae, sub-family Pomoideae, order Rosales and genus *Pyrus.* The pear is believed to have originated in the Eurasian continent. It is grown in all the temperate regions of the world with varied size, shape, texture and flavours. It is next only to apple in importance, acreage, production and varietal diversity. The pear has long been admired in many cultures although never as popular as apple, remains one of the world's most admired temperate fruit. Hitherto, its world production is only about one-quarter that of apple, indicating that appreciation of pear has not attained the universality of appeal of its better relatives (Janick, 2002) [16]. The pear is a unique fruit crop in itself having hardy and non-shrivelling type of fruits. It is a nutritious fruit with enough essential nutrients and amino acids and it could serve as potential source in food formulation (Mahammad *et al.*, 2010) [18].
Floral initiation in pear occurs about 60 days after full bloom and flower buds are formed on terminal shoots and two or more years old short spurs. Most pears tend to flower every year (Westwood, 1988) [23]. Pear inflorescence (corymb) contains 7 to 8 flowers and is indeterminate where side or lateral blossoms open first and terminal bloom open last. In general pear flowers consists of 5 petals, 5 sepals, 20-30 stamens with usually red anthers, 2-5 free styles closely constructed at the base and ovary having five locules with two ovules each (Uppal *et al.*, 1993) [21]. Pear varieties are generally self-unfruitful and do not set fruit by their own pollen due to the antagonism that prevents pollen grains from growing on to the stigmas and at least two genetically distinct cultivars are necessary for stable pear production. Therefore, pollination is an important and inseparable component in respect of regular and consistent production. For cross pollination to be effective it is very important that the cultivars produce the sufficient quantity of viable, compatible pollen and bloom at approximately the same time. Thus, the interplanting of suitable varieties for providing

effective cross-pollination assumes significant importance. Recently, two pear cultivars Carmen and Abate Fetel were introduced in SKUAST-K, Shalimar campus. Under Kashmir valley conditions both these cultivars produce abundant bloom but the knowledge of their flowering behaviour vis-a-vis traditional cultivars is not known. This necessitates the study on floral phenology, pollen viability and pollen germination of various genotypes to ensure effective cross pollination.

Materials and Methods

The present study was carried out at Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Shalimar during 2017. The various genotypes of pear were tested for floral phenology, flowering duration, pollen viability and pollen germination using Randomized Complete Block Design with three replications. Prior to flowering, branches of selected pear genotypes in four directions were tagged and evaluated for blooming period and accordingly the dates of blooming were recorded and converted to days after reference date (DARD) fixed arbitrarily as 1st March. The phenological stages were observed visually when the buds started showing respective stages like date of swollen bud (when the buds started swelling), date of bud burst (when the terminal buds were enlarged about 50 per cent or more followed by bud scale split, exposing the green colour of the leaves), date of green cluster(when clusters of green buds start to open), date of white bud (when about 50% of white buds appear) date of initial bloom (when about 10% of flowers opened for each tagged tree), date of full bloom (when about 80-90% of flowers were open) and date of complete petal fall (when 80% of flowers exhibited petal fall) was recorded (Figure 1). The duration of flowering was worked out as the period (days) between the initial bloom and complete petal fall in each tagged tree.

Pollen viability was tested by using triphenyl tetrazolium chloride (TTC) solution prepared by taking 1 g of TTC, 40 ml of 95 per cent ethanol and the total volume was made to 100 ml with distilled water. Then pollens were left for 1 hour for staining and examined under microscope. Deeply stained and normal looking pollen grains were considered as viable while as shriveled and weekly stained were regarded as non-viable. Freshly dehisced pollen grains were used for *in vitro* pollen germination test. Sucrose 15 per cent was prepared with 0.5 per cent agar as solidifying medium and 5 ppm boric acid. Solution was placed in the petri dishes and pollen grains were dusted over it and then covered. Pollen tube growth was observed for each genotype under microscope after 24 hours of incubation period at 22±2ºC. The pollen grains having pollen tube at least two times longer than pollen size were considered to be germinated (Figure 2)

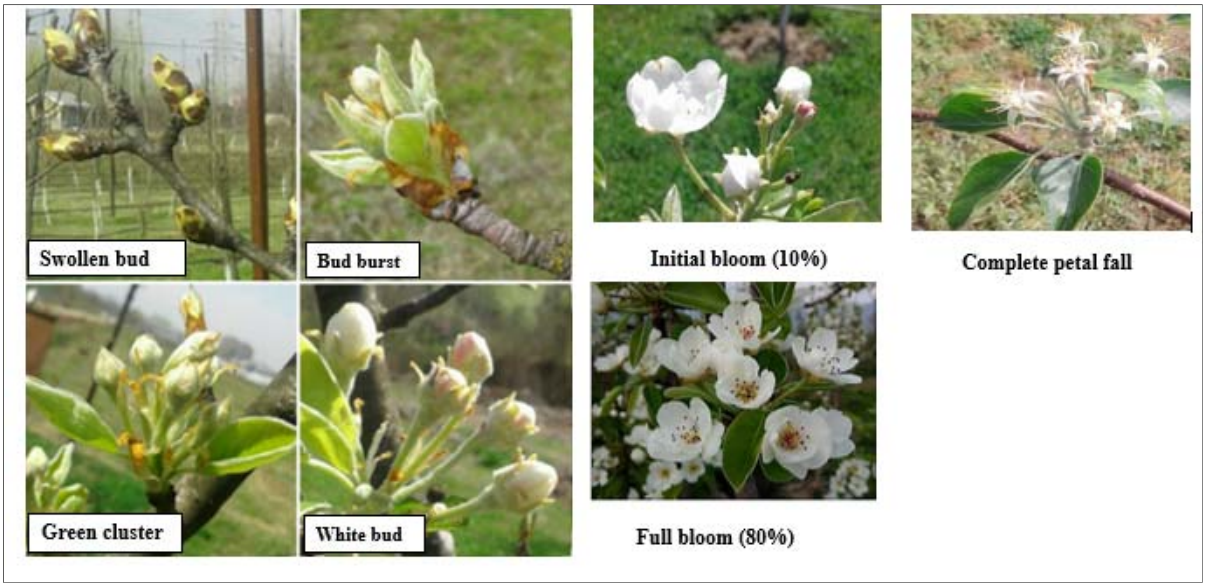
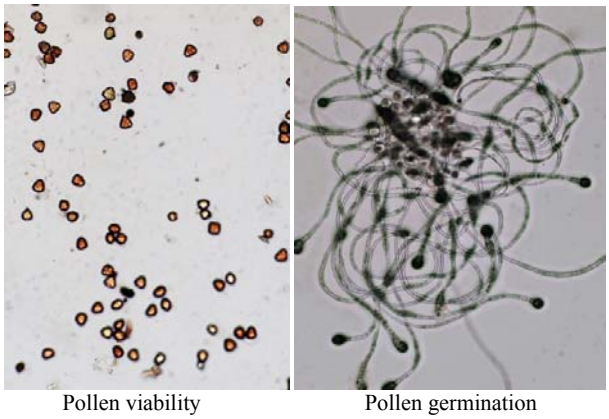


Fig 1: Phenological and flowering stages of pear



Pollen viability Pollen germination

Fig 2: Pollen viability and pollen germination of pear

Results and Discussion

Considerable variations were exhibited by the different genotypes in attaining the different phenological stages from swollen bud to complete petal fall stage (Table 1). It is evident from the perusal of data that cv. "Abate Fetel" took maximum number of days 22.54 days after reference date (DARD) followed by "Carmen" (20.78 DARD) to reach the swollen bud stage as against minimum of 13.12 DARD required by "Chinese Sandy Pear". Regarding bud burst stage data reveal that cvs. "Abate Fetel" and "Carmen" took maximum number of days (26.89 DARD) and (25.44 DARD), respectively to reach this stage and were statistically at par with each other. Minimum number of days to the tune of 18.44 and 19.44 DARD were taken by "Chinese Sandy Pear" and "Kings Pear" respectively. Days taken to enter green cluster stage were recorded significantly maximum (29.99

DARD) in cv. "Abate Fetel" followed by cv. "Carmen" (28.78 DARD), whereas, pollinizers "Fertility" and "Max Red Bartlett" registered 27.89 DARD each. Significantly minimum 22.89 DARD to enter the green cluster stage were observed by "Chinese Sandy Pear". White bud stage was first recorded in "Chinese Sandy Pear" (26.22 DARD) followed by "Kings Pear" (27.11 DARD) and lastly in "Abate Fetel" at (33.33 DARD). The differences in flower bud development period may be due to the genetic makeup of the individuals, which appears to be a principle factor in controlling flower bud development (Anand, 2003) [2].

Significant difference was observed among all the genotypes with respect to initial bloom stage (Table 2). Pollinizers "Chinese Sandy Pear" and "Kings Pear" exhibited this stage earlier at 30.22 and 30.89 days after reference date, respectively whereas, cv. "Abate Fetel" attained this stage later (39.55 DARD). Genotypes "Clapp's Favourite", "Beurre de Amanalis", "William Bartlett", "Max Red Bartlett", "Fertility" and "Carmen" exhibited this stage at 32.33, 34.66, 35.44, 36.33, 36.66 and 37.55 days after reference date, respectively and genotypes "Carmen", "Max Red Bartlett" and "Fertility" were statistically at par among themselves. . However, full bloom was first observed for "Kings Pear" (34.55 DARD) and very late for "Abate Fetel" (43.22 DARD). This disparity in bloom among different genotypes could be due to their different heat requirements (Alonso *et al.*, 2005) [1]. The complex mechanisms of chilling requirements and subsequent heat unit accumulation, may affect flowering date and duration of anthesis differently in different cultivars (Malgarejo, 1996) [19]. Arzani (2004) [4] supported the concept and stated that different genotypes of Asian pear showed different flowering times and periods. Besides environmental factors like temperature, rainfall, relative humidity may directly or indirectly, singly or collectively have played an important role during flower bud development period. Bodor and Toth (2007) [8] studied the floral phenology in scab resistant apple cultivars and stated that high spring temperature shortens the blooming period and main bloom takes only few days for the whole cultivar assortment. Dhillon and Gill (2013) [12], also reported the effect of climatic conditions especially temperature on flowering of hard pear (*Pyrus pyrifolia*). The complete petal fall (41.67 DARD) was observed first in "Chinese Sandy Pear" and late (52.21 DARD) in "Abate Fetel".

Significant differences were observed among the various genotypes of pear with respect to flowering duration (Figure 3). The pollinizer "Fertility" exhibited significantly longest flowering duration for 15.00 days followed by 14.67 days in "William Bartlett" and 14.22 days in "Max Red Bartlett" whereas, duration of flowering was shortest 11.45 days in "Chinese Sandy Pear". Variation in duration of flowering between different cultivars may be attributed to differential development of floral parts in various cultivars which is highly attributed to their genetic difference. Similar variations in flowering duration of different genotypes of pear were also reported by Aulakh *et al.* (1981) [5] who stated that the duration of flowering varied from 21 days in Baggugosha to 29 days in Smith. Flowering duration a highly variable character primarily being a varietal character, but temperature has a great effect on duration of flowering. Cold weather prolongs the duration of flowering and warm weather shortens it. Consequently, the duration of flowering of a specific tree can vary from one week to several weeks (Wertheim and Schmidt, 2005) [22]. These findings are in consonance with the findings of Dhillon and Gill (2013) [12], who reported that flowering duration in hard pear was longer in one year with 14-21 days and 09-11 days in the following year. The reason for longer flowering duration in.

Table 1: Phenological stages of different genotypes of pear (DARD*)

Parameters / Genotypes	Days taken to swollen bud	Days taken to bud burst	Days taken to green cluster	Days taken to white bud
William Bartlett	18.67	23.55	26.99	30.44
Fertility	19.23	24.44	27.89	31.33
Clapp's Favourite	14.45	20.33	24.99	28.33
Chinese Sandy Pear	13.12	18.44	22.89	26.22
Max Red Bartlett	19.56	24.33	27.89	31.56
Kings Pear	14.23	19.44	24.11	27.11
Beurre de Amanalis	16.56	21.44	24.78	28.76
Carmen	20.78	25.44	28.78	32.66
Abate Fetel	22.54	26.89	29.99	33.33
C.D ($p \leq 0.05$)	1.00	1.56	0.43	1.90

*DARD - Days after reference date

Table 2: Flowering characteristics of different genotypes of pear (DARD*)

Parameters / Genotypes	Days taken to initial bloom (10%)	Days taken to full bloom (80%)	Days taken to petal fall (80%)
William Bartlett	35.44	40.22	50.11
Fertility	36.66	41.66	51.66
Clapp's Favourite	32.33	36.33	45.26
Chinese Sandy Pear	30.22	34.56	41.67
Max Red Bartlett	36.33	40.44	50.55
Kings Pear	30.89	34.55	42.67
Beurre de Amanalis	34.66	38.33	46.77
Carmen	37.55	42.33	50.33
Abate Fetel	39.55	43.22	52.21
C.D ($p \leq 0.05$)	1.70	0.70	1.10

* Days after reference date

Second year of study might be due to the more incidence of low temperature in this fruiting season. Furthermore, the time of flowering in pear is influenced by chilling requirement for breaking the rest period and heat requirement to develop

flower buds to bloom. Inadequate chilling in some years result in late and weak bloom. The amount of chilling requirement should be considered for species and cultivars selection in orchard design (Faust *et al.*, 1976) [13].

Pollen viability and germination varied significantly among the various pollinizers and cultivars under study (Figure 4). The highest pollen viability (84.07%) was observed in "William Bartlett" followed by 83.48% in pollinizer "Max Red Bartlett" and 82.82% in "Fertility" being statistically at par among themselves whereas, lowest pollen viability (59.49%) was found in "Beurre de Amanalis". This range for viability obtained could be due to different genetic makeup as mitochondrion and endoplasmic reticulum when present in large quantity may also effect the pollen viability (Bellani and Bell, 1986), likewise highest pollen germination (73.25%) and (73.23%) was recorded in "William Bartlett" and "Max Red Bartlett", respectively followed by 70.78% in "Fertility" which was statistically at par with "Carmen"(70.72%) and lowest (50.48%) in "Beurre de Amanalis". Pollen tube length at least of diameter of pollen grain or twice the length of pollen grain was considered to be germinated. Pollen being a rich source of auxin and gibberellins which have been isolated from the pollen of a number of temperate fruit plants helps in pollen tube growth (Leopold, 1964) [17]. These variations may be due to the pollen fertility, as a result of regular meiosis and activation of certain enzyme systems present in the pollen grain itself. This phenomenon is attributed to the genetic differences among the various genotypes (Nogueira *et al.*, 2016) [20]. Besides genotype, environmental interactions also influence the pollen germination, and the germination media play an important role in pollen germination. The optimum temperature for pollen germination of pear pollen is 22-25 ºC in 10-15 per cent sucrose or glucose solution. Germination did not occur below 9 ºC or in distilled water (Ifteni and Toma, 1972) [15]. These findings were corroborated also by Aparecida *et al.* (2004) who reported that temperature is a basic factor in the control of environmental conditions and influences pollen grain germination and longevity. Furthermore, low temperature might have led to intracellular ice formation, cell death and thereby loss of germination (Bhat *et al.*, 2012) [7] while as, very high temperatures cause degradation of the proteins and enzymes essential for the development of the pollen tube (Breton and Berville, 2012) [9]. Boron concentration of the pollen grains also play a significant role in germination. Chagas *et al.* (2009) [10] stated that the addition of boron in germination media was beneficial to the germination of pollen grains of the pear. Boron is a fundamental element for the germination of pollen grains in Rosaceae. It stimulates the growth of pollen tube and reduces the possibility of the pollen splitting (Franzon and Raseira, 2006) [14], formation of the ionisable sugar-borate complex which reacts with the plasma membrane and thus promote greater growth of the pollen tube (Dantas *et al.*, 2005) [11].

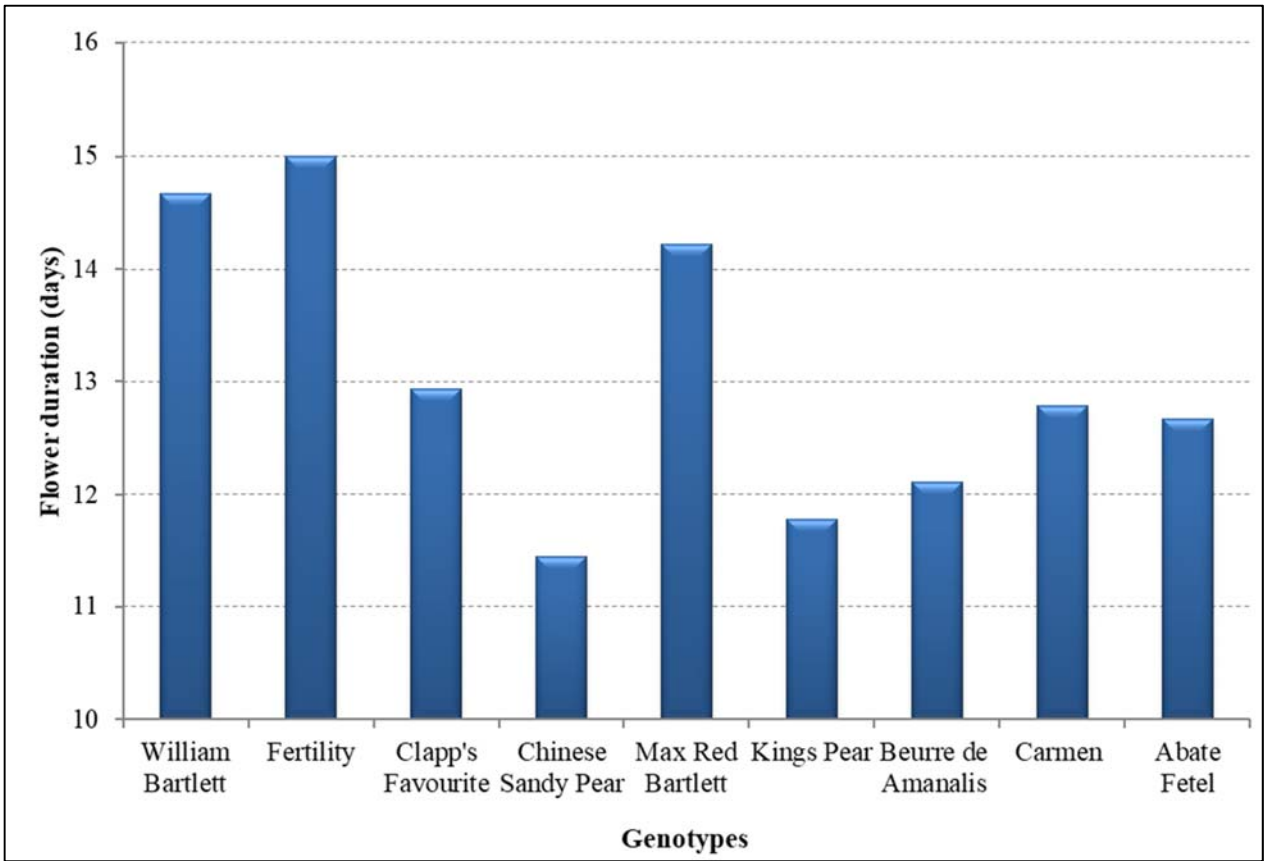


Fig 3: Flowering duration of different pear genotypes

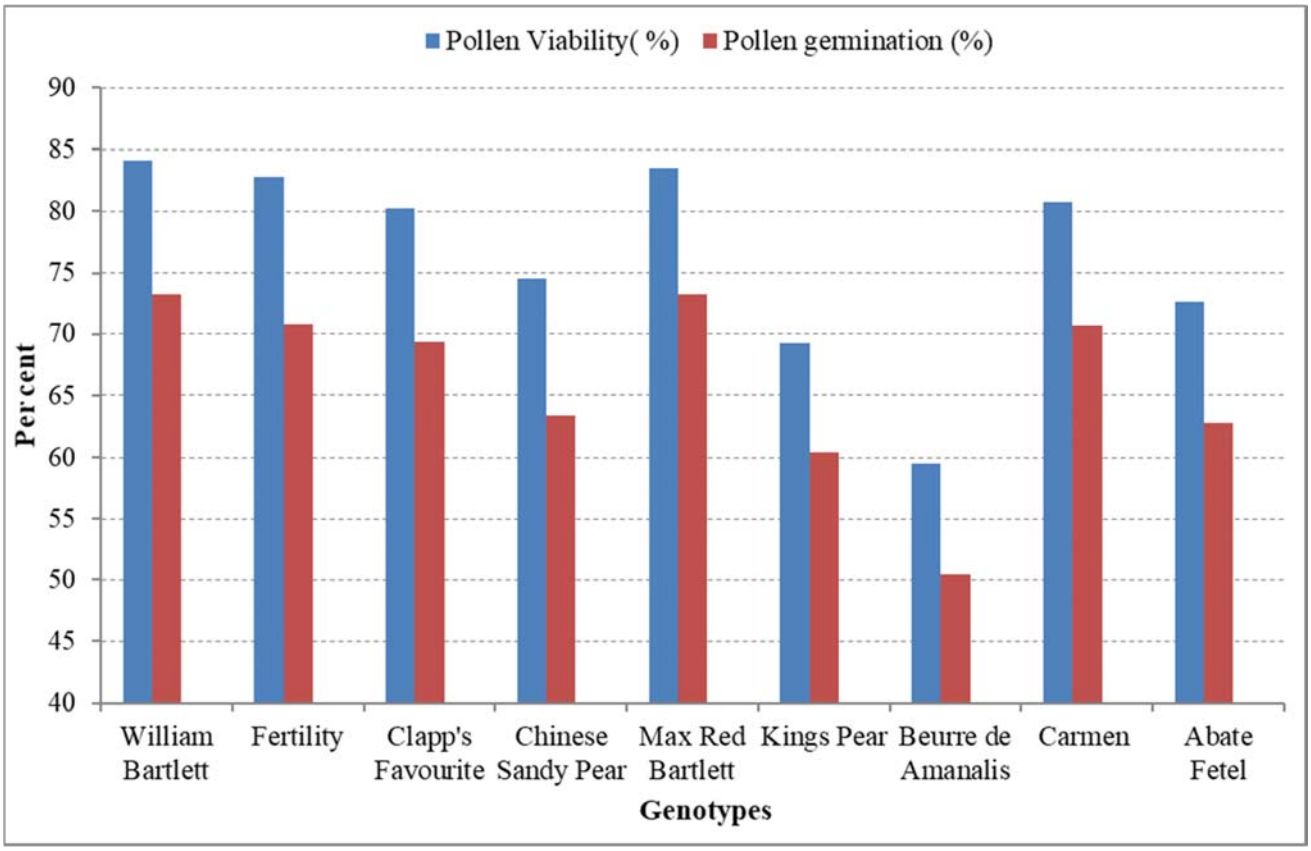


Fig 4: Pollen viability and pollen germination of different pear genotype

Conclusion

Among the different genotypes evaluated, "Chinese Sandy Pear" was earliest to show all the phenological stages. However, "Abate Fetel" was the last to exhibit different phenological stages. The flowering duration was longest in genotype "Fertility" and shortest in "Chinese Sandy Pear". The maximum pollen viability was registered in "William Bartlett" and minimum in "Beurre de Amanalis".

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